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The semiotics of configurations for the immanent design of interactive computational systems

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ABSTRACT

In this paper the authors propose a novel semiotic approach to the design of interactive systems and computational systems, grounded in the most recent contributions within the debate around semiotic theory and analysis. This approach, that is here called Semiotics of Configurations (SoC), is proposed for its analytic power in describing material artifacts and settings with a purposely a-conceptualistic stance. The resulting analysis informs a kind of design that is aimed at reproducing and supporting the programs of action detected in the use of artifacts, as this use is "abducted" from the physical and material form of the artifacts themselves and from the observation of how content is transformed within and across them. This approach to design, called immanent design, has inspired a platform for the user-driven development and use of electronic documents and forms in cooperative and organizational domains. The framework is illustrated with a case drawn from a study performed in the domain of hospital work.

1. Motivations and background

This paper proposes an alternative approach to the design of computational artifacts with respect to those that are based on the theoretical analysis of work settings and on the conceptual modeling of the technologies that can support work: we call our approach *immanent design* and propose it along with a semiotic approach to the analysis of socio-technical settings that is new with respect to the design of interactive systems.

In our design-oriented proposal *immanence*[1] is evoked as a general concern of an approach that is wary of abstract and conceptual categorization and of the theoretical pursue of causes and effects, intentions and purposes [45] — at least for the sake of design. This approach assumes that this kind of theoretical analysis is *not* necessary to understand *what and how* to automate, in short "what to design". We propose immanent design as an alternative look at design that is wary of taking design as a sort of fabricative "metaphysics of *false depths* — illusional mental contents and determinative faculties hypothesized and reified from out of verbal descriptions of actions (e.g., belief, knowledge, and artistic creation from believing, knowing, and creating respectively), ideal essences, illusions of matter and form, rather than potentialities, actions and

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[1] To our aims, it is immanent something that cannot escape, nor influence or determine from outside, the relations of which is part – and from which usually emerges. In addition to that, we consider also signification to be an immanent process. This means that, for us, there is no room for a transcendental human subject who, from another level, interprets and makes sense of the signs or configurations of signs that are in the world. Obviously, we do not exclude that different perspectives could be possible on the same phenomena. However these points of view would not come from a transcendent level, but rather from the same level and built on the same relations [89]. Because of this immanent approach we do not deny the existence of inner, cognitive, mental activities. However, we do not believe that these activities transcend other kinds of activities; as Latour said in [88] in regard to Hutchins' work: there "is nothing below the skin except the continuation of the same processes that go on outside", namely, relations among configurations of relations. Thus, this stance does not deny the possibility to reason about interaction and work articulation in terms of abstract categories, like concepts, entities, roles, tasks, processes. However, these abstract categories do not transcend more concrete ones: they are just dried-up (purified) and singled-out specific relations (such as inside/outside, insider/outsider, entering/exiting), which are extracted from the mess in which usually relations take place (a nation, an ecosystem, a database, an interacting system, a cognitive system, etc.). In this light, "immanent design" is grounded in radical behaviorism. If we bring these points from the field of signification to the field of artifact design, we can see that the originality of "immanent design" lies in this conscious and purposeful neglect of the (alleged) needs of the users, their (claimed) purposes and the general principles guiding their conduct, which usually transcend the situation taken into account in the design process. As such, "immanent design" does not commit to the traditional "emphasis on purpose" in the design sciences ([123], p. 267), nor to the universal Platonic attitude of analysts to aim to understand the functions of the artifacts to be designed and their underlying principles. The focus is on the relations that constitute the configurations unfolding in any cooperative setting and on the efforts necessary to understand how to automate (or just support humans in) the continuous unfolding and establishment of these relations.

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Table 1
Definitions of the main concepts presented in this work (with no ambition of generality beyond it). Terms in boldface are mentioned in this very short glossary.

Actant	Anything that can enact a **program**, that is make a (portion of) **configuration** change (**translate**).
Artifact	A distinct, sufficiently persistent and physical (i.e., material but not necessarily tangible) **configuration**[1] of tightly coupled inanimate elements purposely designed[2] and *configured* to be used to have some work done in the context of some **practice**.
Configuration	A portion of the world (i.e., a combination of events, objects, **actants**) that is perceived and understood as a fact (cf. Wittgenstein[3]) and whose each element cannot be decoupled from the others with which is in mutual relation to be meaningful and partake in the whole. A networked texture of relations and relata.
Immanent Design	A design approach and activity aimed at implementing computational artifacts whose interface and behaviors try to reproduce (in different formats), respectively, the inherent and external relations that have been identified in a cooperative setting by a **SoC**-informed analysis.
Enframe	Anything acting as a frame or a border that, by *enclosing* something, makes it a *content* and distinct from the rest. In documental ambits, the simplest examples of enframe are the check-boxes and text-areas of a paper form. But also the rectangular sheet of paper is an enframe itself, as well as the record binder and the bookcase.
Practice	A temporally regular pattern (i.e., **configuration**) of recurring and loosely coupled activities intentionally articulated together to have some work done exhibiting some knowledge, skill and competence[4].
Program of action	A set of behaviors aptly enacted by some **actant** and oriented towards an objective, as well as (by metonymy) any *scheme*[5] representing these behaviors and the related competences.
Script	The description of potential external relations that a configuration predisposes, in both affording and constraining someone or something to establish actual external relations with it (i.e., to interact with it). These actual external relations enact a **program of action**.
Semiotics of Configurations (SoC)	A semiotic methodology to analyze and describe cooperative socio-technical settings in terms of **configurations** and relations.
SoC	See **Semiotics of Configurations**.
Translation	The process by which a **configuration** changes over space, time, or both and gets transformed by any human or inanimate **actant**.

[1] This means that a ready-to-use Swiss-army knife with one function open is a different artifact from the same knife with another function open. The same holds for one grip on a Pattada knife from another one [46], or for one software application page from another one. Obviously, these distinct artifacts mentioned above are all very closely related, so much that a more objectivistic stance could consider them just different "modalities" of the *same* artifact. The point here is that the concept of **configuration** can be applied at different scales, to both the whole and to any of its parts.

[2] To this respect we emphasize that artifacts are "things drawn together" [90] with some craft and knowledge and therefore that the concept of tool is more general, including any thing that is used to some aim.

[3] Here we refer to the oft-cited propositions 1.1 and 1.2 of the Tractatus Logico-Philosophicus ("The world is the totality of facts, not of things", "The world divides into facts", respectively), which we feel to subscribe as long as also the intuitive notion of fact is traced back to that of *interpretation*, in the mold of Nietzsche (cf. his writing on a notebook from the 1886 "There are no facts, only interpretations") rather than to the proposition 2.1 of the same treatise ("An atomic fact is a combination of objects (entities, things)."). Intuitively, interpretation for us stands as a cognitive act where some*thing* become manifest in virtue of an interaction and some negotiation. This is close to the supposed original meaning of the word interpretation, which Pianigiani traces back to the Latin preposition *inter* (in-between) and a root *prat* that can be found also in the Greek phrazein: to tell, to perceive, and then to consider. Thus interpretation as something emerging from an active structural coupling between a *subject*, the interpreter, and an *object* (to use traditional categories), that is a relation. This means that a configuration is not just out there, but it is rather constituted in a relational engagement between parts of the world. This also regards what we mean by relational epistemology, which is mentioned in some passages of this work. Adopting a relational epistemology, in both analysis and design, means: first, that we are not so much concerned with objects *per se* (i.e., ontology), but rather with how we interact with them and get to know and cope with them (i.e., epistemology, although a perhaps better term would be *gnosiology*); then, that our approach to the design of object tries to travel a route between the Scylla of (postmodern)-hermeneutics and the Charybdis of (new)-realism. In this route we assume that relations precede and constitute elements, which are nothing but points of intersection among bundles of relations. In this route we are guided by the primacy of practices, which are naturally conditioned, culturally situated, shaped by collective norms and individual intentions, and these latter are seen, at essential level, as *co-constituting relations between objects* (which are also *subjects to* their context), in which some "interpreters" see some "facts".

[4] This last phrase was added to consider the fact that practices are also always characterized by some rule prescribing how things should be done correctly and knowledgeably [124].

[5] For scheme we intend any representation that either precedes, affects and guides the whole sets of actions above mentioned, or that results from the recognition of such an ordered course of events and goal-oriented actions as a whole.

descriptions" p. 142 [43]. Immanent design regards then the idea that what animates a socio-technical setting is already "out there", in the physical and material arrangements of things, people and their places, and that there is no need to make up hypotheses (cf. Newton) about their inter-operation and create new modes of it. Therefore, it advocates to just describe the setting and design to support the "natural" interaction among its *haecceities*, that is the contingent and peculiar aspects of the setting's things and "the lived details of interaction and collaboration" (p.54, [42]) which make these unique and materially intertwined.

However, immanent design is not a radical break with respect to the past. In fact, it is deeply grounded in the practice-oriented strand of research within the broader field of human-computer interaction [83]; we concur with many studies that recognize how "the relationship between technology and practice is internal […] like 'figure' and 'ground', [and such that] you can't have the one without the other" ([123], p. 273). This common origin notwithstanding, immanent design is different with respect to most of the other user-centered approaches. We agree with Kuutti, who writes "despite the general interest in materiality, the artifact side of practices is still somewhat neglected, because most practice theories have difficulties in finding meaningful ways to discuss about artifacts […and exhibit] weakness in the question of dynamics, change and development" [82].

In the design sciences, artifacts and practices are often interpreted through the lens of Activity Theory [79]. In this theoretical strand, the "subject-object" relation of the activity is decomposed into a three-layer structure, where subjects are stimulated by motives and conduct actions aimed at some goals through routine processes called operations [92]. Immanent design is different because it is neither aimed at building a theoretical model of how the social practice to be supported unfolds in concrete and observable behaviors; nor at understanding what the roles and conceptual categories characterizing a practice are; what the high-level goals, motives and aims of each party involved; what the rules, policies and conventions that "normatively govern contingent action" [124]. The utility of these theories is not contested or questioned here; rather we recognize their value in terms of discourses regarding either the so called *meso* level of organization work (i.e., routines, procedures) or even its *macro* level (institutions, infrastructures) [103].

Conversely, immanent design is aimed at a re-discovery of the *micro-level* of work practices; at seeing them as *networks of material and discursive performances* (cf. [62,111]); and at considering the role of interactive systems to be *scriptable* only partially, locally and contingently. In this light, interpolating the points and "connecting the dots" of meaningful practices is up to other portions of the network (or to different levels of the network) of actors that our analysis does not cover. In fact, immanent design focuses on material configurations that can be observed and studied in human cooperative settings with the aim to design and build artifacts that can be embedded [34] into existing networks of actors to either

support, extend, or automate the skills and actions of portions of those networks (e.g., specific human actors, roles and their traditional tools).

To this aim, the analysis of cooperative settings is performed by applying a radical version of semiotics: a semiotics that does not deconstruct the relational nature of human action, like Activity Theory does, but that rather turns radically to relations as first-class objects of inquiry. In this paper we will then also present and discuss the main elements of this semiotic approach, which we call "*Semiotics of Configurations*" (SoC).

Thus, immanent design, leveraging an analysis performed adopting the semiotics of configurations focuses on how *relevant configurations* of actors, objects and inscriptions (i.e., material enunciations) within various information technologies get transformed over space and time (i.e., *translate*), and on the relevant *space-temporal relations* within these configurations and patterns of action that produce an effect on the configurations themselves so that "work is done".

1.1. Outline of the paper

In the above introduction we are aware to have introduced several concepts that need a definition, some discussion and in some cases, due to the conceptual ambition of this contribution, also some more in-depth digressions. In regard to the definitions, in Table 1 we report the working definitions of the main concepts discussed in the rest of the paper. The theoretical digressions, which the reader without a strong interest in semiotics can definitely skip without consequences on the comprehension of our proposal, have been all moved in footnotes. The discussion will be articulated as follows: Section 2 will introduce some important concepts of semiotics with respect to the design of interactive artifacts; in particular, we will introduce to the IT readership the concepts of (semiotic) relation (see Section 2.1, configuration (see Section 2.2) and script (see Section 2.4). These concepts are the main building blocks to understand the first original proposal of this work, that is the semiotic of configuration. This is introduced in Section 2.3 and then illustrated in more details in Section 3. To understand the contribution of this methodological proposal in more concrete terms we illustrate it through the multi-level analysis of a complex artifact that we observed in a field study accomplished in a hospital setting (see Section 4). Section 5 introduces immanent design, an approach that leverages the Semiotics of Configurations to design computational interactive artifacts deeply inspired by the traditional artifacts that are observed in real cooperative practices. In Section 6 we present a prototypical platform, called AdHoc, which we developed to facilitate the immanent design of cooperative artifacts. In this section, we will see how AdHoc can be used to allow for the definition, use and continuous development of complex coordinative and record keeping information systems, without relying on any theory of how work is accomplished through them. Section 7 concludes this ambitious work and sets an agenda for the future work regarding semiotic analysis and its sound application to the design of interactive systems in cooperative settings.

2. Semiotics beyond the sign

The adoption of semiotic approaches in computing and for the design of interactive computational systems has been characterized by an understanding and use of semiotics intended mainly as the *study of signs* [6,48,107]. Such a study has been usually interpreted through Peircian categories [48,107,20] – "representation" (representamen, in original Peircian terms), "object" and "interpretation" (interpretant, in original Peircian terms), just to mention the most frequently recurring ones, as reported in Andersen and Bodker [20].[2] Within this sign-based (Peircian-)Morrisian traditional approaches, signs are seen as the basic elements of signification processes (i.e., meaning production, or *semiosis*), and humans are usually considered as actors who interpret environmental signs, and make sense of these by letting themselves be informed by their situated (and partly contingent) interpretation[3].

However, despite the relevance given to signs also by Saussure, founder of another semiotic tradition, the *sign* should not be taken uncritically as the most basic category "that unites the two [semiotic] traditions" ([20], p. 356). Indeed, at a deeper level of analysis

[2] To indicate one way to denote these related concepts would be overambitious as it is something about which the best minds of the past failed to convene, cf. Russel, Frege, Peirce.

[3] We are aware that within the broad field of the computing sciences many strands and traditions of semiotics are often used and referenced. That notwithstanding, the semiotics developed by Charles S. Peirce seems to be the main reference of some of the most important approaches related to the design of interactive computational artifacts like, e.g., the Semiotic Engineering framework [48,91b]. Also Peter Bøgh Andersen has turned to Peirce (see, for instance, [20]), despite the fact that previously his main reference was the semiotic tradition that had emerged within European Structuralism and that was introduced by Ferdinand de Saussure and then continued by Louis Hjelmslev ([5,6]; see also [22,118]). Andersen acknowledged that this tradition "is more operational and precise in its methodology" than the Peircian one and he also admitted that he has "always found it very difficult to use Peircean semiotics for concrete purposes" so that "as a help for analyzing and designing computer systems" he "definitely prefer[red] the European version" of semiotics [6]. However, not only Andersen has relied more and more on Peirce's work [7], but he has also uncritically accepted that "semiotics is the science of signs" [6], forgetting that for Hjelmslev "the objects of interest of linguistic theory are texts" [76]. Translated in our framework, Hjelmslev's words mean that the object of interest of semiotics is not a matter of signs, but rather of configurations. It does not mean that we do not consider signs; rather, it means that signs are for us but configurations. Thus, differently from the most important semiotic approaches in computer science, our Semiotics of Configurations relies more on the semiotic tradition emerged within European Structuralism. We indeed agree with the early Andersen [5,6] who considered this tradition methodologically sounder and more useful to any design aim. However, we do not intend to propose again the old controversy between supporters of Peirce and supporters of Saussure. This controversy has often unfortunately disguised the old controversy between nominalists and realists, to neither of which Saussure and Peirce can say to belong unproblematically. We assume that the two semiotic schools work on two different levels: Saussure and his successors were more active at the methodological one and focused on description – as admitted also by Andersen [5,6]; Peirce was more active on the epistemological level, by proposing a general categorization of signs and a general theory of their role in knowledge-related processes. The former one tried to build a science; the latter one tried to build the ground for a sound science. Thus, we consider that the two schools are actually not directly comparable, nor actual direct competitors. Peirce said very little about how to describe actual manifestations of signs and knowledge processes – because this was the role not so much of semiotics, but of "phaneroscopy", which yet nobody has so far developed [49]. On the other hand, the European Structural tradition has developed a direct or indirect epistemological reflection, which can be compared to the Peircian one – and this is what we have done in the paper when we discuss the "relational epistemology" that underpins the Semiotics of Configurations (see Section 5). Rather, the controversy that we would like to reconsider here is another one: the one between Dewey [50,51]) and Morris [106] (see Moreno (1985), for an overview and contextualization). Through this controversy, the former one [50] raised serious doubts about the latter's reinterpretation – "misinterpretation" in Dewey's words – of Peirce; Morris himself [106] admitted that his analysis was not "a presentation of Peirce's view". Unfortunately, Morris has been later considered Peirce's best interpreter and successor (see, for instance, [66]), and a lot of confusion has emerged between what Peirce said and what Morris said. Thus, most of the things that are attributed to Peirce today are actually Morris'. For instance, Andersen ([6]) says that he borrows the terms "syntactics, semantics, and pragmatics [...] from Peirce", when actually they were introduced by Morris [105] and they were at the center of the Dewey-Morris controversy [104]. Dewey considered those categories a misleading way of simplifying Peirce's thinking, in order to tame it for the empirical positivist thought, which was Morris' actual intellectual partner. Also in ([48]), Morris' theory is considered "clearer and more direct than its sources", and a lot of relevance is given to his "pragmatics". For all these reasons, in order to purse a consequent relational epistemology and in order to develop an actual method for describing configurations, Semiotics of Configurations follows the trails of the Saussure-Hjelmslev-Greimas legacy and distances itself from a Morrisian version of Peirce's semiotics – which is what in many cases is wrongly called "Peircian semiotics". Our aim is rather to relate to actual Peirce's semiotics, and reflect on what concerns his epistemology.

the common element between the two main semiotic traditions is a *relational epistemology* according to which relations pre-exist and co-constitute the related elements, or *relata* ([44] see [57] or [98], for the relevance of such epistemology for semiotics) or, to use Hjelmslev's ([76], p. 23) formula, "a totality does not consist of things but of relationships, and […] not substance but only its internal and external relationships have scientific existence".

2.1. Relations

In light of this recognition and of the widespread agreement on the fact that signs are "relational structure[s]" ([48], p. 26), we will propose a semiotic approach to design that explicitly rejects what conversely seems to be a common place in the IT-oriented design sciences, i.e., what Barad has once called the "metaphysics of relata, of 'words' and 'things' [and 'data', where] individual relata always preexist any relations that may hold between them" ([11], p. 815).

Thus, we will consider a sign as, on one hand, the *result of various relations*, as, for example, the relation between representamen-interpretant-object for Peirce, or the one between signified-signifier for Saussure; and, on the other hand, as something that allows to establish other relations, with other elements that are external to the sign itself, as it happens in unlimited semiosis for Peirce (according to whom each sign recursively refers to another sign by playing the role of representamen, interpretant or object), or in paradigms (or-relations, substitution) and syntagms (and-relations, association) through which a sign acquires its value for Saussure (see also [86]).

By adopting this relational ontology of signs, and perhaps radicalizing it to some extent, in this paper we propose a semiotic approach to computing that focuses on relations and their coming together into *configurations*, rather than on signs. To this aim we will still consider semiotics as "the study of how meaning is built" [4]; but also how this process is articulated through chains of configurations in which one configuration *translates* (i.e., gets transformed into) the other, thus creating "a trajectory [*sens*, in the original French] out an indefinite number of possibilities" [4]. As Akrich and Latour [4] have underlined, such way of considering semiotics can be "applied to settings, machines, bodies and programming language as well as texts". For this reason, we do not consider our approach in opposition to other ones that are usually purported in the specialist literature, but rather a development of established (and yet still minoritarian in the design-oriented debate) approaches in the age where computing has become ubiquitous, wearable and social, and our existences digitized as never before [75]. We will make clear that by "relation" we intend, to put it simply, what stands in between. Or, better yet, what two or more instances have in common, which also separates and differentiates them. Thus a relation is always grounded on a resemblance and on a difference [65b]. We will not just give relevance to relations considered in this way, but we will also assume that the instances which share a relation – the *relata*, which are connected and at the same time separated by it – do not precede the relation, but come into being together with the relation [11,77] connecting and separating them. A simple example can shed some light on this notion, which is foundational for us: a line traced on the sand gives way to two sides – two spaces – that are in relation to one another, thanks to the very line: "a side/another side" or "left/right", as "inside/outside". Of course, the line emerges itself in relation to the background[4].

[4] Thus, our proposal is only grounded on the category of "relation" and nothing else, as everything else simply derives from this latter one. A relation is just something that stays in between (at least) two instances – elements, other relations or configurations – which separates them while keeping them together, which differentiates them while creating analogies among them. Moreover we consider that a pure relation always precedes and constitutes the related elements (so called "relata"). From this, it follows that "difference" is the basic relation. Difference connects our approach to both signification and semiotics and to information and computer science. On one hand, following Ferdinand de Saussure, we can say that signification is based on differences; on the other hand, as Gregory Bateson once pointed out, there is basically coincidence between difference and information, since information is just "a difference that makes a difference". In the paper we provide examples of differences, and of how they allow for signification to emerge, especially if one looks at shapes and colors. These are relevant issues also for design – as highlighted by a long tradition of design pedagogues who worked and theorized the relationality of design – among which, Johannes Itten, Laszlo Moholy-Nagy and Joseph Albers [1]. In order to provide an example, in this footnote we expand the example of the line that, once it has been traced, creates two spaces. One could say that if the line is relational, the two colors from which the line emerges on a background are not, since they are the two elements from which the line can emerge. However, no white, no black, no gray (nor any other color) can emerge alone by itself: these can emerge only in contrast to another hue. Thus, the line and the color-contrast emerge simultaneously and they are all relational: their existence and their presence depend on the presence of other elements that emerge, in their turn, only when put in relation to each other. Of course, on another domain, all this is also in relation with light or in relation with a perceptual system (be it human or non-human). However, taking into account light or the perceptual system perceiving these differences just adds other relations, and does not undermine our point at all. For sake of simplicity, we assume light and the perceptual system as given. Peirce (CP 6.203) talked about a line drawn on a blackboard in a manner that is very similar to ours: "I draw a chalk line on the board […] What I have really drawn there is an oval line. For this white chalk-mark is not a line, it is a plane figure in Euclid's sense – a surface; and the only line there is the line which forms the limit between the black surface and the white surface. Thus the discontinuity can only be produced upon that blackboard by the reaction between two continuous surfaces into which it is separated, the white surface and the black surface".

2.2. Configurations

The idea of *configuration* is natural and its application universal. Intuitively, configurations are found in the starry skies of summer nights, as well as in the Dunhuang star map, which was drawn in China in the seventh century CE by painstakingly looking at those skies; in the piles of forms staked up on a clerical desk, as well as in the inky spots and marks on a single sheet at the bottom of one pile; in the content of the memory locations during the execution of a computer program (i.e., its state) as well as in the colorful and iconic inscriptions of a control room dashboard.

More formally, configurations have been defined as "arrangements of elements in a particular meaningful combination [resulting from] a mode of ordering things *in relation to* one another" ([129], p. 49, our emphasis). To put it shortly, a configuration is both a portion of the world and the "way" in which this is perceived where any detectable element to be meaningful cannot be decoupled from the mutual connections with the others, *together with which* they constitute a perceivable *whole* whose possible meanings cannot be reduced to the meaning of any of its parts. Similarly, a configuration can be seen as a *set of relations constituting a pattern*, in a sense similar to the one conceived within Gestalt psychology as well as within the Informatics tradition, that is as something that can be found similar to innumerable other occurrences and arrangements that differ for negligible details while the significant relations keep to hold.[5] Configurations are inextricably bound to acts of figuration/recognition,[6] and are processes themselves, which "join bodies, devices, figures and technologies" [128]. In this line, Castañeda noted that configurations "can also be considered in terms of their uses" ([129], p. 49). This point suggests what the trivial examples mentioned above were hinting at: a configuration can be both a spatial arrangement of something

[5] To this respect it is clear the distance between the idea that single objects are instances of an archetypal class (or concept) and the idea that any configuration can be considered in terms of similarity/dissimilarity with respect to some pattern.

[6] Figuration is, literally, the act of shaping into a particular figure, but also of seeing figures, things, matters of concern out of the undifferentiated.

and its temporal trajectory, as well as the tangle of relations spanning across multiple dimensions of the reality of interest.

In cooperative settings and any setting where interactive technologies could be used, this means both assemblages of objects and ensembles of people, as well as the visible and material traces of their practices [64]. According to this perspective, looking for, and accounting for, configurations and their continuous transformation is a way "to unpack the domains of practice and significance" that are embedded into each configuration, and to recognize the frailty of any essentialistic and static conception of the things found in configurations, which we understand at the root of the current "cult of data" [133]. Focusing on configurations instead of signs means to both change the level and the method of analysis as we will see in the next Section.

2.3. Semiotics of configurations

In light of these reflections, we propose a *Semiotics of Configurations* (SoC). As any other semiotic approach, also SoC is concerned with meanings and their articulation, and sees in the translation of a configuration into another configuration a way in which signification takes place.

In what follows, we will discuss SoC's potential for the design of interactive systems. To this aim, SoC sees interactive systems as "technical objects [that] simultaneously embody and measure a set of relations between heterogeneous elements [and] participate in building heterogeneous networks that bring together [elements, in the original "actants"] of all types and sizes" [3].

Such an approach to semiotics aims to enable the analyst and the designer in two distinct but related activities: first, to look at the big picture of a human setting, which encompasses (but cannot be reduced to) the typical objects of semiotic study, like texts, symbolic inscriptions and icons. Second, to look at the "smaller pictures" (con-figures) constituting this setting, since the semiotics of configurations looks at the relations between perceivable portions of the world. Consequently, within the semiotics of configurations the main concern at hand is *how to describe the relations making the configurations up, as well as the relations connecting two or more configurations*.

SoC, is basically a descriptive methodology: a way, which also includes a particular language and sensitivity, to describe human and socio-technical settings in terms of relations, to describe their coming together into configurations, and to describe their connecting in further configurations.[7] This is in line with Louis Hjelmslev ([76], p. 15) who conceived semiotics as "a procedural method by means of which objects of a premised nature can be described", and who argued that "objects can be described only with the […] help [of relations] and can be defined and grasped scientifically only in this way" ([76], p. 23).

As such, our approach radically differs from that of Semiotic Engineering [48]. This latter approach mainly focuses on the designers' and users' intentions, on how designers and user express these intentions through illocutive and perlocutive acts, and how these are interpreted. Thus, Semiotic Engineering focuses on the extreme "terminals" of the assemblage that encompass humans and artifacts – that is the relata, rather than on the relations. In order to account for designers' and users' intentions, Semiotic Engineering is a linguistic based approach, in which user interfaces are considered messages [91b]. The SoC, differently from Semiotic Engineering, focuses on what *lies in between*, on relations, on how they mediate and get articulated, and how they dispose other mediations and unfold in them.[8] Thus, the SoC focuses on what is between designers and users, on the relations mediating these two positions. In order to account for such mediating relations, which are usually actualized by artifacts, the SoC does not privilege linguistic categories – notwithstanding the relevance given to the linguistic tradition within semiotics (Saussure, Hjelmslev, Benveniste, Greimas). Indeed, thanks to its relational epistemology, it tries to account for any relation, despite the language through which a relation is articulated. Thus, the SoC draws on visual semiotics and on the semiotics of objects as much as on linguistics. Therefore, interfaces are not so much considered messages, but configurations taking part to transformations. Then, in order to adequately address the design of interactive computational systems, the SoC focuses on *acts*, seen as *transformations of configurations*, which inevitably unfold (or even *are*) semiosis. In this view, the interactive systems to be designed can be seen as *configurations evolving depending on the context*, and design as an activity aimed at understanding *what* the meaningful (stable) configurations are that support cooperation and work in a certain setting, and at reconstructing *when* they have to change, on what conditions of the context, which itself is seen as an ever-changing (broader) configuration. Such take allows the SoC to be more sensitive to the operational aspects of interfaces, without resorting any dualism between objects and signs or between "instrumental (tools, machinery) and semiotic (display, conversations) mediation" ([20], p. 354). The latter is instead a distinction that characterizes another stream of research about semiotics and computer sciences, namely that proposed by Peter Bogh Andersen - despite the fact that also Andersen finds that very dualism to be highly problematic ([20], p. 361). Thus, despite the relevance given to relationality by both these semiotic approaches to interactive systems [20,48], they tend to privilege already given entities, which only in a second moment get into relation. Our approach, instead, first focuses on relations and then sees if and how entities emerge from these relations. As we will show through the semiotic analysis of an artifact, such approach allows to take into consideration different aspects of an interface (from graphic, to linguistic, to operational ones), thus setting the bases for a dialogue between the various competences concurring to the design of interactive systems.[9]

We, then, carry on a tradition within semiotics that has been concerned much more with mediations than to the extreme actors of signification processes and even less to their intentions.[10]

To shed light on our proposal, it can be useful to recognize the connections with the other ones that inspired us. From a philosophical stance, the semiotics of configurations is grounded on radical empiricism. This means that experience is a primary concern. From a semiological perspective, it is grounded on a

[7] As a descriptive methodology SoC can be considered the descriptive arm of the "sociology of associations" [89], which has also a second methodological arm related to how to collect data, mainly based on the maxim "follow the actors themselves" [80].

[8] "Folding, in Latour's usage, denotes a type of acting that produces socio-technical relations, through the connecting (in a network-relational sense) of one place and time with another that it would otherwise not have been connected to." [80].

[9] [94] shows that the dialogue between computer scientists and graphic designers is needed. By drawing on Semiotic Engineering he develops a language for such a dialogue in (semio-)linguistic terms. In this way, he is not able to take into account the visual language of interface design and reduces the dialogue to engineers request about what kind of interaction graphic designers have to take into account. We deem that the SoC and its analyses, by considering design activities and results as mediations emerging from and unfolding in various kind of relations, can more symmetrically work to establish a ground for dialogue between engineers and graphic designers, in which all design aspects are considered.

[10] In this tradition, let us consider Umberto Eco's work [53–55] and especially his concept of the "model reader" [55]. Eco [55] completely cuts out the issue of the author's intention (*intentio auctoris*), focusing instead on the intention of the work (*intentio operis*) and the intention of the reader (*intentio lectoris*) and how the two are related. It is not by chance that through the concept of "script" we resort Eco's concept of "Model Reader". Semiotics Engineering, instead, focuses on "Designer's Deputy". Such difference tells a lot about the shifts that this approach introduces to the most renown semiotic currents.

radicalization of the relational framework of the two main semiotics traditions (Peircian and Saussurian). In so doing, it places itself within a broader contemporary movement that is shared across philosophy, and the natural and social sciences concerning a "relational thought" [44]. In this stance, "the relations between things" are taken "as much matters of direct particular experience, neither more so nor less so, than the things themselves" [67]. In this same strand, John Law and Annemarie Mol [91a] in their proposal to unite sociality and materiality speak of *relational materiality* and explain this concept clearly by arguing that material "bits and pieces achieve significance *in relation to others* [and] don't exist in and of themselves. They are constituted in the networks of which they form a part. Objects, entities, actors, processes all are semiotic effects: network nodes are sets of relations, or they are sets of relations between relations [and even] *materials* are interactively constituted; outside their interactions they have no existence, no reality" (emphasis in the original). Likewise, also in the Gestalt movement the *Gestalt*, which in German translates the Latin *Figura*, or "whole form", defines the parts it is composed from, rather than being something that emerges from those parts. For instance, apparent movement is not reduced to a series of stationary sensations of positions, but rather to the creative perception of the dynamic relation binding those sensations together, making them experiences of the same phenomenon.

Furthermore, the SoC shares some categories with other proposals whose influence on IT design has so far (regrettably) remained circumscribed to specific ambits (e.g., tangible computing [8]) like *Distributed Cognition* (DCog) and *Actor-Network Theory* (ANT). In DCog, Hutchins [78] presents cognition as the "propagation of representational states across media" – a process that we assimilate to the continuous transformation of configurations hinted at above. On the other hand, ANT not only shares our relational perspective and a similar idea of cognition to the one proposed by Hutchins [88], but it has also developed a *semiotics of artifacts* [4,86] that clearly inspired our proposal. Finally, our relational approach will allow us to recover the tradition of the semiotics of the text developed between France and Italy in the wake of the strand connecting Saussure, Hjelmslev and Greimas. Within this semiotic approach, a semiotics of artifacts and design has been developed [61,17,47,93] and it will be used as a relevant source for our semiotics of how humans and interactive computational systems are *figured together* (or con-figured) and how they might be *re*-configured differently [128].

2.4. Scripts and programs of action

More technically, SoC is an approach to the design of interactive systems that grounds on the concept of *script* (see Table 1), and on the de-scription/in-scription of socio-technical *programs of actions* [3,4,86]. In particular, with the expression "program of action" we denote an articulated and coherent set of behaviors that create effects on the world that are consistent with the achievement of a goal: the goal is actually a particular final configuration. Speaking of programs of action and final configuration allows us to abstract from the idea of actual and isolated agents that perform those behaviors having purposes in mind, and rather to focus on the *action itself* (i.e., the doing, or das Tun in Nietzsche[11]). Behaviors, that is actions, are performed by *actants* [3], and these can be either humans or artifacts, or any set of interrelated *actants*[12], usually portions of greater socio-technical networks.

On the other hand, we denote scripts as *the detailed and textual description of the potential relations that can be realized across configurations* (also over time, like in the case of the sequence of transformations that are necessary to pass from a configuration to another one). Before us, scripts have been similarly defined as "outlines of recurrent patterns of interaction that define in observable and behavioral terms" [122] the actants' doing. In a similar way, Akrich and Latour [4] called script any observable configuration of programs of actions that dispose actors' capacities (namely "competences"). For Akrich and Latour these configurations of program of actions can be inscribed in the machine which embodies them and, in so doing, makes them available to users (so that others speak of configuration of the user, [129]), in terms of layouts that "guide the behavior of the user, in a more or less forceful way, to comply with values and intentions inscribed into the product by its designer" [68], or in terms of those "structural features of artifacts encouraging certain user actions while counteracting others" [69] in clear analogy with the concept of affordance by Norman and Gibson.[13]

We propose a wider notion of script, as the description of the relations that an artifact, or better yet any set of nodes within a network of actors (i.e., actants), has with any other actor in the network, that is as a configuration of *outward relations* (see below). As such, a script can describe some of the logic by which a configuration can be transformed, by also indicating what actor(s) are involved in some configuring acts (in which they enact the relations enunciated in the script).[14]

Semiotics of configurations applied to computational system design is then the study of how to describe initial (i.e., input) and consequent configurations (i.e., output) that are produced by programs of actions, and how to specify (the portions of) scripts that bring from one configuration to another, until a final configuration is produced (observed). This analytic process is what we denote as *de-scription*, i.e., *a description of the script* as this can be expressed in relational terms from (cf. *de*) the observation of the program of actions (performance, behaviors, or input-output mappings) exhibited by a network of *actants* of interest. In the words of Akrich and Latour [4] "de-scription, usually by the analyst, is the opposite movement of the in-scription by the engineer […] the designer". In our proposal, however, the script is what can be reconstructed of programs of actions that not necessarily have been (all)

[11] "In just the same way as people separate lightning from its flash and take the latter as an action, as the effect of a subject which is called lightning […] there is no 'being' behind doing, acting, becoming: 'the doer' is merely a fiction added to the 'doing'. Doing is all." Nietzsche, 1887, On the Genealogy of Morals.

[12] Actants is a term we gladly borrow from ANT, which in its turn borrowed it from Greimas, to hint at the fact that is not an agent, a performing entity. It is just the locus of action, an agency about which intentions are not necessarily assumed (nor denied) and effectiveness evaluated only in terms of final configurations (objectives).

[13] The concept of "script" is thus similar to the much more famous – at least within semiotics – concept of the "Model Reader" proposed by Eco [54]. With that concept he indeed intended a "system of instructions aiming at producing a possible reader whose profile is designed by and within the text" which "can be extrapolated from it and described independently of and even before any empirical reading" ([56], Eng. Transl. 52).

[14] This is in close analogy with the code-program dyad that is a common notion in Informatics: the code represents the step-wise specification of instructions, a script, that an interpreter will enact into sets of programs of action by changing its internal structure to conform to the intended input-output mapping(s). The execution of the script/code (in this case by a network of components of a machine-interpreter including also power supplies, sensors and effectors) can have either internal or external effects in the physical world. This close analogy is drawn not by chance. One of the most consolidated notions of computation conceives it as the *rewriting of symbolic strings according to rules* ([119]), that is as $\alpha \mapsto \beta$ (being α and β two arbitrary configurations of symbols). The script is but the rules by which a configuration is rewritten into new ones. These rules do not have necessarily to express business rules or the rules of prescribed work practices within a cooperative setting, although this is often the case, according to the granularity and level of de-scription of a cooperative setting.

predefined by the designers, but nevertheless are performed with regularity and as a behavioral expression of some actant: it is then a merge of the two complementary perspectives, the one by Akrich (focused on the designer' script) and the one by Latour (focused on the artifact's script). To make a de-scription, analysts have to detect the smallest actions that is convenient to identify in a socio-technical settings (network of actants) and see how these can be composed in more complex structures, by which of what conceptual operations. As anticipated above, the output of the process of de-scription is the script [3], but this also encompasses elements of *future scripts* [21] or better yet, explicit relations imagined between the current de-scripted program(s) of action and the potential new programs that can be established by adding new elements to the network. This point leads us to consider the design-oriented part of our proposal.

In the following we will provide examples from the hospital care domain in the aim to demonstrate the relevance of such semiotic approach to the analysis, assessment, and the design of interactive systems supporting human work.

In order to show the possible productive collaboration between semiotics of configuration and immanent design, we propose in the following pages an analysis of a medical form, the FUT. The analysis will elicit the relevance of the basic relations mentioned before for the articulation of an interface. These same basic relations will be then used as a ground to build an digital interface which replaces the form.

3. Using the semiotics of configurations to analyze artifacts

The SoC – though concerned with meanings and signification – does not account for the way in which users actually understand, interpret or use an artifact, for instance, a document form. The SoC is, indeed, mainly interested in accounting for what the relations are that set the base for an understanding, an interpretation or a use – i.e., their "conditions of possibility" [63]. Within a design oriented perspective, accounting for such "conditions" is key in order to preserve them in view of a digitization of a form or a procedure (or in order to change them in view of a re-articulation of forms or procedures). Taking into account these "conditions" is thus the first step of a process of format translation.

When analyzing an artifact, the SoC can take into account a specific practice of use or a particular interpretation of it. However, these uses or interpretations are seen as further configurations, as ways in which the artifact can be translated into another configuration – the one outlined by the use or by the interpretation (e.g., from a blank form to an inscribed form). For those further configurations, the analyzed artifact plays the role of one of their conditions of possibility. An analysis conducted through the SoC should then account for the contribution of a specific artifact in a specific situation to the emergence of a certain use or interpretation. In order to account for such contribution, a description of the relations through which the artifact articulates itself is required. These relations can be either inherent or external to the configuration. Inherent relations provide the configuration with a relative autonomy, stability, closure and individuality. External relations are relations occurring across configurations.[15]

In order to guide the description or analysis [76] of relations, a map of the relations has been outlined by Mattozzi and colleagues [99–101]. Here, we develop further this map of relations as an aid to delve into the semiotic foundations of the concept of "script" (see Table 1 and Section 2.4), as well as a way to extend its scope along the strand of the Italian and French semiotics of objects (among others, [47,17,60,93]).

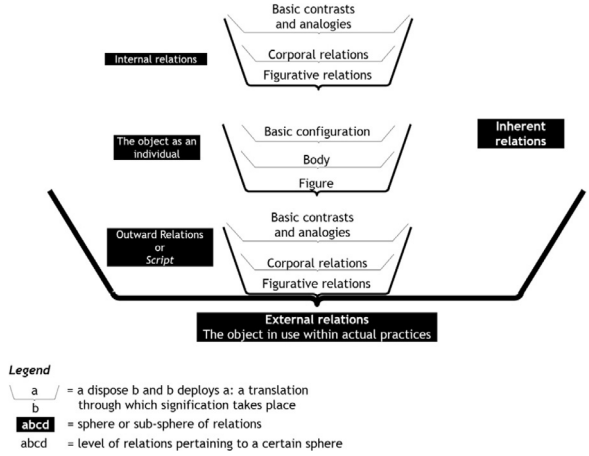

Fig. 1. The Map of relations adopted in the Semiotics of Configurations.

This map, depicted in Fig. 1 considers different *spheres* and *levels* of relations.

In regard to the spheres, we distinguish between *inherent* and *external* spheres: the former sphere is constituted by the set of relations that take place *within* the configuration; the latter sphere by the relations taking place *outside* the configuration. Thus, within the inherent sphere two sub-spheres of relations can be found: the *internal* ones, which give way to an *individual* with its autonomy, stability and closure; and the *outward* relations, which are relations based on the closure mentioned above. They "go out" of the configuration itself, or, better yet, they address other configurations external to the one they are part. Thus they represent what Latour and Akrich [4] and others after them have denoted as script (see Table 1). Lastly, the *levels* of relations, i.e. the strata in which types of relations can take place, from the less complex to the more complex: respectively, *basic* relations of contrast and analogy; *corporal* relations, mainly related to inclusion/exclusion and the subsequent dynamics concerning penetration, envelopment, expulsion; and *figurative* relations, i.e. relations established between recognizable and namable figures.

Whereas the first taxonomy – the *spheres* – should be quite clear in the light of the introductory remarks mentioned above, the second one – the *levels* – needs few more clarifications. With "level" we intend a layer within a hierarchy. On the most basic layer certain kinds of relations can take place and these create the ground for the emergence of another layer, within which other kinds of relations can also take place.[16]

[15] Needless to say, the distinction between inherent/external relations is relational too.

[16] The three proposed levels – basic, corporal and figurative relations – are first and foremost a re-formulation of the two levels considered by the Greimassian semiotics of images [65,61], integrated by the recent reflection on the semiotics of the body [59]. Indeed, the Greimassian semiotics of images [65,61] has always considered a "plastic level", within which colors and shape take place, and a "figurative level", within which figures, formed by colors and shapes, take place. Our stratification takes also into account the fact that these three levels recall closely the Peirce's categories of Firstness, Secondness and Thirdness [115–117]. In particular, secondness can be related to corporal relations. Indeed, Peirce (C.P. 5.469) introduced it as a "reaction", or as "actions of one subject or substance on another". Thirdness, as it is well known, is related to symbols. "Figures" in our map are akin to symbols. Moreover, Peirce sometimes refers to Thirdness as "representation" and we can say that "figures" have something of a representation – knowing that neither Peirce, nor we, use "representation" in a common sense way. As for Firstness, Peirce referred it to qualities, such as colors. He admits that "[e]mpirical psychology has established the fact that we can know a quality only by means of its contrast with or similarity to another" so that "by contrast and agreement a thing is referred to a correlate", which is also our basic definition of relation. However, he also thinks that Firstness is not actually relational: it refers to a ground, which is an abstract quality – for instance, black refers to blackness [114] or the white of a chalk-mark on a blackboard is grounded on whiteness, considered as Firstness (Peirce, CP 6.203). Instead the difference, "the boundary between the black and white", which for us would be

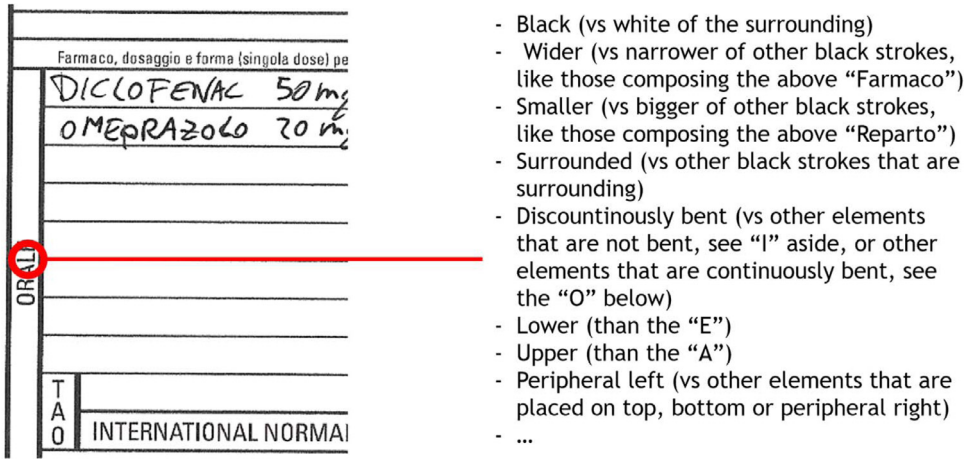

Fig. 2. Elements as intersections of bundles of relations.

The first *level* – the one we called "*basic relations*" — regards relations of contrast and analogy, as the basic form of relation based on difference. Thus, describing an artifact at this level means to elicit the configuration made up by all the contrasts and analogies through which a configuration articulates itself. For instance, if we are to describe a document form – as we will do next in Section 4 – we would consider the contrast between hues – usually black and white – , the contrast between the shapes of black lines – short/long, straight/curve – , as well as the analogies among white elements, long lines, etc.

These contrasts and analogies come together in bundles in order to outline each specific element taking part to a configuration. For instance, a specific sub-configuration as the one circled in Fig. 2 is outlined by the various contrasts listed on the right. Each specific element, being the point of intersection of various contrasts, is usually characterized by a specific shape, extension, and duration, as well as by other specific features among which, very likely, also a core and an outline or envelope.[17]

These elements, in many cases but not necessarily always, give way to figures, i.e. elements which are recognizable and nameable by a specific group or community of practice. These figures relate to other figures through different kind of analogies or associations.

Thus, the map not only allows to single out spheres and levels where relations take place, but also outlines the dynamics among them, through which signification is articulated.[18] Each configuration, taking place on a specific level or in a specific sphere, predisposes the following configuration, taking place on the following level or in the following sphere. At the same time, each configuration, taking place on a specific level or in a specific sphere, is the unfolding of the previous configuration taking place on the previous level or in the previous sphere (see Fig. 3). Moreover, each configuration can also refer to another configuration, which is not part of the configuration itself (see Fig. 3). Thus, signification takes place both horizontally and vertically.

Besides an insight into signification, the map implicitly provides also a repertoire of types of relations: these are inclusion/exclusion,

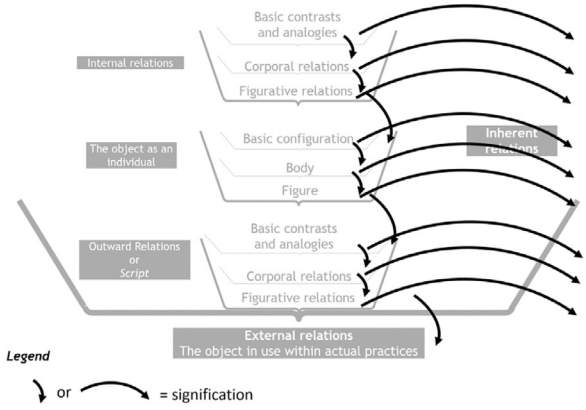

Fig. 3. How signification takes place in between spheres and levels.

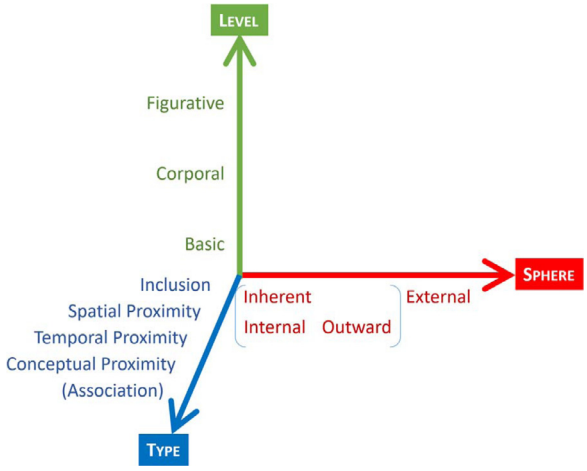

Fig. 4. A 3D representation of the SoC relation map for the immanent design of interactive artifacts.

predisposition/unfolding and contrast/analogy. To make this semiotic repertoire of relations more suitable for the design of computational artifacts, we adapted it into a set of roughly equivalent relations. This set encompasses (see Fig. 5):

- *inclusion*, which creates borders (enframes) and the opposition between inside and outside;
- *spatial proximity*, which can be seen as a sort of *inclusion* of two or more elements within the same enframe without any other element between them;

(*footnote continued*)
part of our basic relations, is for Peirce (CP 6.203) a Secondness, since it comes out of the interaction between two Firstnesses. Here, we suppose, lies the most relevant epistemological difference between Peirce's approach and ours. Our semiotics is groundless, it relies only on differences, following thus the Saussurian tradition ([121], p. 108) and radicalizing it in a Deleuzian direction.

[17] Following and extending the *semiotics of the body* [59], we consider any element displaying a core and an outline-envelope as a body. Any body interacts with other bodies through relations of inclusion/exclusion and through the related dynamics of envelopment, unenvelopment, penetration, expulsion.

[18] Following [79], we intend signification as a process taking place through successive translations between configurations – "forms", i.e. sets of relations, for [79].

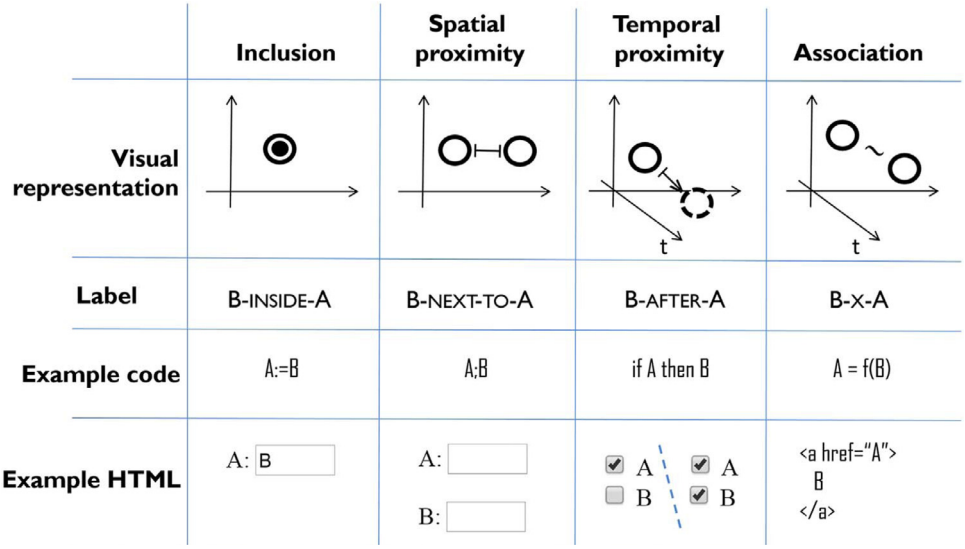

Fig. 5. The basic types of relation considered in immanent design, derived from semiotics of configurations, and some examples.

- *temporal proximity*, which is a specific case of predisposition/unfolding, where an element B comes after an element A so that when A then B;
- *association*, which mainly expresses relations of opposition and analogy (either at basic or figurative level), and also any sort of conceptual proximity;

Spheres, levels and these design-oriented types of relations are represented in Fig. 4, where each relation can be characterized as a point in a three-dimensional conceptual space.

Let us consider these types in some detail. In regard to *inclusion*, this kind of relation has been thought relevant considering that users of paper-based forms enunciate values by inscribing them in due places, like text boxes or areas. Users, then, make these values contents of the record within specific outlines, which we call *enframe* (see Table 1). The SoC analyst can at first track and describe possible *enframes*. In this way the SoC analyst can account for their pertinence and relevance and, thus, for the ways these *enframes* will possibly frame – provide a pertinence and a relevance to – what is inscribed, and hence included, in them. These processes of *enframing*, are connected also to "temporal proximity" relations since, whenever users inscribe particular signs in particular places of the artifacts, it is needed to account for what previous sign has triggered these inscriptions, or for what further inscriptions are thus predisposed.

As for *association*, it has been observed that in hospital paper-based artifacts many associations of redundancy take place. These occur when users undertake practices of "data replication" across documents within the same ecology of artifacts. These activities are not reckless, but rather related to specific needs to "knit together" different artifacts and keep the whole patient record tightly together. We observed users copy the same data in different parts of the patient record and this made data look different in virtue of the place where they were included – in virtue of their inclusion in a specific *enframe*. For instance, data reported in the medication form that we will describe in the next Section are used by doctors during the daily round in the ward; the same data copied in the nurse diary are used for accurate and comprehensive hand-over conferences at the work shifts [25]. We also observed reporting different data for the same clinical fact to reflect different perspectives in looking at the same aspect of an illness trajectory [26]. In these works we discussed the positive role of these redundancy-related associations, which unfold whenever information is either duplicated, replicated or *supplemented* (e.g. by metonymy) in coordinative practices.

As for *spatial proximity*, they are important for the design of an interface layout of an application, that is how the pages of an EPR must look like, especially on a topological level, that is in regard to what data to display, and in which relationship with other groups of data. However, *spatial proximity* can also be detected among artifacts, in relation to their *inclusion* in specific places of storing, transportation, writing and reading (like a folder, or a cupboard, or even a letter-size sheet of paper, a 16:9 screen page, as well as any rectangular text box displayed in such a page). The importance of the physical arrangement of artifacts in the physical environment has already been proven [74] and discussed also in regard to hospital work [12]. By detecting all these relations and how they occur in practice, the designer can understand what configuration translation should be automated and to what extent [112].

4. A concrete example of artifact analysis

4.1. Introduction to the analysis

In this section we want to show how the perspective introduced before and the map that summarizes it can be used in order to carry out an analysis of actual artifacts and practices, which can inspire and inform the digitization of the related configurations and transformation.

Thus, the analysis we are going to propose has two aims. On one hand, it allows us to illustrate our method, as well as to provide a ground for many of our epistemological claims that up to now have remained too abstract. On the other, it allows to show how the SoC can work productively with immanent design, in order to foster End User Development [58], that is an activity of continuous artifact development ad refinement that is carried out by the end users themselves, autonomously from the IT professionals and designers. Our analysis will mainly focus on the "outward relations", i.e. the *script*. However, we will start with a detailed analysis of the "internal relations" at the "level of basic relations of contrast and analogy".

4.2. A concrete example: the FUT

The Foglio Unico di Terapia (FUT, or Unified Form for Therapies) is one of the possible names that practitioners give to the

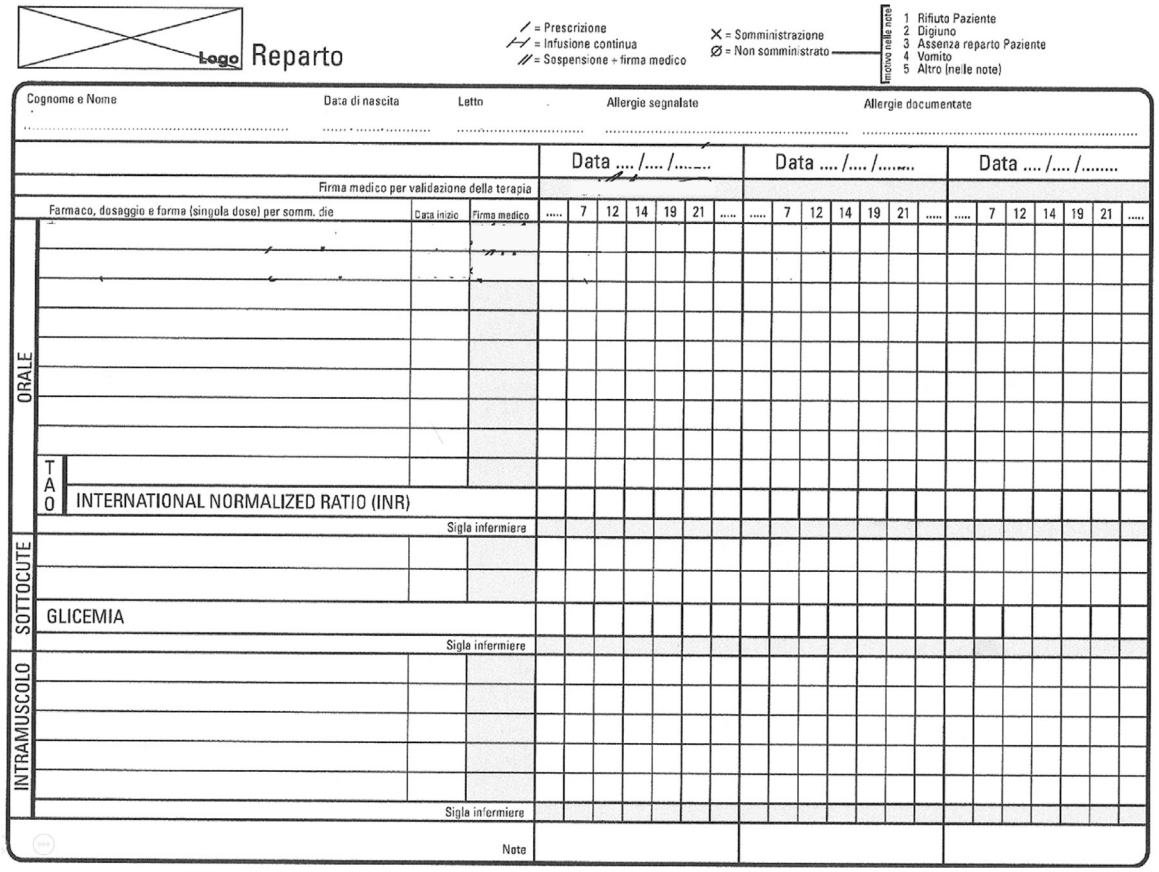

Fig. 6. The FUT observed and analyzed in our field study.

(paper-based) artifact that mediates the coordination between several actors in a hospital setting [15], especially between Medical Doctors (MDs) and nurses (but also patients, pharmacists and other health operators). In particular, through inscribing the FUT, medical doctors prescribe medications (i.e., drugs and treatments), by specifying which patient should take which active substance (or drug name), how and when, and nurses report the progress of this process.

In what follows, we will describe the FUT form as a configuration constituted by relations and related to other configurations, according to the maps described in the previous section (see Fig. 1 and Fig. 4). To this aim, we will first look at the inherent characteristics of the artifact, and then at its external ones. Traditional artifact analysis and design usually overly overlook the former ones to focus on the latter ones. Conversely, we will indulge in the former relations for a twofold aim. First, in order to demonstrate how a coherent relational analysis represent its phenomena of interest with the due level of details. Then, to demonstrate how this approach represents a concrete turn with respect to objectivistic and ontological approaches to design and to convince the reader that functions and behaviors (i.e., outward and external relations) are inextricably bound to multiple levels of internal relations (e.g., data structures and layouts).

4.3. Internal relations

4.3.1. Basic relations level: difference and importance

Look at the form depicted in Fig. 6. What do you see? At a basic level, black and gray strokes; white and gray areas. If one looked at a hospital chart with no preconception, as if she were looking at a painting of contemporary art, she would see but black strokes surrounding white and gray areas. However she would also notice that certain black strokes are surrounded by white areas. All black and gray strokes – and also the black thick one varying continuously and surrounding all the other black and gray strokes – are actually surrounded by an overall white area that surrounds everything else, what we call the *whole* FUT form (see Fig. 6). It is thanks to these contrasts, these relations of contrasts – black vs white vs gray, surrounded vs surrounding, narrow vs wide, long vs short, low vs high, etc. (see Figs. 7 and 8) – that these black and gray strokes and these white and gray areas can emerge, one from the other, one through the other.

We could say that what is white is the ground and that what is black are figures, but this will come later. As for now, what emerges is a contrast in hue - black vs white vs gray -, a contrast in size - narrow vs wide, short vs long, high vs low -, and a contrast in positioning - surrounded vs surrounding. And from there, other contrasts related to the way black or gray strokes, white or gray area surround or are surrounded (Figs. 7 and 8).

As we can see (Figs. 7 and 8 show only few examples of these contrast), all that emerges, all that is there, is the result of relations. All that is there and yearns to signify is the result of relations. That is why we can say, by borrowing the words of anthropologist Eduardo Viveiros de Castro [130], that we do not see differences, but differences are what makes us see. Besides contrasts, the form is articulated also by relations of analogy (Figs. 7 and 8): for instance, black strokes contrast in general with white areas because they are all analogous as for hue.[19] All these contrasts and

[19] As Saussure ([121], p. 108) would say, talking about verbal language: "The linguistic mechanism is geared to differences and identities, the former being only the counterpart of the latter". As semioticians, and not linguists, we are just extending this idea to other languages, to other systems and processes of articulation of

Fig. 7. Some examples of contrasts and analogies among surrounded areas.

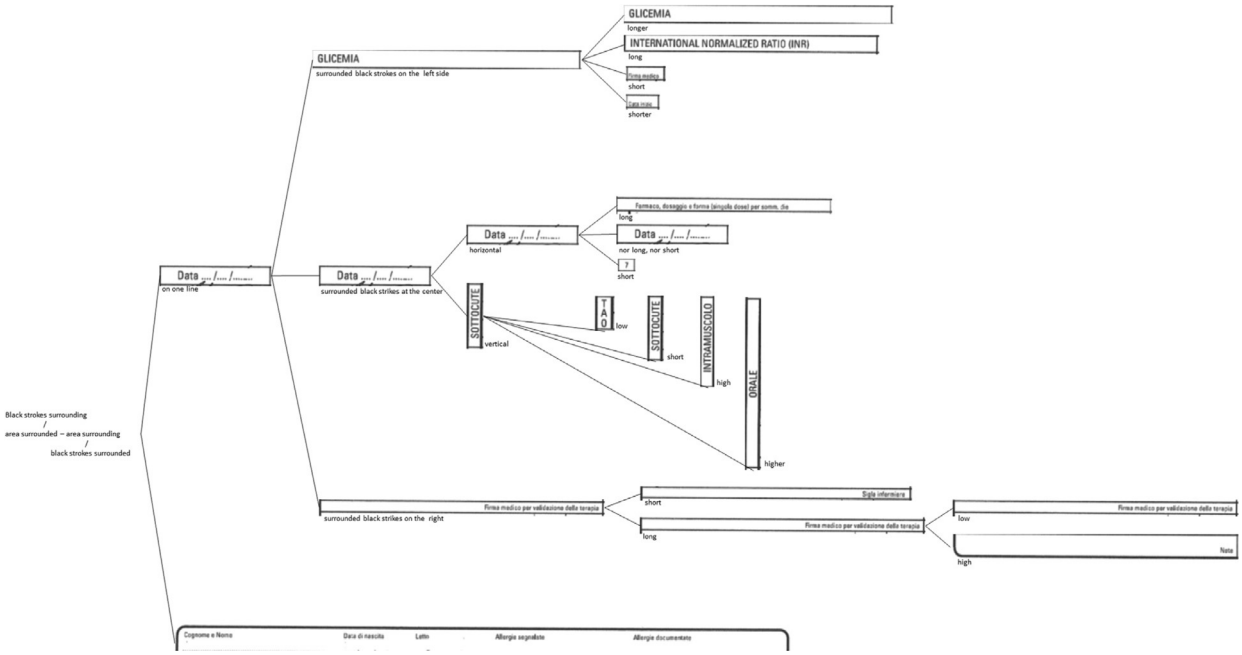

Fig. 8. Some examples of contrasts and analogies among surrounded strokes.

analogies constitute a pattern, i.e. a configuration, the layout of the FUT. If the general layout is a configuration emerging from relations, also each element taking part to the layout emerges as a result of relations.[20] Each element emerges from the intersection of various relations. What emerges in such intersections are then individuals, points, elements. For instance, what we, at another level

(*footnote continued*)
meaning. Thus, what we see in the image (what at another level we will recognize as a form – in the sense of "a printed or typed document with blank spaces for insertion of required or requested information" (Merriam-Webster on line)) – is first and foremost the result of a pattern created by these contrasts and analogies, by these relations – black/white/gray, narrow(er)/wide(r), surrounded/surrounding, horizontal/vertical, long/short, high/low, straight/bent, continuously bent (curved) / discontinuously bent (angle), etc. – and by their reciprocal positioning – upper/lower, on the left of / on the right of – and by the positioning relative overall pattern – top/bottom, central/peripheral, left/right.

[20] As Louis Hjelmslev [76], p. 108) would say, "[…] the 'objects' of naive realism are, from our point of view, nothing but intersections of bundles of such dependencies (i.e. relations). That is to say, objects can be described only with their [of the relations] help and can be defined and grasped scientifically only in this way. The dependencies [i.e. the relations], which naive realism regards as secondary, presupposing the objects, become from this point of view primary, presupposed by their intersection".

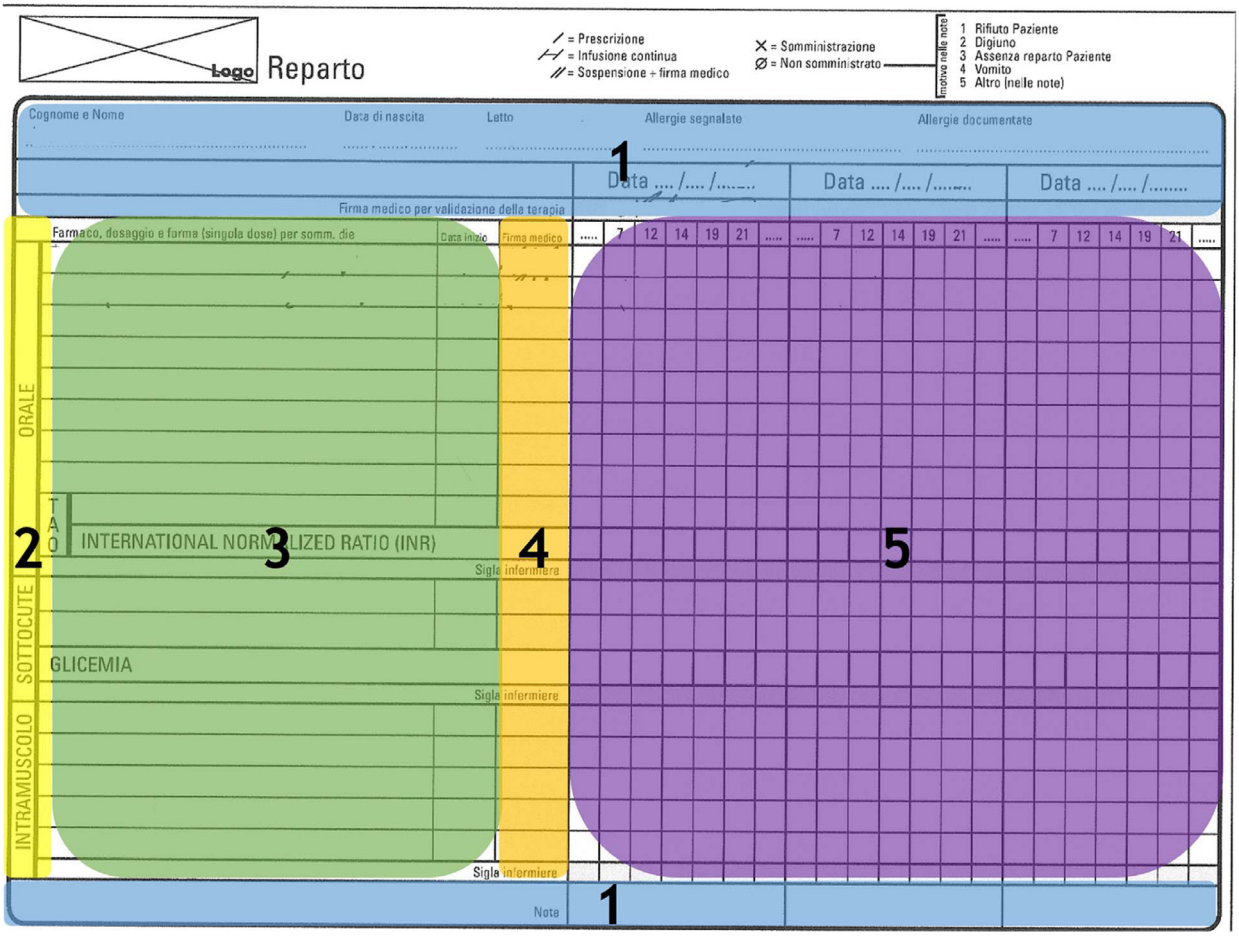

Fig. 9. Emerging portions of the overall configuration.

(see below), can recognize as "L", at the level we are considering, is characterized by traits (relata within a contrast relation) listed in Fig. 2.[21]

A difference - a black line distinguishes itself from the white surrounding, for instances - among other differences and all together create other differences, which, in turn, dispose the former. Not really an origin, but complex aggregations of differences disposing other differences up to the creation of a relatively stable configuration, as the form we are describing. The various surroundings (Figs. 7 and 8) place themselves one in relation to the other. Some on top of others, some on the bottom of others, some in the middle, some on the left, some on the right. Thus, our form reaches its configuration: on its top and on its bottom longer and higher surroundings, where white dominates (Fig. 9, portion 1), even though the white areas tend to surround also black strokes; on the left side a column of vertical surroundings (Fig. 9, portion 2); the portion on the left of the column is occupied by horizontal surroundings: white areas that do not surround black strokes (Fig. 9, portion 3); almost at the center of the form a gray column emerges (Fig. 9, portion 4); the right side instead is mostly occupied by a dense grid of vertical surrounded areas (Fig. 9 portion 5).

Each element and each portion of the configuration emerges more or emerges less if it contrasts more or contrasts less with other elements and portions, contributing, through these contrasts, to the constitution of the configuration. Therefore, the more difference, the more contrast, the more perceptibility (visibility in this case), the more information.[22] Configurations usually articulate hierarchies of differences, contrasts, information. By looking at our configuration - the FUT form - (Fig. 6), we can see that there are at least three criteria through which elements or portions of the configurations can emerge more or can emerge less:

- amount of contrast: black, for instance, contrasts with white more than gray does;
- density of variance: more variations let emerge an element or a portion more than less variations;
- extension of surrounding: features that surround more elements or portions can emerge more;

Thus, for instance, the thick black stroke surrounding all other gray and black features, emerges more than the rest of the strokes for the first and last criteria, as does, to a lesser extent, the vertical column on the left (Fig. 9, portion 2), which takes place between two straight black strokes. The dense grid on the center left part of the configuration emerges for the second criteria (Fig. 9, portion 5). The white top and bottom (Fig. 9, portions 1) emerge for the first criterion especially in relation to the contrast with the dense grid on the center right of the configuration (Fig. 9 portion 5). At

[21] Each element emerging from a bundle of relations can be considered a sign, if we want to resort to the classic semiotic concept. However, as we can see, a sign is a configuration too, a configuration of traits, or as the Italian semiotician Gianfranco Marrone ([97], p. 14, our translation) would say, a sign is nothing but the "tip of the iceberg of a complex underground work", since "a sign […] is the manifest outcome of an underlying structuring of parts and […] the element of a wider structure".

[22] As hinted in other passages of this manuscript, Gregory Bateson once noticed there is basically coincidence between difference and information.

this level, then, a first relation of signification emerges by association between differences and importance: the more difference, the more contrast, the more perceptibility (visibility in this case), the more information, the more importance. Since, diverse criteria of importance are at play, not necessarily only one hierarchy emerges, as it happens in this case. The other levels constituting the internal relations (see map 1) will help in setting clearer hierarchies among elements and among portions of the configuration.

At this level, then, signification takes place as an association between (a hierarchy of) contrast – expression – and (a hierarchy of) importance – content.

4.3.2. Corporal level: inclusion and pertinence

Up to now, we have considered the configuration only as the intersection of basic relations of contrasts and analogies. However, we have also seen that these relations give way to elements or, as we consider them, bodies, intended as instances formed at least by a core and an envelope [59]. Bodies, seen in this way, thanks to their envelopes, envelope or include. Of course, when we talk about bodies we tend to think of them as voluminous, as something developing along three dimensions, with the envelope wrapping up the volume of a body, as it happens with the skin for the human body. Nevertheless, a body can also have only two dimensions. In this case, the outline work as an envelope. We call such kind of envelope *enframe* (see Table 1). Thus, an *enframe* includes. Therefore, all those relations that have been previously seen as surrounding/surrounded, can be now seen as inclusions. Then, besides a hierarchy of importance, a configuration can give also way to a hierarchy of inclusions.

What includes *enframes* what is included, so that what includes modulated the "pertinence" of what is included. What includes provides then the ground or the manner in which what is included pertains to what includes – for instance: all black strokes and gray areas pertain to the same white area, the sheet. Therefore, a this level we have a hierarchy of inclusions which is a hierarchy of pertinence. Despite the impression that we are dealing with just a two dimensional space, the kind of configurations we are considering usually articulate itself also through a third dimension, which is not based on volume, but on layers. Each feature of the configuration results to be positioned on a specific layers.

As for the configuration we are taking into account, the white area including all the other elements (Fig. 6) together with all the other white areas result to constitute an overall body, positioned on a layer lower than the one on which gray areas and black strokes are positioned. The body constituted by white areas performs, then, what Gestalt psychology would call a ground: a lower, and of somewhat neutralized relevance, layer on which other elements – figures, in Gestalt parlance – lay and are outlined. Each body positioned over the "ground" rises above the ground and becomes more or less prominent. Thus, we have to consider also a hierarchy of prominence which interacts with the one of inclusion.

The gray areas, differently from the white ones, are always included within black *enframes*. Thus, they do not seem to constitute a ground as the white areas do. Nevertheless, they look to be on a layer lower than the black lines. Therefore gray areas occupy a layer more prominent than those of the white areas, despite being less prominent than that occupied by black strokes.

Because of the role of layers and the hierarchy of prominence that can result from it, inclusions can take place from below – a ground that include all the figures taking place over it; or from above – an outline that includes all that is inside it (see Fig. 10).

All that considered, the hierarchy of inclusion-pertinence of the form results as the one shown in Fig. 11:

At this level, signification takes place as an association between (a hierarchy of) inclusion – expression – and (a hierarchy of) pertinence – content.

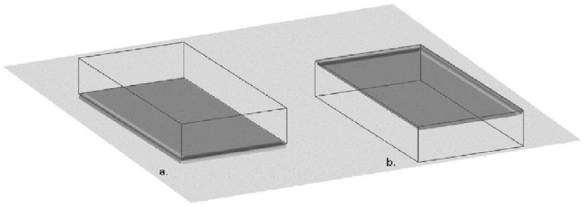

Fig. 10. Inclusions from below (a, boxing) and from above (b, covering).

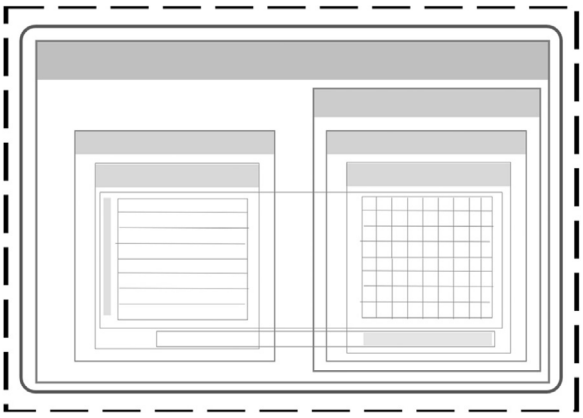

Fig. 11. Hierarchy of inclusion and pertinence.

4.3.3. Figurative level: enunciation and relevance

Many of what up to now we have considered black elements, can be recognized as specific figures with a name and, most importantly, a *sound*. These are letters, such as "R", "e", "p", etc. and they form words – "Reparto" (department), for instance.[23] Thus, through these words the hierarchy of pertinence outlined before is provided with a specific relevance. For instance, we know not only that the lines of upper parallel lines of portion 3 (Fig. 9) refer oral medications, but also that they refer to a specific patient. And we also know, that whatever will be written in one of these cases refers to oral medication and to a specific patient. Such hierarchy, based on the previous surrounding/surrounded and inclusion hierarchy is a hierarchy of *enunciations*[24]. As for what concerns us, enunciation usually manifests its presence in the visual domain through outlines which outline cases or boxes, through frames [96] or *enframes*. Any *enframe* outlines then a specific domain of relevance, where meaning – a specific meaning related to that relevance – can take place. As for Informatics, enunciation can be assimilated to the act of giving a value to a variable or to the creation of the instance of a class or, also, to the creation of a textual *enframe* where some text is inserted or can be inserted.

[23] The fact that competent (Italian) readers could immediately and effortlessly read the word "Reparto" from the black curve lines that constitute it only testifies to the competency of literate practitioners to swiftly pass from the basic relation level to the relations at corporal level and then to those at figurative level. The effort and sometimes strain that this process instead requires is well illustrated by a passage of the Theseus by Euripides (fr. 382) in which an illiterate herdsman describes the letters which spell out the name Theseus (which he had seen "written" on a ship) in terms of basic figures and analogies.

[24] Enunciation is a semiotic concept originally introduced by the French linguist Emile [14] in order to account for the individual mediation taking place between *langue* and *parole* when uttering words. Despite its relevance and productivity, this concept has being basically neglected by a large part of the semiotic research, especially by semiotic researchers not related with French semiotics. Today, we intend enunciation as the act through which signification becomes explicit. Enunciation can be then considered a configuring act, through which a certain meaning is not only created but also framed in a certain way and put in relation to other meanings as well as in relation to the position of the *enunciator* (sender) and the *enunciatee* (receiver).

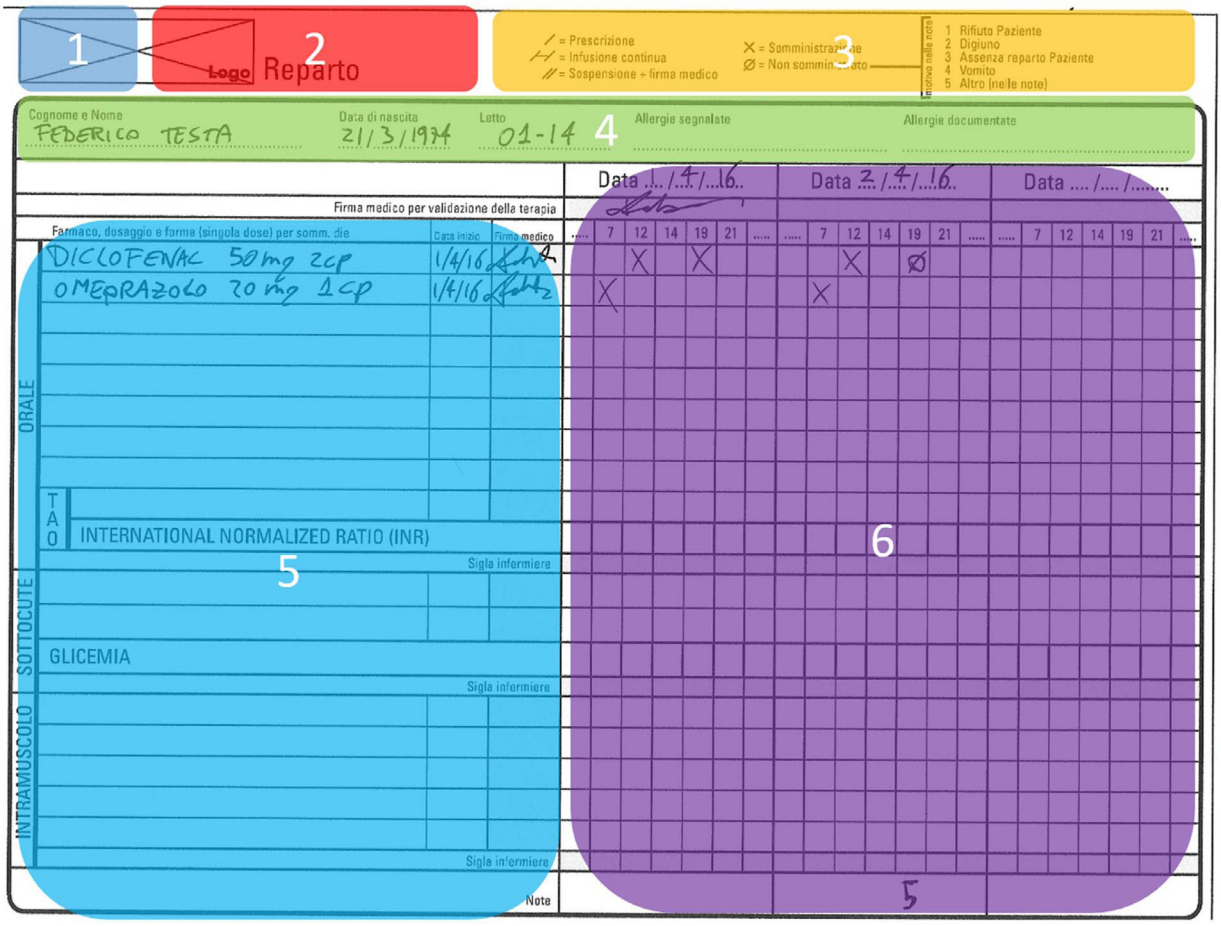

Fig. 12. The main enframes detected in the FUT form (including many others).

It can also be assimilated to the act of creating a specific document (*parole-sintagm*) from a document model (*langue-paradigme*), which implies its inclusion in a greater data structure. In our case, enunciation is clearly related to the various text-boxes which constitute the form, most of which, as we said, are empty. However, in order for enunciation to be there, it does not need that explicit, visible, enframes be there too. In our form, for instance, the upper little writings developed on the right of the word "Reparto" are part of a different enunciation, even though a clear outline separating them is not present. The enunciational architecture divides the form in six main enframes (see Fig. 12), each one with its own relevance:

1. Form ID;
2. Hospital, Department, Unit;
3. Legend;
4. Patient identification;
5. Therapy prescription;
6. Therapy planning;

The form itself (depicted in Fig. 12) is an enframe that includes other areas (enframes), which are close to each other. Each area includes smaller enframes, i.e. fields, like the drug name, or the time slot.

As we can see the enunciational hierarchy tend to go from above-left to below-right: thus all that is placed above or more on the left provides the enunciational *enframe*, and thus predispose the relevance, of what is placed below or on the left. For instance, all that is below the "Patient identification" (Fig. 12, area 4), pertains to that patient, as well as all that is at the left of a certain prescription (Fig. 12, area 6), pertains to that prescription (Fig. 12, area 5).

4.4. *Outward relations: the* script

The internal relations we have just described predispose the constitution of the FUT form as an individual, as a specific artifact with a relative closure, stability and autonomy. Such artifact, thanks also to its relative closure, stability and autonomy, takes part to other relations, external to the form. It can move across the hospital, even get lost somewhere, get soaked with saline solutions, be trashed, etc. The artifacts can then take part to almost any relation. However, some relations are more probable than others, not only because of the situations in which the artifact is usually employed, but also because some external relations are inscribed in, i.e. presupposed by - or, as we say, predisposed by - the artifact itself. These external relations predisposed by the artifacts itself are what we call *outward relations*, i.e. the description of potential external relations that a configuration predisposes, (script for [4], see Table 1). As we mentioned above, any form (and therefore also the FUT) provides blank spaces for the inscription of either required or requested information. Indeed, inscription can be considered "the program of action" of any form. As for our case, the program of action is specifically related to medical information, and specifically to the medications given to patient as, for instance, the title "Farmaco, dosaggio e forme [...]" ("Drug, dosages and forms") states. Blank spaces afford inscription.[25] Enframes (that is blank spaces

[25] As also the phenomenon of urban graffiti could vouch for.

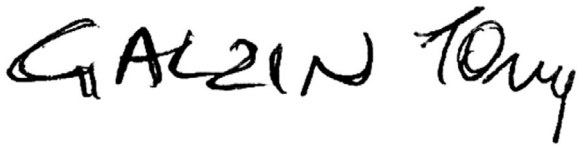

Fig. 13. An ambiguous writing, showing the importance of context in sense making.

clearly enclosed by some line) afford filling in (especially to the competent practitioner), that is *enunciation*[26] (see Section 4.3.3).

Furthermore, the form does not only provide blank spaces but, as we saw, also a specific architecture among them: an enunciational architecture, based on relations of inclusion.[27] This enunciational architecture of the form provides or, better, predisposes anchors for the indexicality (i.e., situated meaning) of expressions used to fill in the blank spaces. For instance, the inscription depicted in Fig. 13 will be more likely read as "Galzin Tom" if placed in the blank space under the writing "Cognome e Nome" (Last name and first name), whereas it will be more likely read as Galzin 10 mg if placed in the blank space under the writing "Farmaco, dosaggio e forma […]" ("Medication, dose and form").

This point would seem to be made anachronistic by the advent of the "paperless hospital", which though is far from being unproblematic or actual [132] nowadays. However, the contextual nature of information in healthcare [16] is relevant for all of the signs mentioned in the legend (see Fig. 12, area 3): /, /—/, //, X, Ø. Their relevance completely depends on where they are placed within the grid, that is on which enframe(s) these are enunciated (Fig. 14).

As we see from the presence of the mentioned legend, in this case, the form does not only provide blank spaces to fill and an enunciational architecture that predispose a meaning for the inscriptions inserted in the blank spaces, but also what Akrich and Latour [4] would call *pre-inscriptions*, i.e the competences needed to use the artifacts proficiently. Indeed, one should know the code in order to fill in and read the form correctly, that is within a consolidated and meaningful practice[28] [124]. Thus, the form predisposes different competences ([65b]; see also [4]): not only the do's and don'ts,[29] but also a "know-how to do" (*savoir-faire*) [65b].

There is another feature that must be taken into account to understand the way in which the configuration we have been previously described works by addressing external relations and making them more or less likely: the gray areas. As we have already mentioned, the gray areas actualize a layer in between the one occupied by the white of the lower level and the black lines, boxes and letters. Thus, what is inscribed in that gray blank space acquires a different prominence from what is inscribed in the white blank space. As we can see, from the inscriptions that give the name to the *enframes* that include gray areas, all these latter areas refer to signatures or initials.[30] The enunciator of a certain inscription is enunciated in the text. In this way, not only the enunciator of some inscription becomes visible – enunciated – in the very form, but also accountable and responsible: she validates her very inscription, her very action of writing in the form. Thus, the form predisposes also the space for the expression of a "wanting-to-do" (*vouloir-faire*) [65b]. These inscriptions are for MDs specific *programs of action* they propose to the nurses – like, for instance, "administer this amount of Diclofenal at 9 in the morning and three times a day" – who have to carry them out. As we can see, such inscriptions are clearly hierarchic, following the general enunciational hierarchy of the form: doctors sign the order – they provide nurses with a *program of action* – and the nurses perform the actual administration – the *programs of action*'s execution.[31] Thus, not only does the form allow to manage information and coordinate action, as rightly pointed out in [15], but it also enacts a specific political and organizational structure, through the specific hierarchy of the *programs of action* that it predisposes[32] [134].

4.5. External relations, or the practices in which artifacts are used

As we already said, the form can take part to many, different spatial and temporal relations, that is practices of use (see Table 1). Some of these relations are predisposed by the form itself through its shape or script (for instance, having holes in the left margin allows it to be included in a binder); other relations are not predisposed by the artifact, as in the case of unanticipated use, or of practices in which the form is just a material object (sheet of paper) to be, e.g., disposed in a drawer or piled up on a table.

Some external relations are predisposed by the situations that the form partakes – configurations that are broader than the one of the form itself, like the complex articulation of resources, technologies, competencies, energy that are necessary to fax the form to the Pharmacy to have trigger the urgent preparation of an infusional chemotherapy. Thus, *through* and *within* practices, as well as in less structured, conventional or normated activities, new relations can continuously emerge, not necessarily fully intended or anticipated ([15,19]). We will try to account here for some of them, which we have observed in our field studies (e.g. [26–28,33]).

The legend depicted in Fig. 12 (area 3) gives us like a guide to recall the main practices of prescription, preparation, administration that unfold around the FUT.

[26] As also discussed in a previous note, we assimilate enunciation to the act of assigning a value – an inscription – to a *variable* space (that is a physical space that can be varied or changed, variable as adjective) that represents a conceptual *variable* (variable as a noun), or class.

[27] As we know, any expression – be it a sign, a symbol, a word, a drawing, a gesture, etc. – is, to a certain extent, indexical. We intend indexical in the sense that ethnomethodology gave to this concept, which is broader than the one introduced by Peirce and then used by pragmatics. For ethnomethodology, indexicality "refers to the fact that a word may have a meaning which holds true for all situations in which the word is used (e.g., its dictionary meaning), but a word also has meaning which relates to the particular situation in which it is being used." ([10], p. 185). Thus, the meaning of any expression depends on the context or co-text, i.e., on the relations that this expression partakes along with other expressions and elements of the situation in which it takes place.

[28] However, it should be noted that the legend just reminds the code. As such, the legend is just a meta-information and no wonder it is usually placed on the margins of documents and forms, directly on the white all-encompassing space playing the role of the ground, from which it can include all the rest. The legend constitutes a sort of figurative set of outward relations, which are inherent to the form, but do not strictly prescribe behaviors. After all, although the legend is certainly something suggesting (literally) how to read some conventional marks on a form (i.e., their denotational meaning), and therefore it does facilitate the establishment of certain external relations with the artifact, it tells very little on how to write it, nor when or to what aim.

[29] Also "being allowed to do so" — *pouvoir-faire* or "allowance" for [4] and "being not allowed to do so" – *ne pouvoir pas ne pas faire*, or "prescription" for [4]).

[30] Thus they require what in Peircian terms would be an index of the presence of the MD or of the nurse. In Greimasian terms – signature or initials – produce "engagements" (*embrayages*) – (*shiftings*) in Latourian terms [86].

[31] In Greimasian terms, they maintain different *actantial* roles: the Sender-Actant, for the Medical Doctors; the Subject-Actant, for the nurses.

[32] Before, considering the actual external relations, it is interesting to notice that, according to a traditional view of semiotics, the legend, establishing a code among certain marks and certain meanings would be the most relevant element of the form, semiotically speaking. As we have shown, however, this code is just the most explicit semiotic system here in use. The form predisposes and unfolds many other meanings and processes of signification, which rely on many other systems or, better, configurations. If semiotics stops at signs, symbols and codes and is not able to account for the other configurations articulating meanings, loses a great part of its relevance and gets ghettoized in a very marginal role – this is actually what has happened during the last 30 years especially in the English speaking world. Greimasian semiotics and Latour's use of Greimassian semiotics show that semiotics can have a much broader scope, that we are trying to exploit and systematize through the SoC.

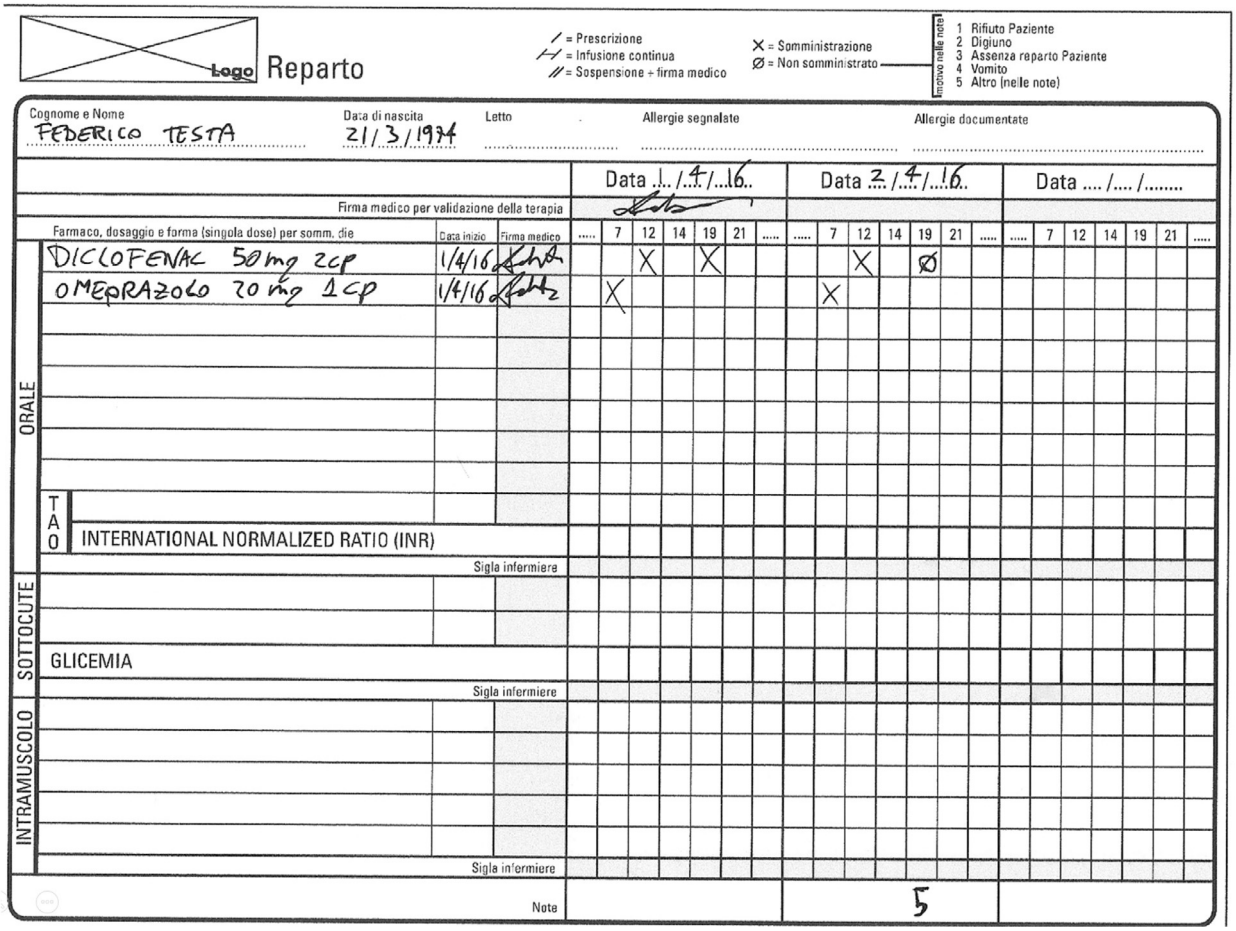

Fig. 14. A FUT that was actually filled in to both document and coordinate action in a hospital setting.

In its simplest role, the FUT acts as a mediator: MDs speak to nurses through it, both asynchronously and distributed, implicitly about a patient's condition, explicitly about what interventions to accomplish upon her body: take a blood sample, administer her a drug. By filling in the FUT (Fig. 12, area 5), MDs aim to minimize misunderstanding, convey the essentials, maintain high efficiency, share a decision, tell a story of responsibility, express expectations and directions, order actions and responses. To some respect, all of these things are achieved with great economy by exploiting the enunciational architecture of the FUT: MDs indicate the due time of administration by tracing a slash (/) under the corresponding time slot. If anything makes her change her mind, she can retract the order, or "undo" it, with a second parallel slash (//). This inscription creates an order: far from considering this a spurious entity, we see it as a bunch of (external) relations that "gush from the form" (so to say) and connect the patient, the nurses, the MDs (the prescribing one as well as those of the next work shifts), the pharmacists, the drug itself (in a specified dose and form), and any other actor involved, together. Some of the actions and behaviors of these actors become thus invisibly intertwined, knit together by the inscriptions that account for the expectations, duties and operations that realize the idea of practice and articulation work [127] that is held by the actors of the same hospital ward.

According to these ideas, which nevertheless are completely transparent to the analyst's gaze, a nurse tries to administer the medication, and she will accordingly produce a second mark: if she succeeds in administering the drug, this mark will be a backslash (\) crossing the MD's one, thus forming a × (a planned task has been completed); if, conversely, something goes wrong, she will circle the previous slash so as to form a slashed O (Ø). However, while MDs do not have to justify their orders, nurses have to account for their good reasons in not executing the orders, if this is the case: consequently, the Ø mark requires a second mark within another *enframe* at the bottom of the form, that is a figure according to the legend (see Fig. 12, area 5) to record what happened: the patient refused the medication (1); she had to fast and avoid taking any substance (2); she was missing at bed or unavailable (3); she took the drug but immediately after she vomited it (4); or any other occurrence (5, e.g., the drug was not available).

Each inscription, by either a MD or a nurse, is an enunciation which takes place within the enunciational architecture predisposed by the form. Moreover, nurses' enunciations take place after MD's enunciations, adapting to the relevance provided by MDs. What is typical also of the ward we observed is the fact that inscriptions enunciated in the form are also enunciated in other *enframes*, related to other artifacts than the FUT (i.e., nurse diaries,…). In so doing, a chain of redundancies is purposely created which goes across artifacts and *enframe*, providing always a different relevance to the same inscription [26].

Lastly, we want to mention that the marks listed in the legend (Fig. 12, area 3), as well as the writings requested by the *enframes* ("Cognome e nome" (Surname and first name); "Farmaco, dosaggio e forma…" (Medication, dosage and form…); "Data…./…./……" (Date…)) are not the only inscriptions taking place on and in the form. Other inscriptions, in terms of informal annotations and side notes [24,23,33], can create new relations, flanking and integrating the boilerplate structure. These signs in SoC are considered at the same level of legitimacy and relevance of what would instead go

into the regular grid of the form fields and textboxes, as also the sheet margin is an enframe, with the same enunciational function of other traditional fields.

And even other marks can emerge within the practices, which are associated with meanings that are not predisposed by the form, and which have got consolidated over time through repetition, local agreement among the practitioners, and informal conventions of inscription [27]. This is, for instance, the case of inscribing the capital letter "U" *in lieu* of the date. This mark was not intended by the original designers of the FUT. Indeed, this symbol was not reported in the legend, on the heading of the chart (see Figs. 6 and 12, area 3), but caught in the ward that we studied, as a way conceived by one MD and then silently adopted by her colleagues to make a certain prescription "urgent", so that it would be processed as soon as possible, even in partial contradiction with respect to the temporal slot indicated by the enframe containing the mark.

5. Immanent design

The semiotics of configurations is proposed as the analytic lens for a kind of design that we have called immanent design, mainly for its purposeful focus on the material artifacts that are used in a cooperative setting, as a unique source of indication for the design of their digital counterparts and the underlying information system.

The relationship between the semiotics of configurations and immanent design is tight and strong. Both share important points:

- a relational epistemology;
- a theory of immanent signification
- a theory of distributed action and hybrid agency (like in [15,78] and more generally in Latour);
- an artifact-centered perspective, as argued in [28], where this phrase denotes a materialistic and immanent approach to artifact analysis for their gradual digitization;

In light of these affinities these two approaches, developed in different fields and brought together in this contribution, can reinforce each other. On the one hand, the semiotics of configurations gets a practical justification in immanent design, as it can be applied beyond mere descriptive aims, yet rather to shape technology and the artifacts that augment and help constitute any human agency. On the other hand, immanent design needs a method of description and analysis of artifacts that focuses on their concrete affordances and physical constraints, with no indulgence in any hypothetical theory about the motives and the purposes that could regard their use. This is exactly what the semiotics of configurations (and transformations of configurations[33]) has got to offer.

Indeed, an objection to any strongly artifact-centered approach regards their (possible) excessive attention to the physical layout and affordances of the traditional artifacts to be digitized and, therefore, the risk that their electronic counterparts could just mimic how those artifacts look like, thus missing important opportunities for redesign and improvement.[34] SoC helps immanent design to minimize this risk (if any): for instance, detecting internal and outward relations allows the immanent designers to extract only the meaningful "lines of force", so to say, from the materiality of the forms and artifacts used in a cooperative settings, so that only these essential features could be preserved in the digitization and the rest to be left to any kind of evolution and improvement. Likewise, detecting outward and external relations, as a way to focus on how documents can be filled in and how they have to process their content, promotes a focused look at how actual practices unfold and thus promotes the discovery of the conventions of use that make sense for the practitioners but stand "out of the box" with respect to the ideas of functions and commands that are typical of requirement engineering and software design: side annotations, workarounds [32] and shadow tools [73] emerge as first class concerns and objects of study in cooperative settings.

Thus, immanent design is proposed as a design aimed at utilizing the de-scription of material practices to either preserve or augment the programs of actions that are already found in the "things"[35] of a cooperative settings, and at keeping a very cautious attitude towards the theory-driven creation of new programs of action. Indeed, the analytic activity of detection and description of both spatial and temporal relations that immanent design requires is aimed at minimizing the creation of spurious categories that can affect unsuitable in-scriptions (i.e., computational coordination mechanisms, [31]) in the interactive technology. In so doing, immanent design aims to support the smooth *re-format-ting* of configurations and their transformations (trans-configuration) within and across "representational media" [78], that is the *change of format* occurring in the transition from paper-based media to the digital ones.

5.1. Differences with other approaches

The various methods proposed under the umbrella of user-centered design have so far focused on the study of practices intended as *normated-normative behaviors* [124]. Immanent design studies practices intended as *regular patterns of actions that transform configurations*. The difference is subtle but important. While the traditional approaches aim to detect the motives, goals and rules that drive, cause and order human and social action in complex social structures of roles and responsibilities, immanent design adopts the semiotics of configurations to look for and conveniently describe *regular, simple and orderly* (cf. Gestalt theory) patterns at different levels of description, with no interest in *causes* and *goals*.

[33] To some respect, immanent design can be conceived as a design activity aimed at making these transformations either totally automated or computationally supported, according to the cooperative requirements. In other words, it is a *design for trans-configuration*. The concept of trans-configuration shares clear affinities with that of translation by Latour (which is not totally the same by Callon), which regards a 'continuous transformation' ([84], p. 268) in both the physical and semiotic space: that is both a mobilization of human and non-human resources 'in different directions' resulting in 'a slow movement from one place to another' ([85], p. 117), and the related semiotic drift, in terms of transformation of meaning occurring during the movement of the object in question across different contexts [131]. In Latour's words: a translation implies both displacement and mediation, i.e, "the creation of a link that did not exist before and that to some degree modifies two elements or agents" ([87], p. 32). In the same vein, in [110] Nicolini defines translation as "the active process of establishing relationships that induce multiple entities to coexist". In this light, the concept of trans-configuration can denote more precisely this kind of relational process of emerging, which immanent design interprets in terms of relations of physical and temporal proximity: how a configuration gets to be moved in space (so as to change mutual relationships of topology and displacement with other configurations); and how it has to change or be changed so that new relations can come into existence.

[34] As argued in [28], an artifact-centered approach to software application design does not necessarily pursue skeuomorphism as a design driver, that is the purposeful resemblance of digital artifacts with their original objects. That notwithstanding, such an approach usually assumes that traditional artifacts, i.e., paper-based artifacts that the practitioners and their users had the opportunity to improve and change over time, do not take a specific shape or structure by chance, but rather because they represent a sort of stratified and evolutionary outcome of multiple adjustments, compromises, corrections, and design trials and errors done over time, under the pushes of opportunities and best practices. Thus, it is true that an artifact centered approach tends to mirror closely the affordances and layouts of these traditional artifacts; however, it also usually acknowledges that many of their features can be either fortuitous, inefficient, dependent on the limitations of paper, the lack of resources, or just the gullibility of the layman.

[35] This is especially the case if one considers the famous epigraph by Becker not just a provocation: "Things are just people acting together" (p.46) [13].

This is not because these are not considered relevant at human level, all the contrary. Rather, it is questioned the *utility* of thinking of causes and goals to inspire and inform the design of technology in socio-technical settings. If we take an historical perspective, and consider the plethora of different models, frameworks and design methodologies proposed in the last thirty years in fields like the Information Systems [94] and the Computer-Supported Cooperative Work field [71], one would rather argue that the above theoretical approach could be even *harmful*. This would not be argued for the sake of being provocative, but rather in light of the still nowadays relevant rate of failures in the organizational domain [38,52]), and in particular in healthcare [18][36].

Thus, it is not a matter of bashing or down-playing the role of theory, but to consider theoretical accounts of the setting to be digitized either "king or subordinate" [95]. In favor of this latter stance, immanent design programmatically rejects the study of practices in terms of theory formulation and rule definition to focus on *the dynamics of the superficial (i.e., acting at interface level) transformation of representational states (that is configurations) that inform the autonomous action of humans and machines, and their mutual interactions*.

To this aim, immanent design advocates a *de-design*, that is a de-emphasis of the theoretical[37] in favor of a continuous development of the already existent, that is of the partial automation of the transformation of configurations as these already occur to have work done, and have an effect on the world.

While there is a sort of continuity in the tenets between immanent design and user centered design, the former one opposes any objectivistic stance in the design of computational systems including mainstream approaches like the conceptual modeling based on entity-relationship modeling (which is at the basis of object-oriented programming) although both denote themselves as relational.[38]

On a practical level, this means that our approach explicitly avoids the so called "assumption of inherent classification" ([113], p.50). This assumption pervades almost all of the approaches to information modeling and is reflected by the common practices in software design to, first, identify the classes (or types of things) needed to describe the domain [120]; and then to use the is-a relation as a building block of this modeling activity. Like in [113], we also believe that this assumption "is the source of some major difficulties in information modeling [that] arise when there are multiple users, when users' views change over time, and when information has to be integrated from multiple sources". Since this is often the case, more radically than the proposal by Parsons and Wand, we propose "to follow the relations" as a specialized application of the methodological cue suggested by Latour in regard to

[36] Failure in IT development projects is not an open secret, although perhaps this is a topic that has not received as much academic interest as it would be necessary. Consultancy groups, like KPMG, OASIG and the Standish Group, every now and then report statistics and rates that, although they must be taken with a grain of salt on the definition of success and its opposite, shed some light on a phenomenon that cannot be overrate. The academic community has reacted to this phenomenon from the 1960s, vague age that some denote as the "software crisis" (Haigh, 2002). The first reaction was the establishment of a new research community gathering around the tenets of traditional building engineering: the software engineering one. We call the fundamental value underpinning this movement the *designer-centered* approach to computing (conversely, in the early days of computing, this was more a matter of craftily low-level coding than orderly designing cf. [70]). In this approach, the designer's introspection, modeling capabilities and creativity are valued most. Then, some wariness about how office work was being automated rose (Bainbridge, 1983; Winograd and Flores, 1986; Zuboff, 1988): new communities gathered to investigate the reasons of discontent (Grudin, 1988) and developed new theoretical and methodological approaches (Schmidt and Bannon, 1992) whose focus passed from the human factors to the human actors (Bannon, 1991). This has been the *user-centered approach*, where anthropology and ethnomethodology borrowed their methods and techniques (and practitioners) to IT design in order to observe the users, interview and talk with them, try to understand what their needs, motives and goals are by interacting with them, instead of thinking on behalf of them (cf. the designer-centered approach). These two approaches are still active and mutually informing each other, both in professional practice and the academic discourse, so much that it would be just chatter to argue whether any of them is prevailing over the other. Partly informed by both the previous approaches, but in clear discontinuity with them, we are now proposing to explore a new one, which we dub *artifact-centered*. In such an approach, the focus would be on how artifacts are used; how these mediate human-human interaction and collaboration; how their inscriptions and related practices of inscription support human cognition, cooperative decision making and knowledge sharing, to understand what of these artifacts and the related practices should be automated (Tedre 2008). - Bainbridge, L. (1983). Ironies of automation. Automatica, 19(6), 775–779.c - Bannon, L. From human factors to human actors: The role of psychology and human-computer interaction studies in systems design. In Design at Work: Cooperative Design of Computer Systems. J. Greenbaum and M. Kyng, eds. Lawrence Erlbaum Associates, Hillsdale, NJ, 1991, 25–44. - Grudin, J. (1988). Why CSCW applications fail: problems in the design and evaluation of organizational interfaces. In Proceedings of the 1988 ACM conference on Computer-supported cooperative work (pp. 85–93). ACM. - Haigh, T. (2002). Software in the 1960s as concept, service, and product. IEEE Annals of the History of Computing, 24(1), 5–13. - Haigh, T. (2010). Crisis, what crisis. In Reconsidering the software crisis of the 1960s and the origins of software engineering, presented at the Second Inventing Europe/Tensions of Europe Conference, Sofia, Bulgaria. - Rochlin, G.I. Trapped in the Net: The Unanticipated Consequences of Computerization. Princeton University Press, Princeton, NJ, 1997. - Schmidt, K. and Bannon, L. Taking CSCW seriously: Supporting articulation work. Computer Supported Cooperative Work (CSCW): An International Journal 1, 1–2 (1992), 7–40. - Tedre, M. What should be automated? interactions 15, 5 (2008), 47–49. - Winograd, T., and Flores, F. (1986). Understanding computers and cognition: A new foundation for design. Intellect Books. - Zuboff, S. (1988). In the age of the smart machine: The future of work and power. Basic books.

[37] And hence of the ego of the designer. See also [35], for a discussion of this approach in the contemporary design sciences.

[38] Codd borrowed the notion of relation from mathematics, where a finitary relation is a set of ordered sets (n-tuples) defined on other sets, or domains, which are considered as "pools of values". This relation set would ideally represent, as a whole, how the components of each n-tuple are connected, and all the ways that different aspects of the property can be connected together at the level of single tuples. This idea was grounded on the logic of relations formulated by De Morgan more than one century earlier, for whom a relation is the name of the connexion under which two objects are seen when they are "viewed together by the mind" [102]. The traditional interpretation of the relational model is mediated by the entity-relationship method to the conceptual design of a data base: this semantic data model [40] assumes that objects (called entities) preexist and have properties (called attributes), connected by being properties of the same class (entity type). This approach was not intrinsic to the relational model. The historical example produced by Codd himself was not objectivistic: he considered the relation "*supply*, which reflects the shipments-in-progress of parts from specified suppliers to specified projects in specified quantities." ([41], p. 379) The objectivistic interpretation of the relational model lies in the treatment of the null values: in a truly relational perspectives, if a tuple contains even a single null, the entire tuple should be undefined (and hence not represented) as the whole property misses one piece and the rest cannot be interpreted. This is clear in the example mentioned above: each elements is necessary to define a shipment-in-progress. Another classic example is the ternary relation [person-x]-knows-that-[person-y]-likes-[person-z]. Also this relation would be meaningless in describing an actual relation observed in the world if any of these three pieces of information were missing. On the other hand, in an objectivistic stance, each tuple is seen as a representation of an object (instance of the class represented by the relation) endowed with some property (corresponding to an attribute, or place in the tuple) and it is totally acceptable that this representation could be incomplete to some respect. For instance, if each tuple represents a patient, while some attribute could be considered mandatory to identify a single person (like the name or fiscal code), many other attributes could be optional, like the phone number or the home address. In purely relational terms the composite property of, say, "having a name, a phone number, an address" would be undefined, but no current DBM would discard a row just because one of its fields is empty. Codd proposed the relational model [41] as a response of the software crisis of the sixties, when data base management systems and organizational information systems grew too complex to be maintained with the little systematic development methodologies of the time [70]. As a matter of fact our relational approach is close to a radical application of the Codd original proposal. Therefore, quite paradoxically, also close to the network data model approach that the Codd's model was aimed at substituting in the information systems of the previous century to "free the records in the database from the tyranny of the links" ([113], p.50). However, as noted by [113] "this flexibility did not come without cost, as it required additional processing power and special implementation mechanisms to avoid performance deterioration."

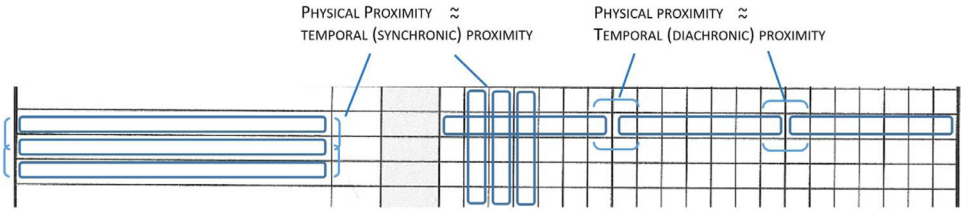

Fig. 15. Proximity relations in an excerpt of the FUT.

the study of the artifacts, "to attend first to the associations out of which [they are] made" ([89], p.243).

For instance, when a SoC analysis detects relations of physical inclusion between form elements (e.g., some text included in some enframe), an immanent designer can interpret these relations in terms of either hierarchical (*is-a*) or mereological (*part-of*) relationships but abstain from transforming that inclusion in neither one to avoid embedding its interpretation in the computational artifact. Likewise, immanent designers can recognize that relations of physical proximity (left-right, top-down, see Fig. 15) can express either pertinence or sequentiality (and in fact often both of them) and, accordingly, conceive to implement constraints that inscribe the corresponding (and *additional*) relations of temporal proximity (e.g., rules checking that sequences of Xs are written from left to right, the slash is written before the backslash, and so forth) in the electronic FUT. Instead, traditional IT designers would more often transform the physical proximity of paper-based forms and documents into *page sequentiality*, that is substitute relations of physical proximity with relations of temporal proximity, which are thus imposed to the users for the sake of less information overload and allegedly greater safety and efficiency. However, in doing so, traditional design risks to destroy the *overview power* that in traditional artifacts is allowed by the physical proximity of its parts and elements.

These examples show how immanent design provides analysts and designers with the language and the rhetorical power [71] to recognize these basic relations, and in so doing how it promotes a conservative and responsible [94] sensitivity towards what to automate, obliterate [72] and, more importantly, preserve [32] in a cooperative setting.

6. THe AdHOc platform: from analysis to (re)design

AdHoc is a digital platform for the creation and management of electronic documents that we developed to assist the immanent designer – and the end users themselves – in translating a SOC-compliant analysis into computational data structures and behaviors. In so doing, AdHoc is also our proof-of-concept, that is a prototype that proves the feasibility of this translation and that allows for the construction of new information systems. To this aim, AdHoc implements natively the main concepts of the semiotics of configuration, i.e., relations, enframes and enunciations. These three concepts have suggested to conceive the underlying data structure of AdHoc as a graph: each identified enframe is translated into a node of the graph, which is possibly connected to leaf nodes representing enunciated values; and to parent nodes representing their including enframes (i.e., templates, repositories, etc.[39]).

Since the main characteristic of an immanent approach regards the relief from conceptual models of practices and social structures to focus on the concrete material artifacts already in use in a work setting, AdHoc has been specifically conceived to allow end users to create their own document templates, and to make documents out of these templates much similarly to how they would create working documents from printing out paper-based templates on demand.[40] To this aim, AdHoc adopts the tenets of End-User Development.

In particular, AdHoc users can define both the data model, the control logic and the presentation layer of the information system. As a matter of fact, there is no rational and unified data model underlying AdHoc-based information systems: users can define their documents and forms in a bottom-up manner and, more notably yet, by manipulating their superficial features – others would say the interface – so that *the model* (if any) *follows the layout*, that is (to use the analytic categories introduced above) by enunciating spatial relations of either inclusion or spatial proximity between enframes.[41]

The presentation layer of the information system – or its "surface" [36] – is in the full control of end users. These are called to both generate their own *layout structures*, as well as some *control structures*, that is application behaviors, that can either manipulate the document's content or change its appearance [30].

To the former aim, AdHoc provides users with a visual editor (see Fig. 18) by which they can define basic data structures, or *datoms* [34] and then include them recursively in greater and more complex (layout) structures: simple datoms in more complex datoms; these latter ones in templates, these ones within other enframes and so on (e.g., records, folders, repositories). Thus, datoms are sets of inscribable enframes that will contain those data that users will consider meaningful to bind strictly together, for any reason, like the name of a drug and its prescribed dose of administration, or the name and family name of a patient.

As said above, a datom can recursively be a composition of one or more datoms: e.g., the "patient name" datom can be combined with the "current address" datom into a "patient details" that encompasses both. Thus, a document template is created by connecting enframes together with the inclusion relation seen above: in AdHoc users just include structures within greater inclusive structures/containers.

Active documents are then created from these datom bundles or templates, by the enunciation of the template in a given context. This can be the hospital record repository, where the patient records are stored. In so doing, the platform instantiates the un-

[39] To use a purposely suggestive phrase, in AdHoc documents are just ways to "see" portions of this graph in a bottom-up manner, i.e., from the enunciated values, up to the higher level containers.

[40] As end users tend to create templates very closely to their situated and ever-evolving needs, this primary requirement has been caught in the name itself of the platform: users must be enabled to create artifacts *ad hoc*, that is for a specific task, non-generalizable, and not intended to be able to be adapted to other purposes.

[41] In this paper we do not give implementation details of the prototype. Here it suffices to say that AdHoc has been built on top of Play (http://www.playframework.com/): this is a Web application framework that adopts the Model View Controller architectural pattern, and is stateless, REST-ful, and written in Scala and Java. In AdHoc, Play integrates an Event Bus mechanism provided by the Google Guava Library Mechanism Manager (https://code.google.com/p/guava-libraries/). The rule manager has been developed using JBoss Drools (http://www.drools.org/). The persistence layer adopts a NoSQL and JSON-based database, called MongoDB (https://www.mongodb.org/).

Table 2
The scope of the replicating behaviors implemented across AdHoc documents.

	Data Shared Between:		
	Active Documents	**Active Documents from the same Templates**	**Active Documents of the same repository**
R0	NO	NO	NO
R1	YES	NO	NO
R2	YES	YES	NO
R3	YES	YES	YES

derlying flat data structures that are necessary to store the content that these active documents will contain when the user will enunciate the inclusion relation between datom enframes and data (in short, when users fill in their forms).

Notably, the same datom can be re-used in different templates, thus creating different kinds of associative relations between active documents that spread the data inscribed in a document into other related documents. The user can exploit this feature to automate the practices of replication and redundancy that we hinted at in Section 4. To this aim, a users who creates or modifies a datom can specify the degree of redundancy that she wants to establish between the different fields (in different documents) that refer to this datom. Technically speaking the redundancy-related associations that we have identified after multiple field studies [25,26] are implemented in terms of replicating behaviors of the AdHoc platform that are governed by an attribute (i.e., the *replica* attribute) whose values are reported below (see also Table 2).

R0 This is the default option. The fields of an active document generated through a template with a R0 datom will just hold data that are local to that specific document, e.g., the value of the daily measurement of the patient's temperature that the nurses inscribe on the *Daily Sheet*.

R1 in this case, the content of the datom's fields are shared between all the instances of a document based on that particular template and within the same repository (e.g., the patient name will be replicated in all of the prescription forms of the same patient.

R2 the fields share data between the instances of some documents that are based on different templates, but that are related to a single resource, e.g., some portions of a patient's personal data (like the patient ID, her name and surname) within the same patient record; the prescription of a patient, inserted in the prescription form is also replicated in the nurse diary.

R3 the content of R3 datom is replicated in all of the documents using the same datom, without any constraint both on the template and the containing repository (e.g., all of the documents within the same hospital).

Users can also specify how their documents should change later in use under particular conditions. To this aim, AdHoc provides users with a visual editor (see Fig. 16) by which they can define specific rules. With rules here we intend simply *if-then computational constructs*, that is *behavioral structures* whose patterns match (by analogy) the enunciated content and in so doing can enact the relations of temporal proximity detected in the SoC analysis.

As a matter of fact, in AdHoc the whole execution control is rule-based. This means that users can define local rules that act on the documents' content and, as hinted above, change how documents look like (i.e., their physical affordances), to make users either aware or mindful of pertinent conditions according to some integrity/security check, social convention or business rule like, e.g., the need to revise the content of a form, or to consider it provisional, or to carefully consider some contextual condition [31].

Rules can act on a single document (in the hospital case, the single sheet of a particular patient record), or on a single container of documents (in the hospital case, a single patient record), as well as cross-document, on a single template. This flexibility is achieved by applying rules to datoms, which as said above have different scopes according to their *replica* attribute with the others.[42] These latter rules implement at the same time both redundancy-related associations and temporal proximity relations that bind different documents together on a temporal dimension, e.g., to insert a warning in the prescription form if a drug is going out of stock, according to the quantities recorded in another document.

6.1. A scenario of digitized practices

In what follows we present a short scenario of use of the digitized FUT that is inspired by the analysis of the relations observed in our field study and illustrated in Section 4. Although briefly, in this section we therefore aim to connect the relations that were detected in the SoC analysis to categories of immanent design (see the "type" axis of the 3D map in Fig. 4) and see how these can be mirrored in AdHoc constructs. In particular, we will not consider internal relations, assuming that the digitized FUT has been built with the datom editor as much similar to the paper-based artifact as possible and that all of the relevant enframes have been digitized in terms of text boxes and input fields. We will rather focus on outward and external relations, that the AdHoc user can translate in terms of control structures, i.e., rules to be associated with the FUT template and applied to any document that enunciates that template within the AdHoc environment.

As we anticipated in Section 4, the FUT form, like any other similar form, can be used by authorized people only. A register at the hospital is kept and updated regularly with the names, signature and initials of those people, with an indication of their role at the hospital. As widely known, only MDs can prescribe drugs, thus only their initials can be inscribed in the proper slots. Likewise, nurses are supposed to administer treatments, so they can put their initials in the cells that in the original form were at the intersection of the "initials" enframe with the "administration time" enframe, when they jot down the proper mark (see above).

The signature registry (not depicted in Fig. 17) creates a relationship[43] between each FUT (or better yet some of its specific enframes) and the authorized person according to her role (see relation A in Fig. 17). From a computational point of view, the registry is implemented by any *access control* mechanism. However, according to an immanent design approach, the AdHoc user would conceive specific rules that associate specific access rights (and available marks) with specific roles and people. Although this could sound inefficient (e.g., with respect to an access right table in a database), the rule-based mechanism is intended to facilitate both maintenance and, mostly important, temporary waivers of the access policy, according to contextual conditions (like night or understaffed shifts, emergencies, and the like).

As said above, the FUT structure (or enunciational architecture) requires competent filling in by knowledgeable practitioners. In certain slots, only MDs can write (see Relation A) and only in predetermined ways; actually, in the smaller cells depicted in Fig. 15 only one mark is allowed for the inscription by the MDs (the /). This creates a limited number of temporal proximity relations

[42] Technically speaking also the local rule that has a datom in either its antecedent (if-part) or consequents (then-part) is replicated to be applied to different entities within the whole AdHoc document system.

[43] Fig. 17 represents binary relationships only for the sake of readability. However, a SoC analysis most often detects bunches of many-to-many relations, which then the analyst can trace back to either ternary or binary relations for the sake of simplicity.

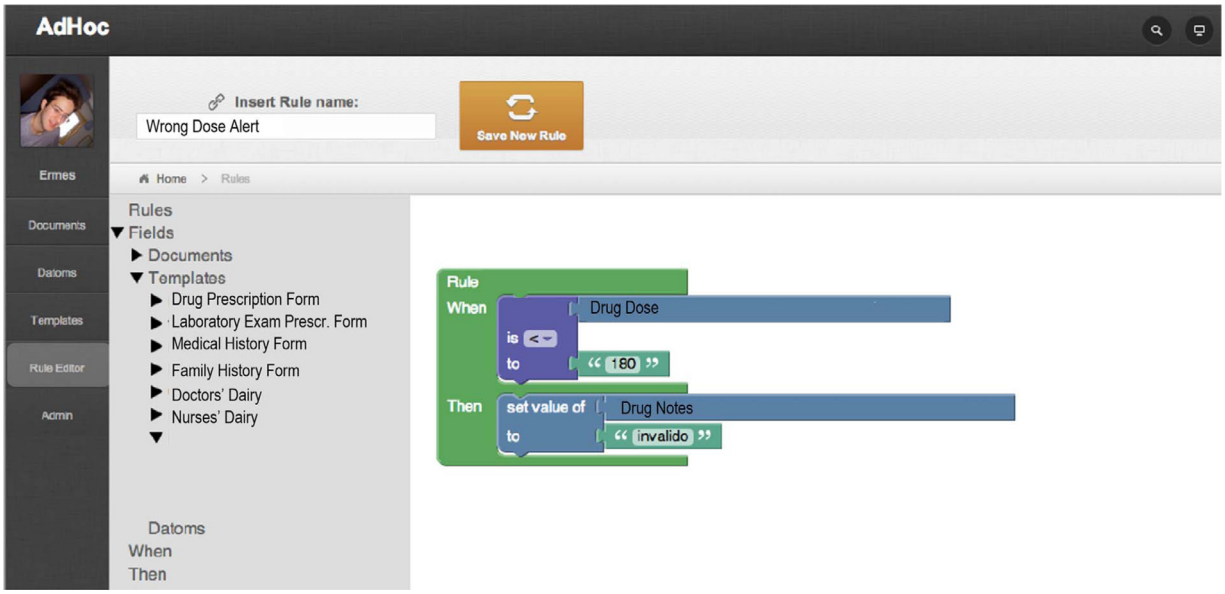

Fig. 16. A screenshot of the Rule Editor, by which the users can define the rules associated with their documents.

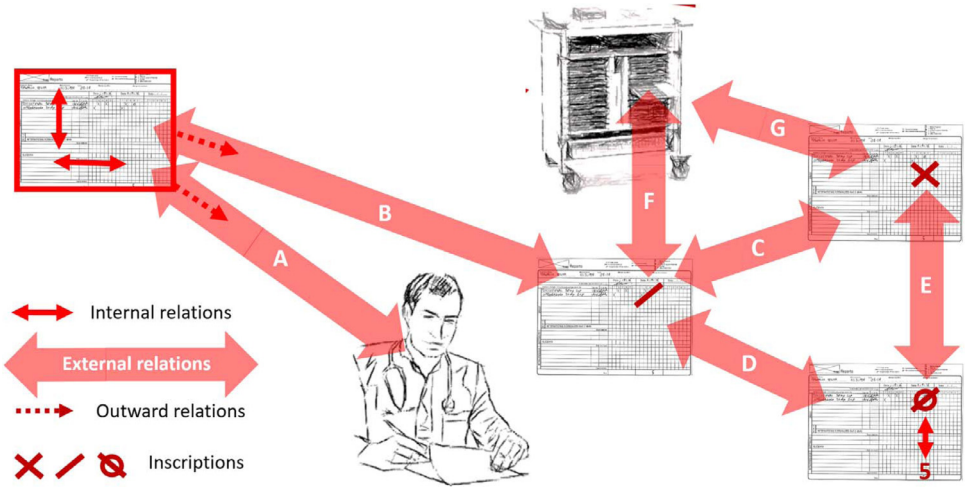

Fig. 17. A short scenario of use of the digitized FUT in AdHoc. For sake of readability relations are depicted as binary, but they are not necessarily so.

between the configuration in which the FUT is empty and all of the *meaningful* configurations that contain legal inscriptions, that is the inscribed configurations that are capable of triggering the therapy process and of ordering the execution of the related activities: of these relations in Fig. 17 we see Relation B, E and F. These respectively express the constraints that: the first mark on a prescription-related enframe must be a /(relation B); the following mark can be either a \ (relation C) or a O (relation D); and that these two marks are strictly exclusive (relation E, which is an association of mutual exclusion). Moreover, as shown in Fig. 17, the Ø sign is bound to another mark representing a category of exception by an internal relation of proximity.

The detection of these relations (from the observation of recurring patterns of actions, which empirically confirms the practical application of the FUT legend, but also makes some of its implications, or better yet *implicatures*, explicit) suggests the creation of corresponding rules that either prevent illegal inscriptions, or create alerts and prompts to users to justify any deviation from the formal policies [30]. In this latter case, the rules can change the affordance of the fields: for instance, if the field of the doctor's signature under the date field is empty (correspondingly in the digital format – if the MD who is logged in the system does not confirm the administration plan for the day that she has just reported in terms of a sequence of /signs), the border of any other fields in the administration row of the patient's FUT must be highlighted to indicate a situation of administrative irregularity. In so doing, the system would augment the form by making specific enframes "present at hand", so to say, that is to stand out of the original enunciational architecture, so that the users could be reminded of the enframes' enunciational role and function.

Up to this case, the scenario of digitization has mirrored the paper-based FUT and the related practices of inscription, potentially augmenting them like in the case of the highlighting of data fields and of the automation of the behaviors of data replication. However, as said in Section 5, digitization can also allow for the emergence (and strengthening) of other external relations (identified by the SoC analysis), and for their *reformatting* (see Section 5), that is translation in terms of alternative representational media. For instance, when the MD jots down a / the information can propagate across different artifacts and media: for instance, a new document can be created (enunciated) in the pharmacy agenda (that is another AdHoc document); a new message (which is still another

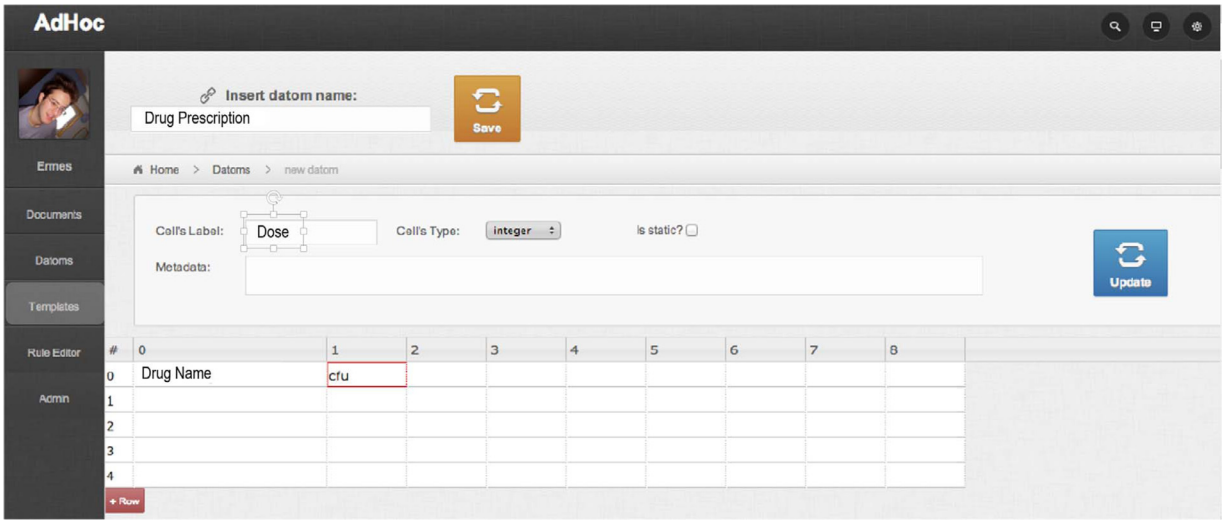

Fig. 18. A screenshot from the Datom Editor with which users can build theor own templates.

document, in the pharmacy mailbox repository) is dispatched for the responsible pharmacist on charge; and (relation F in Fig. 17) an automated dispensing cabinet can fetch the right pill from an internal repository, unlock the drawer associated with the right patient and switch on a guiding light to help the nurse take the drug, after having scanned the bar code on her bracelet (log-in) and on the patient's one. Only after that the pill has been extracted (relation G, of temporal proximity), the nurse can report the right administration (with a *X*) or that something went wrong instead: in this latter case the nurse has also to specify the reason (see Section 4). In both cases, the dispensing cabinet draws back the drawer, locks it again, and logs the movement of unloading from the drug internal stock.

AdHoc also supports the relation that in immanent design we denoted with the generic term of *association*. When users work on documents they can create an association between documents elements (that is one or more enframes and/or one or more enunciations) and an enunciation, which characterizes the association itself. This is what it is usually called an *annotation*, linking one or more portions of a document (the target of the annotation) with another content (usually a comment, or a label/tag). As we began describing in [29], AdHoc integrates a tool that allows users to create n-ary associative relations between document elements, documents and annotations themselves. In Fig. 19 we show an AdHoc document, defined (enunciated) from a template containing an anatomic diagram. The user has inserted three markings, namely three small circles and has put them in three different places of the image to indicate where the patient reported pain. Then she selected these three elements and created a textual annotation linked to these elements. The annotation, depicted on the right, contains a short textual comment. Graphically AdHoc makes the anchoring between the comment and the target explicit (the thin blue lines), so that the annotation acts as a ternary relation, relating three elements of the documents together. Once an annotation has been created, this is an element on which any kind of rule can be created, in order to enact relations with any other element that is represented (or accessible) on the digital platform.

Figs. 18 and 16 show the user interface of the two visual editors integrated in the AdHoc platform: the first allows users to create datoms (atomic sets of fields, or nested enframes) and create templates in terms of spatial arrangements of datoms. When enunciating (instantiating) a document from an existing template, the datoms are transformed in data-holding spaces (fields), which automatically establish content relations, according to the schema represented in Table 2. The resulting information system is then a parceled set of related active documents that can be annotated in all parts and sections and be associated with any other document, comment and computational behavior.

To wrap things up. AdHoc implements the relational approach of immanent design: it offers a document management system conceived as web of elementary relations that either constitute the artifacts (in case of the spatial relations) or bind these together (in case of the temporal relations and associations). In particular, templates represent topologically ordered sets of datoms, i.e., enframes in mutual spatial relation. Rules represent temporally ordered sets of behaviors or temporal proximity relations, activated according to contextual conditions. Associations allow to put any surface element of a document in relation to any enunciation (field values and annotations), and possibly (not necessarily) with any other surface element of the same or other documents within the nested repositories of AdHoc. In our ambition then, AdHoc is a system enacting composite data structures for the "complex, the changing and the indeterminate" [108].

7. Epilogue

"A man clambers onto the streetcar after having bought the daily paper and tucking it under arm. Half an hour later he gets off, the same newspaper under the same arm. Only now it's not the same newspaper. Now it's a pile of printed sheets which the man drops on bench in the plaza. It hardly stays alone a minute on the bench, the pile of printed sheets is converted into a newspaper again when a young boy sees it, reads it, and leaves it converted into a pile of printed sheets. It sits alone on the bench hardly a minute, the pile of printed sheets converts again into a newspaper when an old woman finds it, reads it, and leaves it changed into a pile of printed sheets. But then she carries it home and on the way home uses it to wrap up a pound of beets, which is what newspapers are fit for after all these exciting metamorphoses" [39].

This very short tale by Julio Cortazar tells an ordinary situation. And yet, in the words of Cortazar, such an ordinary situation acquires a specific nuance of strangeness. We are thus able to pay attention to what remains unnoticed all too often: things, beings, items, creatures are never given in themselves, but always in relation to others – other things, other beings, other items, other creatures. And, in such a way, they change, and become.

According to a certain semiotic framework we could say that the newspaper is interpreted in different ways. We could say that

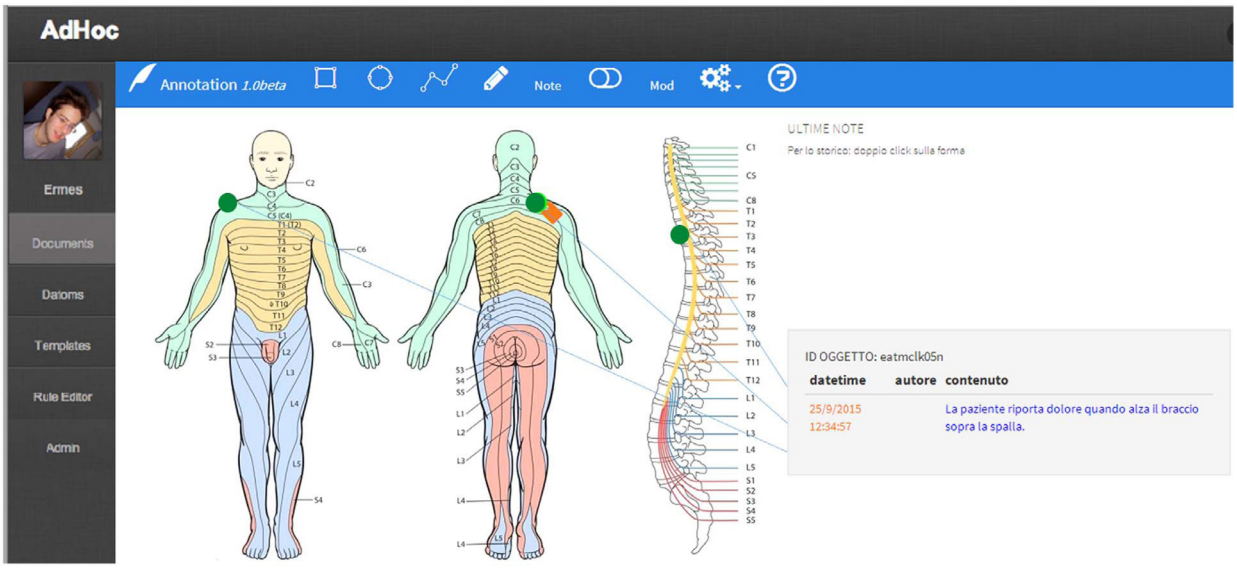

Fig. 19. A screenshot of an AdHoc document, annotated by users.

different meanings are attributed to the same thing. However, we believe that Cortazar's very short tale tells us something else – whence its ostensible oddity. It is not that much how the newspaper is interpreted; but rather how the configurations between the newspaper and its users emerge, get stabilized, and eventually dissolve, when they change into another configuration. When they become.

When what in the previous situation worked as a newspaper is used "to wrap up a pound of beets", what-in-the-previous-situation-worked-as-a-newspaper becomes one body with the beets, becomes their skin, their envelope, keeping them all together into a new configuration.

IT design seems to neglect this kind of lessons quite often [109]. In so doing, it leaves itself open to any kind of problem related to unintended use, low appropriation, user misconceptions and conflicts; in short to the very reasons behind the still high rate of failures in the digitization of organizational settings [52].

Therefore, in this contribution we have proposed a novel kind of framework, another kind of semiotics.[44] This semiotic framework does not exclude interpretation or attribution of meaning; rather, it posits that interpretation and attribution of meaning *emerge* in relation to a specific configuration and to the practices this disposes.[45] According to this intuition, this framework suggests that IT design can limit its scope to address the continuous transformation of configurations, by automating some arcs of the trajectories in which configurations keep unfolding, and thus leaving the construction and reconciling of meanings, the "big picture" of work and cooperation, and making sense of them in situated human practices to the competent practitioners.

Is such an idea in counter-trend with the progressive digitization of our lives, automation of work settings and the diffusion of smart devices and services that are designed around the user, putting the user at the center? Almost 25 years ago, it sounded "plausible that a good theory of cooperative work could help [the designers] in finding new design metaphors" [81]. In this light, our proposal is not a good theory of cooperative work. As a matter of fact, the Semiotics of Configurations is not proposed as a *theory of work* at all, but rather as an instrument for the *description of the extended phenotype* of artifacts, so to say, that is their material shape and sphere of influence in the complex network of relations and *association chains* ([4], p. 263) they partake. In so doing, it does not provide designers with useful or evocative metaphors, which probably are necessary devices to narrate how people work and why (which is typical of ethnography); rather, it provides a vocabulary by which to describe relations that regard artifacts and their use (i.e., configurations), that is aspects that designers should be aware of when they decide to make those artifacts electronic, or to automate any function in some socio-technical settings.

Taken together the Semiotics of Configuration and an immanent approach help designers in several respects: after Halverson [71], who discussed what kinds of capabilities a design framework should support to be helpful in practice, we notice that SoC and immanent design fulfill both *descriptive* and *rhetorical* functions, by providing designers with a technical vocabulary (see Table 1 and Fig. 5) and a map (see Figs. 1 and 4) to describe socio-technical settings, their artifacts and how they change to (help) articulate work and mediate interaction.

Halverson [71] discusses also *predictive* and *application* power. Like for any other design framework, it is difficult to honestly claim that our proposal is capable to bring inferences about the consequences of making changes in a socio-technical setting, especially in the light of the so called "law of the unintended consequences", which marks these settings clearly, and also the specific domain of drug prescription in hospitals [37]. However, change is a primary concern of our proposal, and signification is equated to the transformation of configuration, so that the purposely "limited scope" of immanent design (i.e., the micro level of configuration change) can be rightly interpreted as the awareness that any ambition to anticipate and control the direction of vast portions of the

[44] Our approach is different from other semiotic approaches because immanent design focuses on the material artifacts with coherence from the phase of analysis to their digitization (see AdHoc), and because it conceives artifacts as concrete nodes of action, relation and mediation among other nodes of action within hybrid agencies of humans and *other* automata. To this regard, the reader should notice that hybridizing human agencies with the insertion of machines and automata as symmetric, yet different, elements is not a de-humanizing operation, nor an operation where machines are humanized. The conundrum is solved with reference to Peirce, for whom the human, as any other thing, is there where its effects are (cf. [126]).

[45] In other words, the process of signification unfolds in the passage from one configuration to the other. Following Madeleine Akrich's sociology of technical objects, we can then say that the signification of an artifact coincides with the transformation that it performs of the "net of relationships – any possible kind of relationships – within which we are set and that defines us" [2].

practice trajectories would be naively fanciful. Lastly application power. Strong validation and generalization of results are like the myth of the pillars of Hercules, which we believe no general design framework can really cross, since IT projects are not a direct emanation of frameworks but rather result from the clash between the designers' plans and the users' situated actions. Therefore, we interpret this power in terms of the capability of a framework to inform the development of real platforms and of the extent the platform can support the first class concepts of the framework natively and coherently. In the case of immanent design, this means to inform an End User Development environment like AdHoc and show how analytic categories and findings are easily translated into computational constructs and structures, as the scenario described in Section 6.1 has succinctly illustrated.

All in all then, as a pragmatic approach to design (rather than a theory of practice or a structured methodology) that is deeply grounded on so far neglected strands of semiotics and sociology in the design sciences [125], we believe that both the Semiotics of Configurations and Immanent Design should attract further study and interest in the domain of the development of interactive computational systems. We propose them together as a new voice within the debate of IT design to be argued, supported or even opposed in this community.

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