Electronic Interactive Documents and Knowledge Enhancing. A Semiotic Approach.

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1. Introduction

Documents act as a medium to permanently record and communicate concepts, thoughts, procedures and data. Traditional documents of our interest consist of a physical support modified by some physical action performed by an author. Examples are written papers, engraved stones etc. Traditional documentation techniques result from a long evolution: professional communities developed and shaped customized documentation styles, notations and annotation procedures to better express and record their specific knowledge on a permanent physical media.

Electronic documents (*e-documents*) appear as a new media, which evolve, and complement the traditional documents in recording, annotating and making available to a community of practice knowledge but also opens new ways of constructing and enhancing it .

Both traditional and electronic documents can be seen as set of symbols, a message, exchanged among communicants using a language as tool for composing these symbols. However traditional documents and e-documents have different nature. We investigate the digital communication process and the interplay among communicants, symbols and world of phenomena assuming a semiotic approach: in particular, we present a computer semiotic approach [1][2][3] to describe the digital communication process and the new characteristics that the creation and the maintenance of e-documents and the interaction with them present.

The Web strengthens the knowledge sharing and enhancing, supporting a two-way and interactive exchange of ideas through electronic documents [4]. E-documents allow an evolution of the role of author/user and open the possibility of the new ways of accumulation, enhancement, access and distribution of knowledge. Electronic annotation is the tool supporting this evolution.

The paper is organized as following: section 2 introduces our semiotic view on the digital interaction process; in section 3 we discuss a redefinition of document in the digital world; section 4 completes the view on digital communication process and shows how the characteristics of e-documents can help to enhance knowledge. E-annotation is presented as a tool to exchange and accumulate knowledge in section 5. Section 6 concludes the paper.

2. A semiotic view of the digital interaction process.

With the advent of computers, documents become '*electronic*', in that exist as '*virtual entities*', the results of the interpretation of data and programs by a computer: users perceive, access, manage and annotate electronic documents (e-documents) because the computational process generates some physical representations perceivable by them. These physical representations only exist and are perceivable until the electronic machinery maintains them in existence. The physical representation of a document results from a mapping of the content of the document stored inside the machine into output events perceivable by users (e.g. the images on the screen). Because of this virtual existence, e-documents are less persistent than paper-based on and can only be created and accessed by communicating and interacting with the machine. The characterization of this human–

machine communication and interaction process is necessary to describe new ways of accumulation, enhancement, access and distribution of knowledge. Therefore in this section we introduce our view of the Human Computer interaction process. HCI process is seen as based on the exchange of messages – physical representations of the e-document - and contrast e-document features to those of oral and written ones. This approach is a still evolving result of studies which start with [5] and has been influenced by several other experiences developed independently in the same years [6], [7],[8] and [1][2].

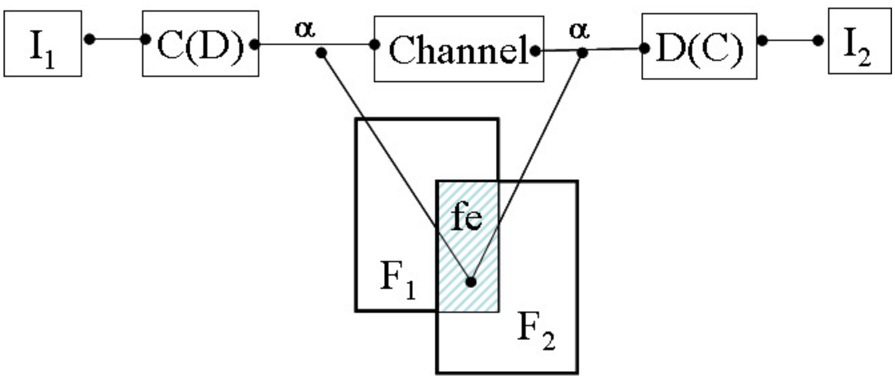
2.1 The digital interaction process

Evolving Tondl [3] approach, we consider that any process of communication presupposes:

1. an environment: a world of phenomena;
2. at least two communicant systems in the environment which:
   a. are able to perceive events generated by the phenomena in the environment (changes in the state of the environment);
   b. are able to assign a relation among the events and their view of the phenomena in the environments (F_i in fig.1);
   c. are able interpret the events and establishing an assignment system, that is set the relations among events and their view of the phenomena;
   d. generate events;
3. a system of means of communication constituted by:
   a. a finite set of events which can be transmitted along a channel
   b. a channel to transmit the events;
   c. tools to support the communicants in coding (decoding) their views of the environments into events to be transmitted along the channel.

According to the system we are analyzing, we investigate the communication process at different level: considering only system 3, we analyze the syntactic level; the semantic level concerns system 3 expanded to system 1; if we consider system 1 and 3 expanded to system 2, we are talking about the pragmatic level. In our analysis, we are interested in investigating the events involving all the three levels: according to Morris, this means to assume a semiotic approach to the analysis of the communication process. In particular, we analyze the generated and transmitted events and their roles in the communication process.

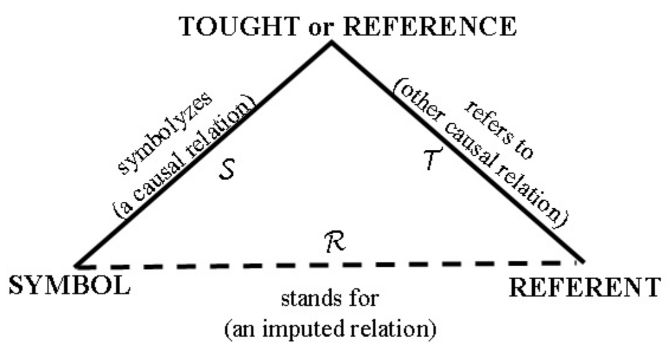
Figure 1. Communication process adapted from [3]: F_1 e F_2 are the worlds of phenomena as perceived by communicant system 1 and communicant system 2, i_1 e i_2 are the information that communicant system 1and communicant system 2 elaborate regarding the phenomenon f, α is the message exchanged between the two communicant systems. The communicant systems code and decode the message.



The events can be combined to form sentences: a sequence of events or sentences transmissible through the channel, is called *message*. Each event is characterised by a physical support and from a structure which can be perceived by both the communicant systems: each event is recognized as characteristic structure (cs). The communicant systems associate to each cs a meaning: the association of a cs with a meaning is called *characteristic pattern* (cp). It is important to note that each communicant performs a semantization process, the process to attribute a meaning to a cs: hence for each cs two different interpretations exists. When the communicants attribute to a same cs a same meaning, we say that the semantization process has been successful. When a communicant system generates an event, it produces an externalization process to symbolises the interpretation it has on the perceived phenomena: i.e., if the communicant system is human, the event can be a set of speech words, the interpretation a thought and the phenomena some perceived thing in the environment. Ogden and Richards represent the result of the semantization process in the triangle of reference (see fig.2): the symbol, the event generated by the communicant system, stands for the referent, the thing or phenomenon to which the symbol refers, through a mediated relationship with the referent (i.e. the thought) [9].

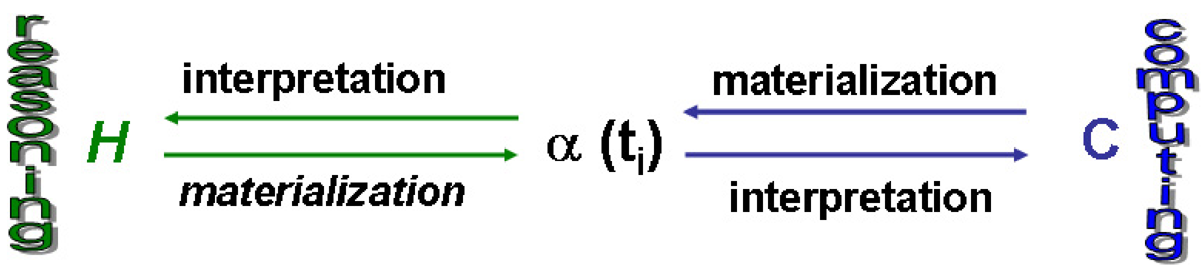
The analysis of Ogden and Richards focuses on the word in a linguistic universe, but they don't distinguish between oral and written word and, as Harris outlines, also decontextualize the symbol abstracting from its context of use. The symbols are the product of the communication process and must be considered in a social and physical context: some material aspects, as the production modalities and the physical duration of the symbol, contribute to the semantization process [10].

Figure 2. The triangle of reference by Ogden&Richards [9]



Following Harris, we study the symbol as characteristic structure in a context of use. In particular, we investigate the digital symbol in a communication process that involves humans and computers: our model of digital communication process, the Milano model, evolves the Human-Computer Interaction (HCI) model developed within the Pictorial Computer Laboratory (PCL) [11]. In the PCL model, the interaction is described as a syndetic process in which the human behaviour is influenced and influences the computer behaviour. Compared with the adapted Tondl model, the two communicant systems are the human H and the computer C (fig. 3): the process is syndetic in that these systems of different nature (the cognitive human – the computational machine) cooperate to achieve a task.

Figure 3. The PCL Model [11].



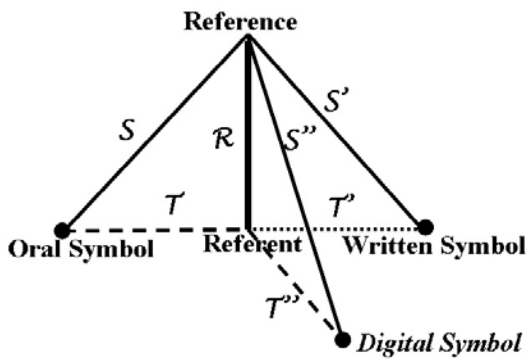
During the interaction, the human H perceives and recognizes the digital symbols composing the message α at time i, materialized through any output device (i.e., image on a screen or synthesized words), interprets it and acts on the input devices to express and materialize his own message. The computer C decodes the message from the human C and materializes an answer message. The human interpretation is characterised by a reasoning process, the computer interpretation is driven by a computational process. So the PCL HCI model presents a double cycle process *<recognize-act>*•*<capture–materialize>*: the interaction is a sequence of these double cycles in a finite time. Focusing on interaction, we consider an evolutional process of communication between human and machine.

The Milano model focuses on the characteristics of the messages exchanged during the interaction process. The css of these messages are digital: they exist only as the results of the interpretation of data and programs by a computer. As a consequence, the css are symbols whose nature differs from that of traditional oral or written symbol in terms of and for which the assignment relations change.

The persistency of the oral symbol is limited to the message emission (except for latency introduced in the channel), the communication process is synchronous and needs that both the communicants are present. Ear is the tool to perceive the symbol, human vocal system generates the symbol.

Written symbol introduces an important innovation: it is created on a permanent physical support. Writing allows authors to externalize knowledge in a permanent form as written documents. Communication doesn't need the contemporary presence of the communicants: the author of a written message doesn't need to be present when a reader sees or touches (i.e. in a Braille text) her/his message. Asynchronous communication requires new strategies to reach a common interpretation of a message. Moreover, the tools to generate the written symbol are not only human organs, but include physical tools to modify the support and to create the symbol (i.e. a pen on the paper). These tools need a learning process to use. Furthermore, an interpreter of written symbols have to know the spatial organization of the symbols sequences, as the direction (i.e. European languages are read from left to right, Arabic language from right to left) and other secondary notation (i.e., the structure in paragraphs, the formatting roles as title and body etc.). We perceive the written symbols as images in which we recognize atomic css (as the single letters), but that we organize and interpret in complex structures (words, sentences, paragraphs).

Figure 4. The relations of reference in the three different communication systems.



The digital symbol introduces new characteristics in the communication process and determines a communication system different from that characterized from the oral or written symbol. The fact that written symbol is created on a permanent physical support, permits to have a persistent memorization of the created symbols: it does not depend on the memory of the person who evokes these symbols. The support guarantees both the use and the memorization of the set of written symbols: materialization and memorization coincide. In the digital world, the process of memorization and the process of materialization of the symbols are distinguished. Recorded symbols are data stored as sequences of bits on a digital support: they are inaccessible to humans and only a computer program can make them perceptible by a human. The materialization, the translation of the internal (recorded) representation into a perceptible one depends on the computing process of a software which interprets stored data. Moreover, data can be stored in distributed supports, and a document, as composed by set of digital symbols, exists as long as a the software program interprets and materializes the data. As a consequence, the memorization is permanent, but the materialization is not durable in time and stable in modality because a set of data can be materialized according to different organization and modality of use (i.e., a document can be materialized as a written text or as synthesized sound).

The oral and written symbol are uniquely defined by their author: if a person says or write some words, no one can change the pronounced or written words. The digital symbol appearance is on the contrary mediated by some program and is open to co-authoring: a user can act on input devices to change the message s/he perceives when materialized by the computer. S/he can choose to save the modified document, modifying also the memorization support, or to save the modified document as a new document in a new support or in a database: in this way, the process of production permits to start from an original set of symbol and to create a new document modifying the organization of the original set of symbol. Also the computer acts as a mediator in the message materialization, selecting the modality to materialize the set of symbols according to the available devices. Accessing and using a document becomes an activity based on the interaction with a program, which is a proactive entity, behaving as a deputy of its designer [2]. The program itself is an e-document, created by the designer to allow the human user to interact with the e-document of its interest [12].

3. Rethinking document in the digital networked world

The advent of the web induced a further evolution of e-document into *web document*, "a unit consisting of dynamic, flexible, non linear content, represented as a set of linked information items, stored in one or more physical media or networked sites" [13].
Pédauque [14] explains this change as *"loss of stability of the documenta as a material object and its transformation in to a process constructed on request, which can undermine the trust placed in it"*. The loss of stability as material object is something different to the weakness or loss of persistency: both the expressions suggest the potentiality to materialize in different ways the e-document, but the loss of stability seems to point out a lack of definiteness in the document. On the contrary, the recorded information describing data and structure are stable and the process of document production leads not to an instable materialization, but to a variable one: program generating the document, can change the materialization modality, but every modality is stable. Moreover, a document can be seen as a process, as an example of boundary objects, *"shared objects to talk about and to think with"*[8], whose boundaries are defined gradually in a knowledge building path performed by the community of co-authors, but it is a step in this path, a temporary and structured milestone. E-documents in the Web appear to users as single entities even when their content is distributed in different, geographically remote repositories.

However the dependence on a machine offers some advantages. E-document are capable of dynamic activities, such as computing and deploying results in reaction to user activities. They can be managed, annotated and adapted by their users, thus evolving during their usage according to user needs. As pointed out, the process of creating the content of a document can be separated by the process of its physical representation: the representation may be multimodal and tailored to the single user. The materialization can be adapted to the culture, skills and abilities of the current user, without altering document or annotation content [15]. The *semantic web* extends the web bringing *"structure to the meaningful content of web pages so that software agents [...] can readily carry* *out sophisticated tasks for users"* [16]: the e-document must be associated with a set of metadata which allow automatic agents to perform such tasks. One important task, which must be performed by automatic agents is the translation of data and information which are in a form that can be easily processed by a digital machine into a form which can be easily processed by a human belonging to a specific cultural (sub)community.

E-documents appear to the members of these communities as virtual entities (ve in the following). Ves can be manipulated by the user, and operate and evolve in reaction to the user manipulation. In this way, ves act as virtual dynamic open systems. They are *virtual* in that they exists only as the results of the interpretation by a computer of a set of programs P; *dynamic* in that their behaviour evolve in time; *open* in that their evolution depend on its interaction with the environment. We are interested in *interactive* ve, i.e. ve for which a human user is part of the environment and interacts with the ve. A ve manifests its state to the users as a characteristic structure (cs) – i.e. a set of pixels on the screen. The interaction begins when the user acts on some input device to manifest his/her requirements or commands to the ve. The ve captures input events generated by user actions and reacts to them generating output events toward users. Output events are characteristic structures materialized on the output devices of a computer to become perceptible by the users. The cs generated as a reaction to input events depends on the current state of the ve. The user perceives the cs generated in reaction to his action and decides what to do next performing a new action.

At each instant, the state of the document ve is specified by a *characteristic pattern* $cp=<cs, d, <int, mat>>$, where cs is the *characteristic structure*, i.e. the set of pixels that is visible on the screen and that are managed by In and Out programs; d is a suitable description of the state of the program Ap, int (interpretation) is a function, mapping the cs onto d and mat (materialization) a function mapping d onto cs. During an interaction with the ve, the user operates on some input device to manifest his/her requirements or commands to the ve. The set I of input events of the ve is thus the set of user activities, defined as $I = \{a \mid a = <op, cs>$, where $op \in OP$, and $cs \in CS_{ve}\}$. OP is a set of names of operations denoting the elementary events generated by the user activities by operating on system input devices. CS_{ve} is the set of the characteristic structures of the ve, i.e. the set of its possible physical manifestations. The set O of output events includes the set CS_{ve} of css of the ve and the css of all the other virtual entities whose behavior is influenced by the ve.

We introduced characteristic patterns as interpretative models to associate a meaning to the characteristic structures: from the computer point of view, a characteristic pattern is the interpretation performed by the program P. Therefore the document is stable and defined at each instant (except that the program is not stable): what is not definable is the behaviour of the user on the document and the following computing process the program should perform. On the other hand, the characteristic structures, carrying the perceptible properties of the documents, support the interpretation of both the human, who perceiving symbols may recognize them and associate a meaning, and the computer, that associates to digital symbols a computational process to materialize them and to react to the human activities on the document. Pédauque seems to avoid this perceptive level: a e-document is not only *structure+data*, but also physical materialization and allowed interaction and pro-activity: in the semantic web software agents, processing metadata, can adapt data and physical organization to user profile and to propose functionalities to the user.

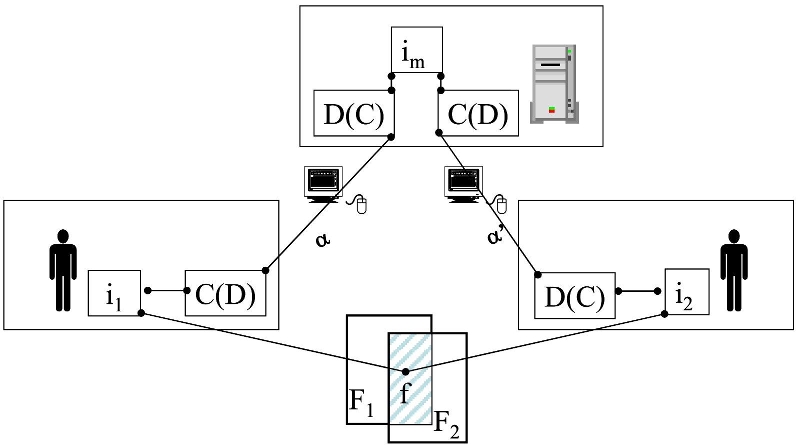
The e-document performs a remediation [17], supporting some traditional media characteristics (i.e, the structured organisation of the content) and introducing some deep novelties as the multimodality and the co-authoring. The core of the document supplies a description of the structure, of the component data, of the interactive functionalities and also of the devices to materialize it. If we consider a paper based document, it needs to specify formatting rules for printing it, content (alphanumeric strings) and support (paper or something similar to paper). In the digital world, formatting rules are composition rules for the materialization (i.e., graphical rules in the case of a visual materialization, tone rules in the case of vocal synthesis).

4. Enhancing knowledge through e-documents.

The characteristics of e-documents are amplified in the Web: customization to the users are automatically carried out through software agents that, processing metadata, build a document accessing to resources distributed in different database, and tailor the document materialization according to the user profile. This means that in the co-authoring process are involved at most three players: the original author, the user of the document who can act as co-author changing the initial configuration of the document and, finally, the computer (or the network of computers) that, through software agent, becomes proactive and, for example, can choose how to display the document according to user needs. The co-authoring aspect requires a further extension of the Milano model: the Milano model focuses on the human-computer interaction, but to describe the document evolution we need the whole communication process in which are involved, as in the co-authoring process, at most two human communicants and a computer (or a network of computers). Because of its pro-activity, computer can not be considered as a simple medium in the communication, but as one of the three communicant systems.

The human communicant 1 send a digital message α. to the computer. The computer records the content of α. The recorded content of α is sended by the machine to the human 2 and is materialized as α'. We consider that the syntactic structure is preserved in all these steps, but α and α' can be perceived according to the different computing process the machine performs considering the communicants profile. The cs of α, the sequence of perceivable digital symbol, can change according to the accessing modalities of the human communicant 2: as said, these modalities can consist in different perceptive deployment (i.e., visual or voice modalities) or in a reshaping of the organizational spaces of the document.

Figure 5. The Human-Computer-Human (HCH) communication process.



The author of the message can be guaranteed about the content of her/his message (except for problem in the transmission channel), but the materialization of the message is determined by the communicant 2 and the machine: the machine and the addressee of the message become co-author of the message.

This can be an advantage because the document is shaped in a more comprehensible way to the skills and the cultural context of the addressee. On the other hand, a different materialization can increase a communication gap between the human communicants because of the different culture, skills and tasks. The semantization process is needed to set the same meaning to a message: in this process the distinction between materialization and recording is relevant. Consider, for example, the case of communicating the content "alarm" through a coloured symbol: in a Western European context the colour associated to "alarm" is red; but in some Eastern Asian countries red means "joy". If we couldn't separate content from materialization, a misunderstanding would happen [18]: to solve it, we should need other information. Adopting Semantic Web technologies, a software agent can process the description of content “alarm” (the content of message α in the HCH communication process) and the information about the cultural context of the addressee: the message is localized according to the cultural shape (α’ materialization in fig.5) and the risk of misunderstanding is reduced. The pro-activity of the machine anticipates the semantization process: the machine (the software agents involved in computing process) joins the content description with information dealing with tacit and contextual knowledge (i.e., the meaning of colours) which permit to understand a message in a different context than the original.

In the Web, as we said, an e-document, the message transmitted along the channel, is composed by many distributed resources: each machine involved in the composition of the final materialization of the e-document operates a computation, an interpretation of the sent or required (i.e., a web page) document. Moreover, many human communicants can access documents and operate their tasks on them: the document can be subjected to continuous transformations operated both by the humans and by the machines, in a distributed co-authoring process. The boundaries defining the identity of a same document become fuzzy: a same document continuously evolves in time and changes its materialized shape according to user profile.

Figure 6. The home pages of Xinhua in Chinese, English, Arabic and Russian.

Let’s consider, as example, the home page of the site of the official Chinese press agency Xinhua [19]: as other sites, the home page exists in many languages (fig. 6). It is interesting to note how the same resources in the same structure are organized so that materialization appears tailored to different cultural contexts. If we analyze the structure of the document, it is the same because the menus (at the top, at the bottom and on the side of the web page) have the same arguments and the topic boxes in the page are the same. What is different is not only colours (i.e., different tonalities of blue for English and Russian, green for Arabic) and reading direction but also distribution of news and organization of the topics. This possibility to compose in a semiautomatic way the same resources according to the user profile, simplifies the production process and permits a tailored access supporting the human understanding.

In the proposed example, the knowledge access is supported through the ability of the machines that translate and tailor the document. However, e-documents, as documents built with Semantic Web technologies, are interactive and permit to users to be co-authors not only by modifying the materialization but also adding the content to the original document: the lability of the digital symbol can be exploited for enhancing knowledge. The communication becomes really bidirectional: the digital symbol (the e -document) has no more a unique author and can be the result of a co-authoring work and the process to build knowledge become a distributed process involving all the actors of the communication.

Following a constructionist point of view [20], the e-documents are at the same time virtual environments to situate the knowledge building process and boundary objects that serve as externalizations [8], capturing distinct domains of human knowledge. As environments, e-documents offer affordances to the users: affordances are environmental properties, the possibilities to act in the environment [21]. If affordances are perceivable by users, they simplify the use of available tools to act on the data and to perform knowledge exchange. As externalizations, e-documents permits to each users, stakeholders of a particular view on a problem, to share this view with the other users and to modify the view according to the exchange with the other users: the Web strengthens the knowledge sharing and enhancing, supporting a two-way and interactive exchange of ideas through e-documents.

A tool to support this exchange, is the annotation that, analogous the document, evolves from traditional to e -annotation.

5. E-annotation: a tool for two-way exchange and accumulation of knowledge

The annotation is a typical tool to add information in studying a document: the annotation can be a note for the single user or a note to be shared and discussed with other persons to exchange and accumulate knowledge. The annotation is referred to a part of a document: the document is called target document and the part of the document is the base of the annotation. The base of the annotation is often made evident by a *visual identifier*. The link between annotation and base is made explicit as a cs (*visual link*). The annotations can only be interpreted in relation to its target document. The result of an annotation performed by a human on a document, is a document that has some peculiar characteristics: it is a multimedia comment because it can be formed by combining texts, images and graphs; it can be *idiosyncratic*, that is not semantically explicit but represented by symbols, understood only by the members of a community who agreed on its meaning - in the extreme case the community formed by the only human who made the annotation for his own use. In the Web, annotation become an e-annotation, a multimedia-multimodal comment which is associated to a part of an e-document.

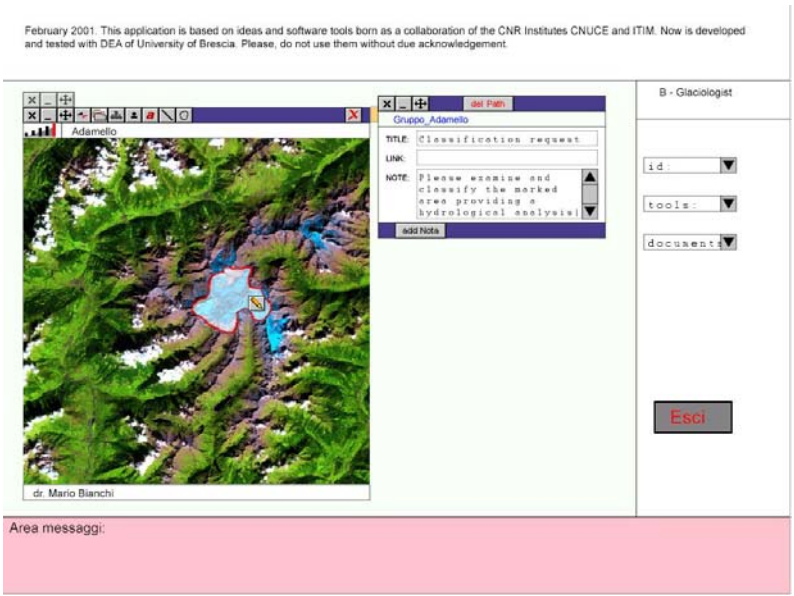
5.1 Exchanging e-annotations: a scenario

In the following we present a scenario to exemplify the process of enhancing knowledge trough prototypal interactive environments that support e-annotation on e-document. In this scenario, we introduce a typical cooperative professional activity based on the exchange of e-documents and e-annotations: the human communicants are a glaciologist and a photointerpreter.

The glaciologist and the photo-interpreter collaborate to the classification of a remote sensed imaged in the context of water resource planning. The two collaborators incrementally gain insight and reach the classification of a digital image by a two-way exchange of annotations. They are supported by two prototypal interactive environments, B-Glaciologist and B-Photointerpreter, which share a knowledge repository, in which data (images and annotations) and metadata are stored. This environment constitutes a two-way exchange system which supports the communication and accumulation of knowledge about glacier classification. The environments run under a web browser and they may reside in (possibly) different places and can be used at (possibly) different time.

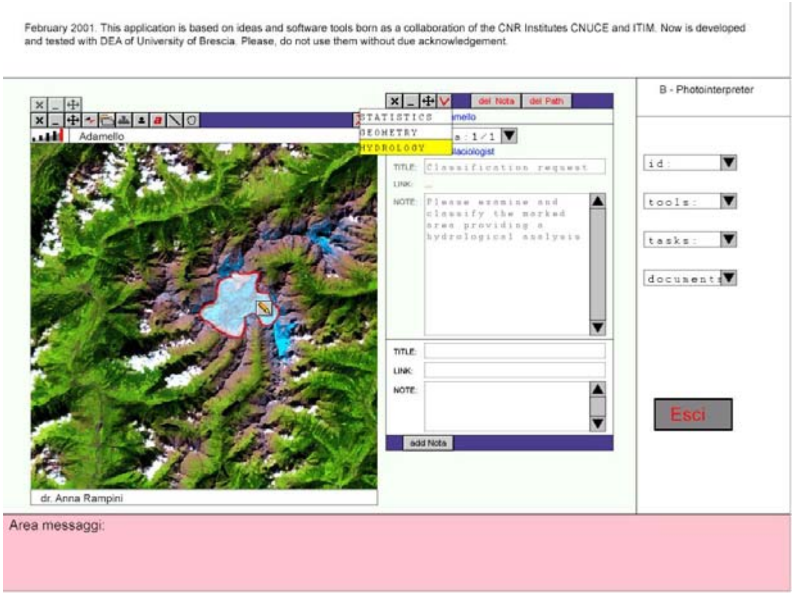
In Fig. 7 a screenshot of the B-Glaciologist environment is presented. The glaciologist accesses an e-document related to the Adamello glacier: e-document includes a body and tools to work on it. The body is constituted by data, the raster image in this case, and metadata, such as the name of the geographical entity ("Gruppo Adamello") and the name of the glaciologist ("dr. Mario Bianchi"). The glaciologist realizes from the study of the image that he needs support from the photo-interpreter to correctly evaluate the current glacier characteristics. Therefore he identify the patterns of his interest drawing a line around the area of interest in the image. Since the glaciologist needs to ask a photo-interpreter for a consultation about the identified area, he formulates the request as annotation on the document: he selects the tool for creating annotations (that one with the icon 'a' in the toolbar) and clicks on the identified area to associate an annotation with it. A visual link (the tool with the pencil icon) appears on the identified area and an annotation manager is displayed allowing the user to add annotations. Figure 7 shows the e-document, with the Adamello image, and the e-annotation performed on it by the glaciologist. The glaciologist titles the annotation "classification request" and types "please examine and classify the marked area providing hydrological analysis of the data" as the annotation body. Then the user can click on the "add Note" button to save the annotation. B-Glaciologist saves the annotation in the data repository shared with B-Photointerpreter, the application used by the photo-interpreter. Finally, the glaciologist may close the document and exit the application.

Figure 7, The B-Glaciologist: the glaciologist has identified an interesting area on the Adamello image and is creating a note for the photo-interpreter



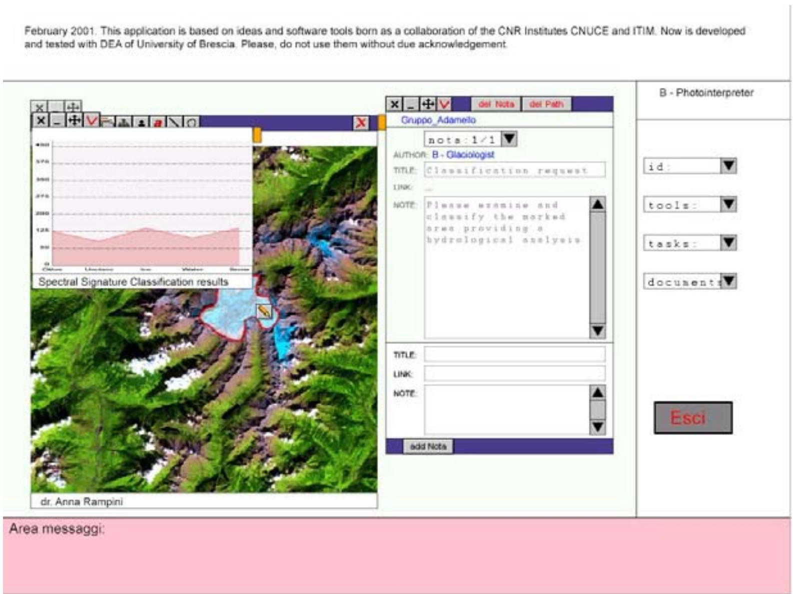
When the photo-interpreter successively accesses the Adamello glacier e-document through her application B-Photointerpreter, she recognizes that an area of interest on the image has been identified and that a visual link exists denoting the presence of an annotation. She may click on the visual link and B-Photointerpreter opens the annotation manager showing the request of the glaciologist (see Figure 8). Note that B-Photointerpreter is customized to a different scientific dialect. Actually, it provides a set of additional tools with respect to B-Glaciologist, which are useful for the photo-interpreter activities. For instance, B-Photointerpreter provides the menu “tasks”, and the annotation manager is also tailored to user culture and needs: the photo-interpreter may interact with a computation button which is not present in the annotation manager of B-Glaciologist. To satisfy the glaciologist’s request, the photo-interpreter can activate different computations from the menu “tasks” on the right bar of B-Photointerpreter or through the computation button on the reply-area of the annotation manager. In the present case, the photo-interpreter selects “Hydrology” from the menu activated through the computation button (fig. 8).

Figure 8: The photo-interpreter is selecting “Hydrology” from the menu associated with the computation button.



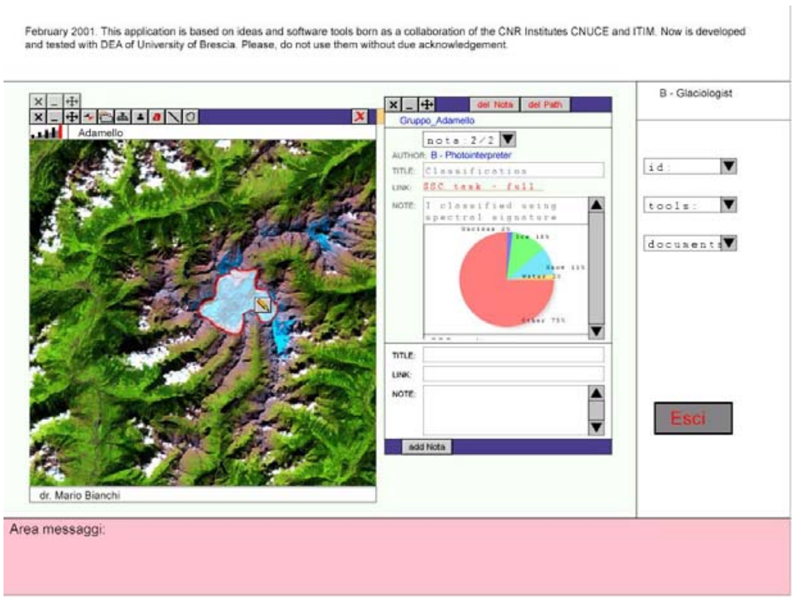
B-Photointerpreter reacts by determining the results of the computation (a spectral signature classification) and showing them according to the kind of visualization chosen by the photo-interpreter. In Figure 9, the graph plots the results in a new small window.

Figure 9. The photo-interpreter sees the graph plotting the results of the computation.



After this, the photo-interpreter selects the fourth icon in the toolbar at the top of this window, thus associating the computed results with her annotation, and she adds the annotation body "I classified using spectral signature". As a consequence, B-Photointerpreter fills the link field of the annotation manager, thus creating an association between the annotation and the classification data. Then the photo-interpreter may click on the "add Note" button, close the e-document and exit the application. The glaciologist successively interacts with B-Glaciologist to access the reply of the photo-interpreter. He thus selects again the visual link over the area of interest and may select the second annotation added by the photo-interpreter, where the glaciologist recognizes the presence of a link to the results of the classification performed by the photo-intepreter. When he clicks on the link, B-Glaciologist shows the spectral signature of the identified area within the area of the annotation manager that already presented the reply of the photo-interpreter (fig.10). Note that the spectral signature classification is now represented as a pie chart, a kind of visualization more suitable to the glaciologist's culture. On the basis of the data obtained by the photo-interpreter, the glaciologist may prosecute his analysis of the glacier.
This cycle is repeated until the two professionals reach an adequate interpretation of the image at hand.

Figure 10: B-Glaciologist annotation manager shows the results of the spectral signature classification performed by the photo-interpreter. These data are represented as a pie chart.



We can identify four kinds of e-annotations, two performed by human and two by the machine. Human can perform annotation as a comment to the target document (the body of e-annotation): it, corresponds to traditional annotation and is highlighted in the proposed scenario. Human can also associate to the e-document some keywords to indexing it. On the other hand, the computer can captures some information from the content, such as author or title of the annotation, which become metadata describing the e-annotation (as in the scenario). Finally, the computer can extract some meaningful words from the content written by the user.

As outlined in the scenario, the tools we have proposed allow users to annotate every document reachable through an address in the Web specified as User Resource Identifier (URI). Users should be allowed to annotate the documents according to the style and notation developed by their community and required by the current situation. The annotation tools should support users in evolving their style and notation according to the new insight on the new media they gain by their usage.

Moreover e-annotation, as resource in the Web with an URI, becomes a new e-document that can also be seen as an independent e-document enriching the knowledge base: it can be shared and access by members of different communities of practice and can also by annotated and modified.

6. Conclusions.

This paper starts from the analysis of a document as a system of signs and highlights the characteristics of the document in the digital world. In this view, the document becomes the externalization of the author view and mean of communication, a boundary object, one of the *"shared objects to talk about and to think with"*[8] which allows the members of a community of practice to build, share and enhance their knowledge. The document in an interaction and communication process involving humans and network of computers, becomes an e-document that is permanent as recorded document but loses stability in materialization: its lability can be exploited for tailoring the document to the user profile and enhance a shared understanding. Moreover, the e-document is open to co-authoring - by the machine through tailoring, by the human through content adding and e-annotation – that permit a collaborative work in accumulating knowledge.

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