Dynamic representation of knowledge context's structure

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The necessity, in the field of network's interaction is typical of e-learning's environment, to support shapes of representations of knowledge context's and to guide the next document positioning and their search, in according to criteria of ontologic structure of the knowledge, constitutes the most obvious field in witch have intersection between e-learning and the largest field of the knowledge management. The requirement is evidenced however to decide of interactive instruments not only adapts to the progressive aggregation of contributions and to their search, but able of supporting a constant process of structural review of the same context, through modality of dynamics graphical reconstruction of its shapes of representation. In this perspective the research of CARID is characterized for a long experience of application of principles and the protocols of production documents dynamics and structured and in research for develop instruments for automatic reconstruction of conceptual maps for navigation of knowledge.

Keywords ontology, knowledge management, e-learning

1. Introduction

The grid, or more precisely the map, understood as a structure comprised of nodes and arcs and conceived of as part of a theoretical system continuously enriched by contributions that are extremely interesting for their interdisciplinary connections (for example, random and scale-free networks), is certainly an optimal tool for providing a detailed expression of E-R (entity-relation) models, and therefore to sustain information organization (or more specifically, its storage and transmittal) in definable and describable contexts on the basis of that model, as are all contexts that may be represented through the structure of a relational database.

The structure created according to these terms answers two needs: on one hand it offers an exhaustive representation of the entity and relation model that characterize the context of knowledge and, on the other, is part of an expressive model, the conceptual map, pre-established and governed by just a few, simple syntactic rules and therefore easy to comprehend and share. It is a document that is produced using a precise mode of graphic writing and is a document with interesting potential for transmitting content that makes it possible to go beyond sequential fruition and, consequently, influences the behaviour of users themselves, giving them responsibility in the choice of the context explorative path.

The forms of representing the fabric of relations that evolve in parallel with the spread of hypertexts and the web and which often combine a purely expressive function with the function of navigational support that, although using different modes of expression, work together to develop the interpretive ability of users. Through these functions, an expressive model is developed gradually that is founded on the explication of the relational network, a model in which the hypertextual connection is not a hidden tunnel, for which the link is the entrance and the path is managed by technological automatisms, but rather a sign in the document.

And, thanks to its graphic simplicity that calls for the use of just two elements (nodes and arcs), the clarity of its reduced number of rules guiding its structure and design, and its ability to best express the relation using the arc sign and comment label, the conceptual map becomes, within the context of content transmittal, the most efficient paradigm for sustaining the evolution of the network structure, from a representational tool to a descriptive and interpretive model of knowledge contexts, as well as a

function object, cultural object, shared form of writing (and collaborative writing) and knowledge fruition.

Added to this gain is the research aimed at broadening and refining the use of conceptual maps in knowledge management and e-learning, in particular those intended to consolidate reconstruction methodologies through the use of software tools and algorithms that connect E-R diagrams stored in databases or structured documents and their graphic transformation into maps.

2. Dynamic reconstruction of concept maps

The role of conceptual maps in e-learning and, more generally, in knowledge management, is not limited to representing the macrostructure of cognitive contexts, i.e., a more advanced form of support of the same function previously played by the hierarchical index, while extending its role in other directions such as the representation of large-scale (thousands of nodes) and complex structures — those characterized by many non-hierarchical interconnections — the gradual broadening and enrichment of the structures through the collaborative activity of the interlocutors in the e-learning process, organized aggregation of knowledge, the unification (within the context of the map) of aspects of representing the context and explication of knowledge – in other words, use of the map as an instrument for both content structuring and writing.

Within this manifold of functions, an important improvement in the use of conceptual maps is derived from their transformation from static to dynamic documents, from documents produced through the direct intervention of their authors facilitated by generic or specific graphic editing tools, into documents reconstructed by retrieving information relevant to the concepts and relations to be represented from a database or structured document, then reconstructing the graphic layout through software procedures based on special algorithms.

In order to concretize the potential of dynamic reconstruction of conceptual maps, the research by CARID has created a number of models of conceptual maps which may be summarized as follows: concentric circle map, map with hierarchical circles and the three-dimensional map with rotating cone.

The first model is based on the gradual composition of the structure in concentric circles which makes it possible to distribute the nodes on the basis of their distance from an original node. The choice of the "root" node (to use a term typical of a tree structure) is a mandatory step for this strict graphic reconstruction. Once the root node has been determined, the procedure continues with the distribution of connected nodes around a circle whose center is the root node itself; the process is repeated distributing around a circle concentric to the previous one the nodes connected to the nodes along the first circle so that the connections extend out in rays. As a result, the procedure tends to expand in proportion to the number of concentric circles required to represent all the nodes: the detailed viewing of this map requires scrolling and paneling functions. This method, which may also be utilized for representing a tree structure, offers a range of options not possible with an index, such as the explication of all connections, including non-hierarchical ones, and the automatable (and therefore rigorous) reproduction of the procedure starting from any node. This makes it possible, therefore, to generate as many different maps as there are nodes, and this is a way to qualitatively improve the expression of the information about content structure.

A second procedure for map reconstruction that is rigorous and effective from the standpoint of communication is based on the repetition of the schematization of the context of each node: as in the concentric circle method, starting from a root node around which are positioned on a circle those nodes related to topics connected to the root, connecting the nodes to it through ray segments, each node along the circle is then taken as the central node of the system, constructing around it a second circle whose diameter is smaller than that of the first, placing along it the nodes connected to it and tracing the ray segments. Just as in the previous model, when non-hierarchical connection between two nodes must be highlighted, a segment may be drawn between them. Unlike with concentric circles, the diameter of the hierarchical circles diminishes as the distance from the root node increases and for this reason, this model, unlike the previous one, does not tend to broaden as the number of nodes and arcs increases, but rather the concentration of the nodes per surface unit tends to increase. Therefore, viewing this map is

based on the zoom function. This form of representation makes it possible to differentiate between the concept of topic represented by the node, and the concept of area represented by the grey circle that surrounds the node and on whose circumference the child nodes sit.

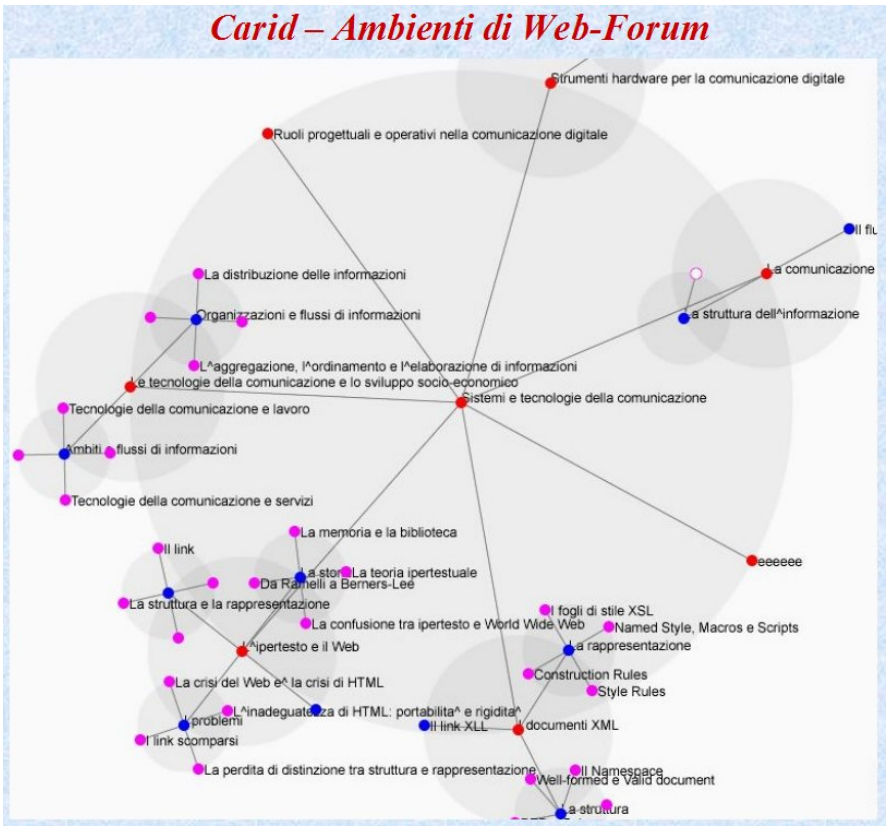

Fig. 1 *Hierarchical circles map*

The algorithmic reconstruction of the cone map is substantially a modality between map reconstruction using hierarchical circles and concentric circles. Following the development of the first circle around the central node and once the nodes connected with it have been placed, the image broadens through the calculation of the circles of expansion of the child nodes and the positioning of the nodes derived from the external semi-circles. The fundamental aspect of this reconstruction is the introduction of the third dimension: with each level further removed from the root node, the image depth is increased by a fixed amount, thus generating a conic form. In the case of maps composed of many nodes and many relations, this distribution entails such an increase in complexity that the image quickly becomes illegible because of the overlapping of nodes, arcs and labels, but the addition of three-dimensionality is motivated by a functional need that is necessarily connected to this graphic model that goes beyond and eliminates that problem of legibility. Viewing cone maps must be backed-up by suitable software tools, including the ability to control the viewing angle, i.e., to be able to rotate in all directions. From the standpoint of usability, this kind of tool noticeably widens the expressive potential of the conceptual map, also lending it an aspect of play connected with its 3D animation that catalyzes user attention not only on the interweaving of relations and topics that make up the map, but also the form of the map itself. This point deserves more in-depth analysis which here can only be referenced, given that the form of the complex conceptual map may be interpreted as further information about the cognitive context.

The structure of proximal development conceptual maps repeats constant patterns (concentric circles, hierarchical circles, the cone) that tend to emphasize the relation network from a standpoint that confers on a single node the role of origin or root. The fact that in the above models this node is interchangeable will all others renders the maps polymorphous but does not get around the need to have “a” point of origin. It is not easy to imagine distribution of the nodes in the conceptual map that is not manual, that goes beyond the limits of proximal development and positioning of the nodes on the basis of an initial “pivot”, but this difficulty may be brilliantly gotten around if using a value, pair of values or other quantitative or qualitative demands, a level of intensity or attraction is associated between the nodes and the relations that connect them. If, in fact, the relations between the elements of the map are “weighted”, i.e., if their length and therefore the distance between the connected elements, are configured as information that renders the intensity of the relation explicit, it is possible to conceive of the construction of algorithms that, starting from a random distribution of elements within the space of the map, or having them start from a single, pre-established position, gradually redefine the position on the basis of the force of attraction or repulsion generated by the relations themselves – a model which thus draws on the concept of gravity.

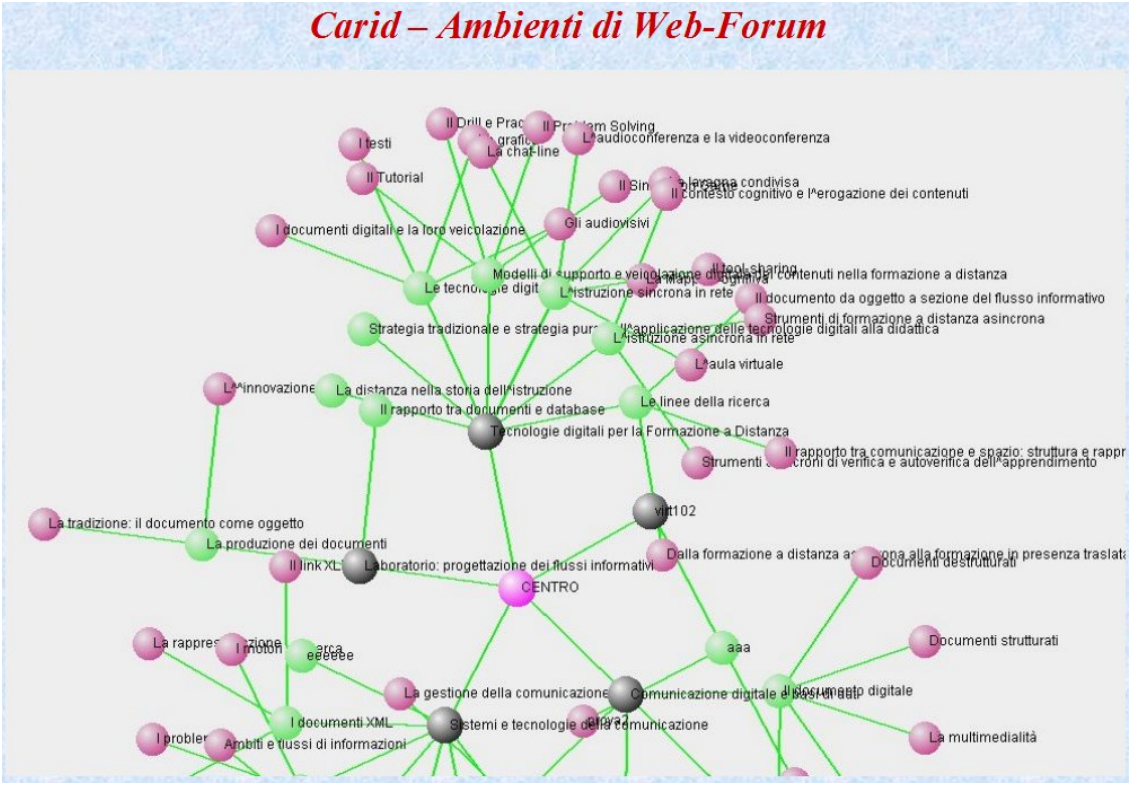

Fig. 2 *Cone 3D-map*

Starting from this point, and adding to the database for the dynamic reconstruction of conceptual maps, for each relation an approximate value of the level of attraction between two concepts, it is possible to develop a software model that performs an original distribution of the nodes within the document space on the basis of a random or pre-established arrangement, and subsequently causes them to move until an acceptable configuration is obtained. In order to arrive rapidly at this point of equilibrium and a satisfactory application of the algorithm, the document space must be three-

dimensional, as in those for cone maps. Therefore, applying the same interception function of a mouse-event, the gravitational development map must also be rotational.

This map marks the end-point of the division between maps and indices in that any reference to a potential hierarchy between nodes/concepts disappears and the characteristic of polymorphism is taken to the extreme on the basis of the initial random placement of the nodes. The other natural consequence is the impossibility of reconstructing the same identical configuration following the repetition of the algorithmic procedure on the same data base.

3. Conclusions

L'aspetto di maggiore interesse nella ricerca inerente alla ricostruzione dinamica delle mappe concettuali è rappresentato dalla possibilità di operare una scelta del modello di composizione, e conseguentemente dell'algoritmo utilizzato, in funzione della peculiarità dell'ambito cognitivo trattato e del contesto di fruizione dello strumento di comunicazione realizzato. la rappresentazione di un ambito ontologico non particolarmente complesso, e finalizzato a supportare l'esplorazione di un contesto cognitivo disciplinare in un ambiente didattico, quale ad esempio un corso erogato in modalità e-learning, troverà un migliore riscontro grafico attraverso una mappa a sviluppo prossimale per cerchi concentrici o gerarchici, di più semplice e immediato utilizzo anche da parte di utenze scarsamente inclini all'utilizzo di questi strumenti. Per contro, contesti cognitivi caratterizzati da un maggior grado di complessità e presenza di relazioni non gerarchiche, e dalla necessità di differenziare le relazioni per intensità, individueranno nelle mappe a sviluppo gravitazionale gli strumenti più idonei alla loro rappresentazione.

Ma al di là di queste osservazioni metodologiche e tecnologiche sull'uso delle mappe concettuali, occorre anche sottolineare l'importanza della loro ricostruzione dinamica per la rappresentazione di contesti che, pur caratterizzati da imponenti masse di dati e da frequenti aggiornamenti, necessitano di una rappresentazione grafica multidimensionale, osservabile a diversi livelli di dettaglio e rinnovabile costantemente in tempo reale: l'uso della mappa concettuale come immagine che veicola contenuti sta permeando sensibilmente la comunicazione, e quindi la cultura, dell'epoca attuale, e sta estendendo la sua fruizione in comparti estremamente diversificati.

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