Images of knowledge.
Interfaces for knowledge access in an epistemic transition

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Abstract. The diffusion of digital and online media and tools have long transformed the dynamics of knowledge and education. Explicit and structured knowledge interacts with the implicit knowledge embodied in the community. The nature of this discourse is not about replacement or merging of models; on the contrary, the dynamics are those of the crisis and the hybridization: structures and rules change and interact in a dialectical encounter that generates new forms.

This transformation of the knowledge dynamics is showing its first consequences in the interfaces for knowledge. This paper proposes an analysis of the relationship that has historically linked the visual tools of access, consultation and representation of knowledge in the epistemological context of reference in terms of mutual influence. New approaches to the representation of knowledge, and specifically those of Knowledge Cartography are presented as possible approaches to the current epistemic paradigms.

Keywords: Epistemology, Representation, Interface Design, Maps, Cartography, Knowledge.

1 Introduction

Technologies and interfaces of knowledge have always lead, and possibly caused, cultural revolutions and epistemological paradigm shifts. As all *tools,* interfaces can be analyzed as a 'mean' enabling the user to attain a previously unattainable goal: not only they allow doing something better, more efficiently, but they also help act on the world, and construct new realities. Interfaces, in other words, are not passive and transparent mediators, but rather they can be described as active *communication devices* that mediate and influence the way we learn, we understand, we remember.

Working on this assumption, and despite the recent drift that relegates the responsibilities of interface and interaction design toward its technological aspects, this paper aims to investigate the relationship that has historically linked the visual tools of access, creation and representation of knowledge to its epistemological context of reference in terms of mutual influence, and to suggest new directions for the development of tools appropriate for the current context.

The aim is to highlight the role of *graphics and visual* tradition in the field of technologies and interfaces for knowledge, both in terms of the *instrumental* functions of these interfaces (i.e. how these technologies help to carry out actions on the knowledge: see, remember, see, etc.), and in terms of *epistemological or cognitive* functions (i.e. how these representations picture or propose a knowledge structure).

In this context, graphic and visual design emerges not as a merely decorative action blindly applied to the logical and organizational structure of the interface, but instead it emerges as the discipline that takes care of communication and interaction modes. To design knowledge interfaces, effectively is comparable to the design of a *tool*, and must take into account its logic, structure, ergonomics, as well as its materials, languages, registers and behaviors.

Knowledge interfaces requires a mature cultural project, aware of its influence in the cultural background in which it operates, that takes responsibility for its active role in human activities.

2 Memory Interfaces

If interfaces can be defined as an intermediary between the two systems, writing and notation systems can be considered the founding block of man-knowledge mediations. The advantages of writing and notational operations (even the simplest ones where a mark *stands for* a unit) are well documented: the mark, the symbol, the sign that takes the place of the thing itself facilitates a number of cognitive processes devoted to the collection, storage, recovery and processing of data. By outsourcing a cognitive function onto a physical medium, reading and writing operations replace the need to keep in mind the contents of the message with the less demanding task of remembering the code used to encode the information and *physically keeping* the support.

However, the consequence of this representation (and mediation) strategy is not a purely quantitative. In other words, the enabling function of the interface is not limited to the augmentation of the user's cognitive abilities and the simplification of information management operations. On the contrary, the emergence of an *artificial memory* effects not only on the ability to remember, but also leads to a profound changes in the organization of thought, and ultimately to a reconfiguration of the scenarios of knowledge. As previously expressed by Maldonado: "The ability to store, secure in writing and therefore to revisit our own thinking has facilitated a more structured way of thinking, less fleeting and precarious. [...] Homo Scribens is not simply Homo Oralis plus writing, it is a whole other thing." [1]

With the shift from orality to writing, thought is detached from the owner and made independent. If oral culture always manifests as *synchronous speech* that is heard at the same time it is produced and thus it can be interpreted in its context, on the other hand written thought, once alienated from its context of creation, become an abstract discourse in which the writer has no way of

knowing who his reader will be, nor in what context he's going to read it. Similarly, the reader doesn't know the author of the text nor its motives, unless such information is reported explicitly in the text.

The need to explicitly state such essential aspects of oral communication, affects not only the writing technique, but thought itself. Text, far from being a transcription of oral discourse or an imitation of natural speech, becomes a *designed speech* in which a series of techniques and mechanisms try to remedy the inherent shortcomings of the written word. Writing is detached from the space and time of its production and creates a form of perpetual, non-interactive, abstract communication.

It create a one-way asynchronous message, a passive monologue, which in turn influences the oral tradition by stressing the need to distinguish *speaking* and *listening* as two different moments of conversation, giving speech the linear character of writing. *Conversation* becomes rational exposure, similar to writing both in structure and in language. *Memory* once outsourced and amplified by writing techniques, isn't merely an instrumental extension of cognitive functions (as, for example, the telescope), but it leads to a *socialization* of knowledge in which the private knowledge becomes (potentially) publicly accessible, and storable. Culture, handed down orally from person to person, from memory to memory, is continually revised, amended, lost, extended, and finally frozen in texts, becoming physical object: preservable, catalogable, sellable. New forms of communication and a whole new typology of interfaces (e.g. the sales ledger, the catalog, the book) are born.

2.1 Books

The book, often confused with writing itself, brings with it significant innovations in format, interface, and knowledge. Books provide the needed knowledge support needed for complex and articulated discourse, organized into chapters, sections and paragraphs, delimited and commented by a new kind of writing, which isn't providing a copy of the spoken word, but conversely it provides support for the reader in interpreting the main content. Beside the main text, a para-text [2] composed not only of headings, subheadings, notes and comments, but also of blank spaces, subdivisions, and dingbats provide interface elements that support the reader in the reading, browsing and exploration of the text, a division of explicit content, structure, reasoning.

In other words, while before the twelfth century text and commentary were mixed in the same text, and the listener was asked to distinguish the two voices, from then on, "the author himself becomes aware of the visual layout as a part of a visual system that helps to guide the intelligence of the reader" [3]. Beside the linguistic content of the words, the visual content of colors, variations in size, position and distribution of words establishes an order to the text, making it no longer just a recording of speech, but the visual representation of a thought.

"Rather than a means to record a *narratio* [narrative] - Illich says - the book of philosophical and theological argument is now the externalization of a *cogitatio*, a

structure of thought. This *cogitatio* is not, fundamentally, the spoken memory of an event, but rather an elaborate scheme of reasons. The layout, in turn, gives the scheme to visual memory. The page is divided into sections, each of which corresponds to a separate, distinct point of view. Different signals draw attention to the sequence of *distinctiones* [distinctions]. The headings, which in ancient times had been used occasionally [...] return strongly in the thirteenth century." [3]

This textual and visual interface, gives life to diagrams that are *seen* but not *read* by the reader. Headings and graphics subdivisions are no longer simple tips for *reading,* but *visual signs* that transfer the structure of the author's *ordinatio*, not to the ear, but to the eye. Notes, *marginalia* and headings on the one hand, and summaries and tables of contents on the other, represent the development of a knowledge interface for browsing and reference, *"a complex device that allows a progressively more active use of information. [...] The book is less and less* linearly read and *more* activated" [4].

The author writes and structures the book visually so that "he who seeks doesn't need to browse through many volumes, but can quickly and effortlessly find what interests him" [Lombardo, cited in 3]. Readers learn how to activate and follow text notes and references, indexes, tables of contents, and eventually the reader teaches his own perceptual system 'not to follow *a footnote on the page, to ignore a marginalia, etc.."* [4].

2.2   Images of Knowledge

While, since the twelfth century, notes, *marginalia* colors and text size are already pert of an interface that merges with writing itself, it is not until several centuries later that the separate graphical interfaces come into use. Tables of contents, alphabetical indexes and bibliographies, which at first reproduce the structure of the textual sequence, later start to provide a second-level classification, independent of the linear layout of the sequence of arguments.

These images slowly become navigational interfaces of knowledge, which permit (or at least facilitate) research and consultation activities, based on different needs and logics. As graphic elements they are not read (declaimed), but instead they are seen and analyzed in their schematic nature, and most of all *used* and operated as interfaces. The interface structure appears clearly in the many structures that provide alternate orders of the contents, designed to address specific needs. The index, or *index locorum communium* starts off as a 'map' of the 'usual places' (or arguments) of the text, sort in such a way to facilitate direct access to the book through the (recently introduced) page number.

The *alphabetical index*, in this sense, marks a real revolution, so that Illich identifies the need to divide medieval culture in *pre-index culture* (in which the text marks the order of reading) and *post-index culture* (where an arbitrary sequence of letters is used to find or recall a topic that is already known).

The deep desire of the twelfth century, says Illich, is to create a new order: "The new layout, the subdivision in chapters, the highlighting of sections, the

numbering of chapters and verses, the new general book index, the introductions in which the author explains the structure of his reasoning, are all expressions of a desire to create new order. In each of them a cultural impulse, a mental project and a graphic device combine in order to create something unprecedented. But to observe the influence of technology on thinking there is no clearer example than the creation of alphabetical indexes." [3].

Summaries that go over the order of exposure, alphabetical indexes that allow access from known words, bibliographical indexes that reference related authors and chronological indexes used to display a sequences of events, are the new interfaces of knowledge: the ancestors of today's digital interfaces that offer alternative strategies for exploration of contents by complementing the linear order of the written text.

While the first outcome of this separation between the order of the text and the order of reading is therefore functional in nature, the second outcome is more epistemological in nature. While, on the one hand, indexes and classification schemes are *machines* for the organization and exploration of knowledge, on the other hand they communicate and disseminate an epistemic model, a new vision of the world.

In other words, these classifications not only divide the world in order to make it easy to understand, but also aim to reveal a *hidden structure* of the cosmos. Following the Aristotelic classificatory tradition, these subdivisions of nature are not only convenient but also an expression of nature itself: they essentially reflect the structure of the universe or the plan of creation. In addition to indexes and tables of contents, diagrams *illustrate* the structure of knowledge.

Stairways and trees. Once visualized, the structure of linear classifications shows all the characters related to the metaphor. In the stairway depicted in Llull's *"Liber de ascensu et decensu intellectus"* continuity, hierarchy, order and progression are transferred from the staircase to the elements represented. Bodies are placed hierarchically from the simplest to the most complete, from the imperfect (away from God) to perfect (God) with varying degrees of purity. The structure, once transformed into an image, becomes a *path* of improvement and growth that has to be climbed (not without difficulty) by the virtuous man. "The physical staircase becomes metaphysical [...] This extension assumes a precise epistemological function [...] that pervades even the bottom of the scale. The staircase order not only objects of nature but also areas of knowledge." [5].

Fig. 1 Stairway of intellect, from the *Liber de ascensu et decensu intellectus* by Ramon Llull

The same mix of natural, human and divine is found in Carolus Bovillus' *Liber de sapiente* [6]. Its structure places in the same scale beings of heterogeneous nature: human characters, vices, things, all in hierarchical order. Minerals and lazy man are on the lowest step of knowledge, characterized by the sole property of existence; the plant kingdom and gluttons *exist and live*, lustful men and animals *exist, live* and *feel,* and finally on the top step of the scale, the scholar represents the virtuous man, who lives according to the rational order, *exists, lives, feels* and *understands*. Here god is not explicitly in the representation, but it is nonetheless the reason of the order. The mnemonic reasons that underlie these hierarchies of knowledge provide nonetheless with

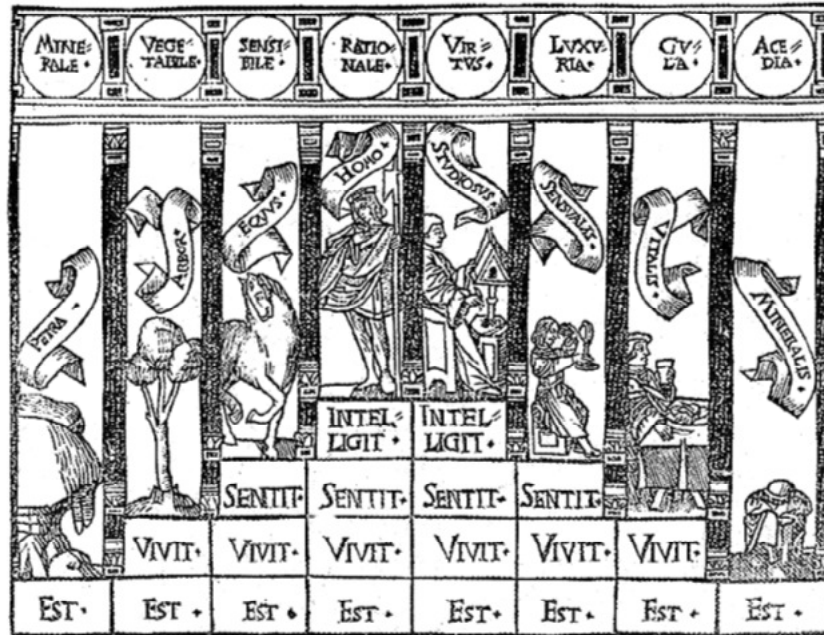an image designed to establish a representation of knowledge. An image of the world.

Fig. 2 Stairway of reason, from the *Liber de sapiente* by Carolus Bovillus

With the development of the scientific method, the Aristotelic structure turns into a system of categories that emerge through the work of observation. Divine stairways are replaced by trees, proposed as a description model of development of science based on human faculties. From the *intellect* (the trunk) stem the three branches of memory, imagination and reason, which in turn grow into further sub-disciplines. The organic shape of the tree becomes a classification structure that sorts elements of knowledge according to a variable that regulates the growth patterns. The improvement concepts underlying the structure of the staircase are replaced with the analytical concepts of classification: they divide reality focusing on similarities and differences in ways that divide, distinguish, and separate.

Knowledge is fragmented in the search for a perfect classification that will later lead to the taxonomic structures of nature developed in biology. The metaphor of the tree, earlier linked to concepts such as growth and nourishment, soon moves toward the language of abstract representation, loosing many of the implied characters: roots, fruits and leaves disappear leaving only the naked structure of branches: the tree becomes a schema where branches represent links between categories.
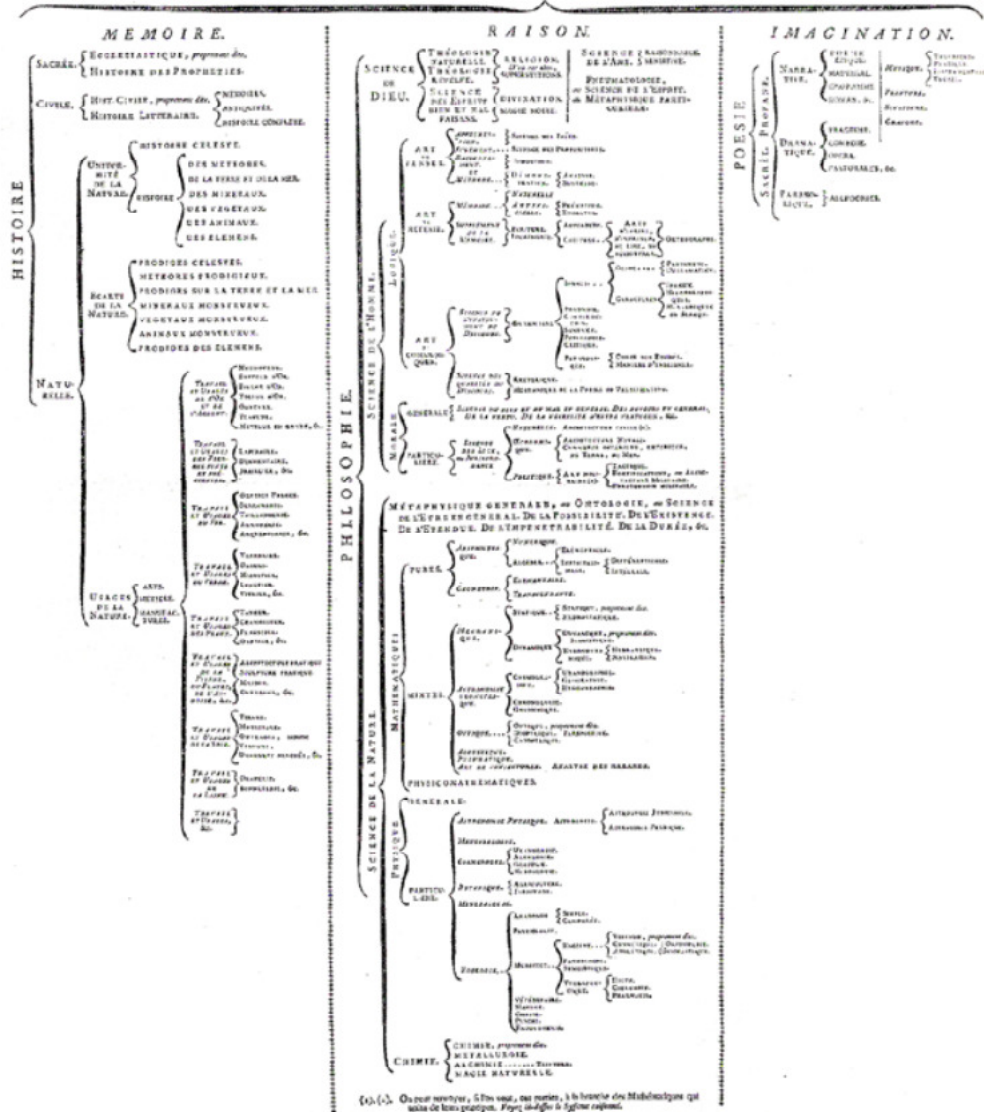
Fig. 3 Illustration of the *Detailed System of Human Knowledge*,
from the *Encyclopédie*.

Maps. In the eighteenth century, the moment of greatest expression of the tree structure is simultaneously the beginning of its decline. The *Système figure des humaines conaissances*, used as frontispiece for D'Alembert *Encyclopédie,* presents visually a thematic order, a possible structure of the contents that in the text of the *'Encyclopédie'* are arranged in alphabetical order. While the deliberately asemantic alphabetical structure describes the *'Encyclopédie'* as a reference text, the diagram in the frontispiece provides a map of its contents which allows an overview of the contents and displays the taxonomic structure which is completely detached from the contents themselves.

This overlap of different interfaces, navigation models and structures over the physical layout of the alphabetical order, are one of the major innovations of the eighteenth century encyclopedism. The articles, placed in random order (from a semantic point of view), are the amorphous material to which the various structures assign a shape: "Thus, three things make up the encyclopedic arrangement: the name of the science to which the article belongs, the position of that science in the tree, and the connection of the article with others in the same science or in a different science. This connection is indicated by the references to other articles or is easy to understand by means of the technical terms explained in their alphabetical place." [7].

The *Système figure* provides the content with a structure that does not claim to match the world, but instead offers a partial image, a section, of the *"infinitely intricate branches"*, in order to allow for a thematic navigation. "Thus, the general division remains of necessity somewhat arbitrary. The most natural arrangement would be the one in which the objects followed one another by imperceptible shadings which serve simultaneously to separate them and to unite them. [...] We are too aware of the arbitrariness which will always prevail in such a division to believe that our system is the only one or the best. It will be sufficient for us if our work is not entirely disapproved of by men of intelligence..." [7].

There is no longer a divine order or the natural Baconian order, but just a convenient order. The human cultural production can potentially be divided on an infinite variety of criteria, and priority is given to the more useful classification, the one "able to determine the highest number of connections and relationships that link science together". The goal is "to place the philosopher at a vantage point, so to speak, high above this vast labyrinth, whence he can perceive the principal sciences and the arts simultaneously. From there he can see at a glance the objects of their speculations and the operations which can be made on these objects; he can discern the general branches of human knowledge, the points that separate or unite them; and sometimes he can even glimpse the secrets that relate them to one another" [7].

The tree metaphor, which reaches with the *'Encyclopédie'* its peak, starts a new period of reflections on classification of the sciences that will continue throughout the nineteenth century. On the other hand, however, these models also start to show the first problems. D'Alembert no longer considers the tree as a faithful representation of the *structure* of nature; conversely, it uses it as a partial simplification of knowledge, and mixes the tree metaphor with a variety of other linguistic metaphors, describing knowledge as a "labyrinth", a messy "tortuous path".

Besides the hierarchical structure of disciplines, the internal cross-references between chapters provide a second order of knowledge, less useful for reference operations, but more faithful to the infinitely intricate structure of knowledge itself. A network of references design to explicitly declare the impossibility of reducing the *encyclopedia of arts and crafts* to any hierarchical structure: "The general system of the sciences and the arts is a sort of labyrinth, a tortuous road which the intellect enters without quite knowing what direction to take. [...] However philosophic this disorder may be on the part of the soul, an encyclopedic tree which attempted to portray it would be disfigured, indeed utterly destroyed." [7].

Path metaphors and the territory metaphors replace the tree structure which has lost the ability to provide a useful interpretation of reality and struggle to adapt to the epistemological framework of the encyclopedia, so much that D'Alembert feels compelled to suggest a better image: "[The Encyclopédie] is a kind of world map which shows the main countries, their position and their mutual dependence, the road that leads directly from one to the other. This road is often cut by a thousand obstacles, which are known in each country only to the inhabitants or to travelers, and which cannot be represented except in individual, highly detailed maps. These individual maps will be different articles of the Encyclopedia and the Tree or Systematic Chart will be its world map. But as in the case of the general maps of the globe we inhabit, objects will be near or far and will have different appearances according to the vantage point at which the eye is placed by the geographer constructing the map, likewise the form of the encyclopedic tree will depend on the vantage point one assumes in viewing the universe of letters. Thus one can create as many different systems of human knowledge as there are world maps having different projections, and each one of these systems might even have some particular advantage possessed by none of the others." [7].

Knowledge becomes impossible to draw as a whole in a truthful manner, but only through the choice of a point of view that is both arbitrary and inevitable. The map projection metaphor becomes an epistemological stance: in order to *display the structure of* knowledge, it's necessary to deform it, to "fix the infinitely intricate branches, in order to highlight one aspect or another". The maps proposed by D'Alembert, unfortunately, remain a linguistic metaphor: the encyclopedia doesn't go so far as to propose an *atlas* of possible trees and maps of the encyclopedia, but simply provide the reader with a single image built on top of Bacon's classification.

3   Territories of Knowledge

As a result of the epistemological change that started more than half a century ago, the methods of creation, organization and management of knowledge are changing, and over the last fifteen years this change has accelerated significantly.

These changes can be divided in two main typologies. On the one hand an epistemological change has transformed the way science is done by highlighting the social component in the construction of knowledge. On the other hand, the changes brought by the recent technological revolution have transformed

channels, tools and procedures for the management of knowledge leading to effects such as the democratization of publishing, transformations in the distribution of knowledge, the emergence of alternative economies for digital goods, the proliferation of easy access to information are revolutionizing the processes of knowledge creation, management and dissemination.

Just like the technologies of the printing press, and those of writing before that, network technologies are having not only a quantitative influence on the dynamics of knowledge diffusion, but are also having a strong qualitative influence on the dynamics of knowledge use, highlighting the social and relational dimensions of cultural processes that were gradually hidden by writing and printing technologies.

Knowledge is assuming the structure of a heterogeneous space, consisting of physical and digital resources, both textual and human, in constant evolution. New in the form of digital resources (websites, blogs, databases), and in traditional formats of knowledge (libraries, books, archives), authors and users interact, albeit indirectly, in the management and creation of new knowledge: they classify, link, comment, amend, and supplement information and knowledge.

Both in scientific research and in everyday life, information and knowledge are changing the shape and dynamics:

- Centralized information, collected in books and universities, is backed by diffuse information, found in forums, blogs, web sites, or implicitly available through individuals, research groups, companies.

- Universal classifications found in encyclopedias, aprioristically defined to sort and organize knowledge are giving way to imperfect categorizations that emerge from personal classifications of thousands of individuals.

- The rigid and permanent structures of disciplines and subject areas are progressively replaced by fluid and dynamic spaces in permanent movement and evolution, able to define cross-cutting paths, areas of interest and clusters.

- Knowledge is less and less considered in terms of possession, and increasingly in terms of access to information and skills. Knowing means having access to social networks and technology able to provide necessary information and insight at the time of need.

Beside the explicit and formalized knowledge that has been collected in its traditional forms (books, patents, libraries), a growing amount of information, know-how and competences are now present in different shapes. As of today, online platforms assemble incredible amounts of heterogeneous contents, different both in type and in degree of structure. They connect the final and static models inherited from print publications, the non-linear structures of hypertexts, the modular and chronological forms of the newspaper, but they also integrate the information models derived from oral culture, characterized by non-finalized, open-ended structures, closely linked to the social context of production. Explicit and structured knowledge interacts with the implicit knowledge embodied in the community. Documents and groups, books and

people, information and communication, are mixed in the definition of a heterogeneous knowledge space.

A new knowledge model emerges in which the structures of writing interact with embodied and social knowledge, in the definition of a dynamic scenario in permanent transition between organization and flexibility, open systems and closed structures, networks and hierarchies.

The nature of this discourse is not about replacing a model with another, or that the merging and leveling out of the two epistemologies; on the contrary, the dynamics of this dialogue are those of the crisis and the hybridization: structures and rules change and interact in a dialectical encounter that generates new forms, independent from both the first and the second model.

However, while the tools for a *social construction of knowledge* (such as collaboration and communication media and platforms) are somehow already part of the present toolset, on the other hand only in recent years are emerging the first signs of what may become the technologies for the construction of a *social knowledge* that allows the development of a collective (or connective[3]) intelligence a "merging of communities and libraries"[8].

Given that the change process defined in terms of "computer revolution" consists primarily of the acquisition by man of technologies that automate the processing and transmission of data, we can say that the scarcest resource is no longer information itself, or the technical ability to perform highly complex processes, but rather the ability to use this information in creative ways, to mix the new with the traditional in the creation of new scenarios for knowledge. The future revolves around what cannot (yet) be automated: hermeneutics, the construction of the relational bonds, to the establishment of intelligent communities able to respond to the demands of societies and economies.

Attention to the network as a communication channel is to be focused so much on content, as in the experiments of self-organization that connect not so much information, as people. "With the Internet not only you gain access to all books and all documents, but also to people that (organized in communities) are the bearers of knowledge"[8].

Collaboration forms of gradually are transformed into self-organization modes, represent a promising direction towards a new mode of organization. A hypertext that links not so much texts as the authors, the minds. In these early prototypes, the intelligent communities seem to follow self-regulating dynamics: the actions of the participants are subject to a mechanism of control by the community itself, yet without flattening the community itself, allowing for a continuous reconfiguration of its knowledge.

3.1 Knowledge Cartographies

In the field of knowledge interfaces this new model of cultural structure demands new model of interaction and representation of knowledge, able to keep into account the social and collective dimensions of knowledge. As envisioned long ago by D'Alembert, the challenge today is no longer the search

for a perfect classification, specific structure able to divide, separate, and sort culture in disciplinary compartments. Conversely, the urgency now is to 'keep together' these heterogeneous aspects of knowledge; to hold together in the same space, social places and cultural elements, people, research groups, tests, projects and concepts; to create tools that enable to explore, describe and design such spaces.

In this context, the proposal for a cartography of knowledge spaces is not merely a visual correspondence, but also as a narrative model for complex, heterogeneous and dynamic realities, such as those of human territory. The map is not just a passive reproduction of reality but a production of meaning and space. The analogy in this case it is not so much visual as structural and methodological in nature: the metaphor provides the methods, languages and tools developed by cartography over thousands of years for the representation of spaces that are complex, constantly evolving, simultaneously cultural and social, just as knowledge itself.

The map is a *communication device*: a mature representation method, conscious of its own language and its own rhetoric, coming with its own tools, languages, techniques and media [9]. A representation model that revives the narrative abilities of pre-scientific maps avoiding the 'naturalistic camouflage' of current representation by proposing a strong standpoint. "What distinguishes the map from the tracing - write Deleuze and Guattari - is that it is entirely oriented toward an experimentation in contact with the real. The map does not reproduce an unconscious closed contact with the real. The map does not reproduce an unconscious closed in upon itself; it constructs the unconscious. It fosters connections between fields, the removal of blockages on bodies without organs, the maximum opening of bodies without organs onto a plane of consistency. It is itself a part of the rhizome. The map is open and connectable in all of is dimensions; it is detachable, reversible, susceptible to constant modification. It can be torn, reversed, adapted to any kind of mounting, reworked by an individual, group, or social formation. It can be drawn on a wall, conceived of as a work of art, constructed as a political action or as a meditation." [10]

Of course this kind of metaphorical operation is not without risks and is exposed to the dangers of using analogy as an intellectual tool, and forcing reality in an artificial model.

As narratives, maps are the expression of communication goals: they operate selections on reality, distort events, classify and clarify the world in order to better tell a particular aspect of a territory. Maps, in other words, can be seen as a 'visual narrative' of space: cultural artifacts created by an author in order to describe a space in terms of a goal.

As instruments, maps are tools that allow to reach otherwise unattainable goals. They allow not only to do things better, more efficiently, but also to create new realities. Maps describe the territory, highlight positions, distances, spatial distributions, groups, boundaries. They serve as tools to act on the space: to orient navigations, to mark paths, to plan trips, to explore territories. Or they can be used as design tools: plans for the construction and modification of space.
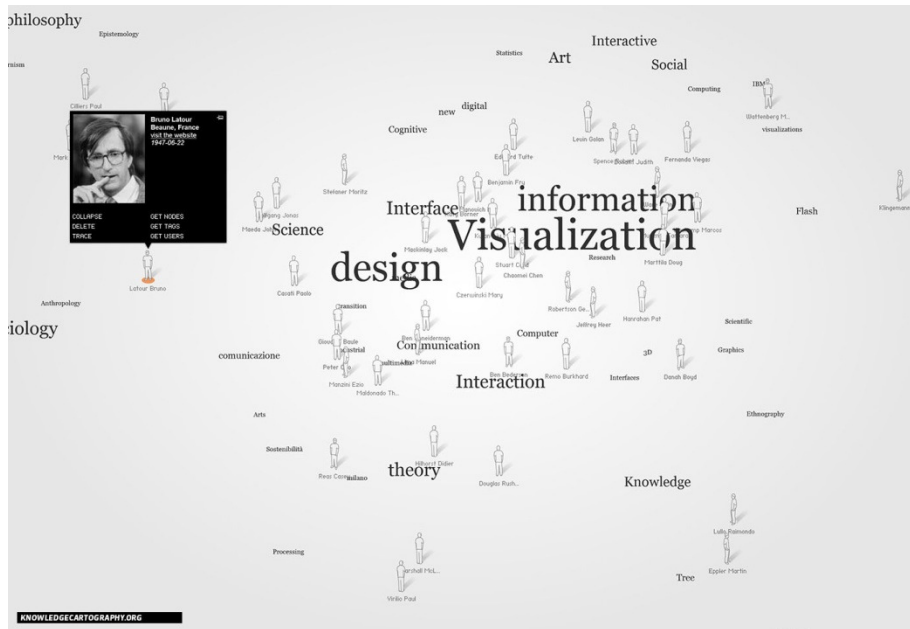
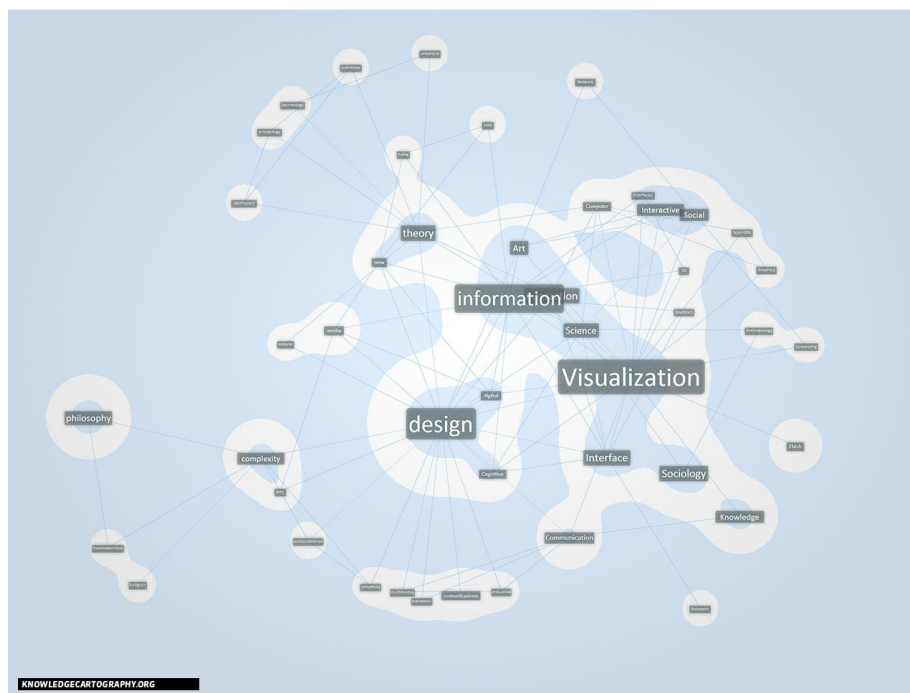**Fig. 4 Knowldge cartography. Thematic map of researchers**

Fig. 5 Knowledge cartography. Thematic map of the research field

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