Visual Reflection: Language, Action and Feedback

Luís M. Carriço†‡ — *lmc@di.fc.ul.pt*

Pedro M. Antunes† — *paa@digitais.ist.utl.pt*

Nuno M. Guimarães‡ — *nmg@di.fc.ul.pt*

† *Instituto Superior Técnico*
Av. Rovisco Pais, 1049-001 Lisboa, Portugal

‡ *Faculdade de Ciências da Univ. de Lisboa*
Campo Grande, C5, 1700 Lisboa, Portugal

Abstract

This paper addresses the direct manipulation of cognitive maps. It describes its components and manipulation and proposes an object model that defines the properties relevant to build elaborated feedback. It also presents a metaphor based feedback dialect that is able to communicate the complex constraints of cognitive maps.

1. Introduction

Cognitive maps are visual languages used to understand thought [10]. They aim at the exploratory classification and identification of the concepts and relations that reflect reasoning, thus including multiple levels of formalization. This flexibility, while profiting from the advantages of a visual representation, lead to its widespread application [12, 8]).

The most common representation of cognitive maps uses graph-based diagrams. The constraints on the visual elements convey the syntax and semantics of the underlying conceptual model. Contrary to formal languages, the uncertainty of the mapped knowledge requires particular constraint forms (e.g. a causal relation between symptoms probably should not be drawn, with a degree of evidence).

While direct manipulation is adequate for the creation of cognitive maps, the dynamics and uncertainty of the constraints introduces new challenges, particularly in the definition of elaborated semantic feedback. The work reported here addresses these challenges.

2. Language and action

The basic elements found in cognitive maps are **Concepts**, **Associations**, **Operators** and **Contexts**. Concepts are nodes that symbolize the variables involved in the reasoning process. Associations are arcs and symbolize relations between concepts. Operators are nodes that combine associations and contexts are regions that group concepts. When instantiated they represent a particular characteristic of a reasoning process. They correspond to the representation level of the visual language (see fig.1).

Concepts, associations and operators are **dependent** objects. The objects they depend on are called **dominants**. Dependents have properties determined by constraints defined in their dominants. Concepts depend on contexts. Associations depend on concepts (at least two) and contexts and operators depend on associations.

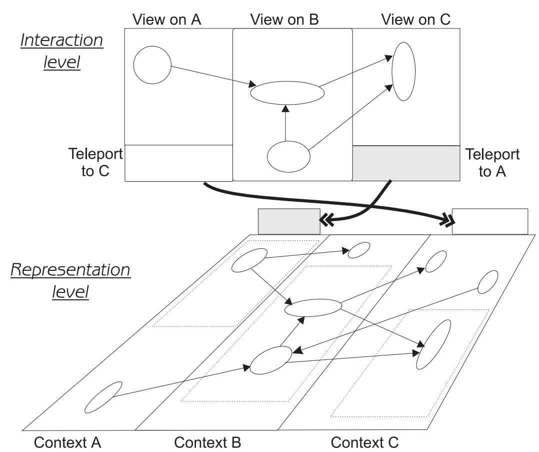

Figure 1. Language levels.

To specify a cognitive map, users engage on an exploratory process, where the language components are created, modified and deleted. This richer perspective of the language will be designated the interaction level (see fig.1). At this level, concepts, associations, operators and contexts exist as well. However, a representation element may have more that one view. Two particular views of contexts where introduced: **Teleports** and **Context Views**.

Teleports are regions that represent channels to other contexts. They do not contain concepts. Instead, they communicate with a target context. Concepts dragged therein will enter the target context. Two teleports are shown.

Proceedings of the Visual Languages '99 Symposium. Tokyo, Japan: IEEE CS Press, 1999, pp. 182-184. (ISBN: 0-7695-0216-4).

Context Views are regions that represent windows over target contexts (see [6] for details). The functionality they provide is similar to that of current toolkit views (e.g. scrolling) with two basic extensions. They change the shape of arcs, so that they flow continuously between views, and hide arcs that end or begin in non-visible nodes (see interaction level in fig.1). Context views are articulated in order to determine the shape and visibility of the arcs. An Integrated Multi View (IMV) object manages a set of context views.

3. Feedback

In order to define rich feedback dialects, an object model was defined and the actors involved in a drag and drop manipulation were identified. Their properties can then be managed to assemble feedback dialects, able to convey to the user the constraints imposed on the language elements.

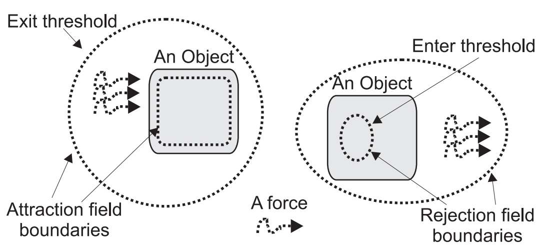

Figure 2. The parents' model.

Objects define an **attraction** and a **rejection** field. In each field they define a corresponding force (see fig.2). When a dependent object is manipulated out of the dominants' influence it feels the dominants attraction force. The **exit-threshold** defines the line where the attraction force ceases. When a non-dependent object is manipulated to become dependent of another it feels the latter's rejection force as soon as it enters its corresponding field. When the **enter-threshold** is reached the force ceases and the first object becomes dependent on the second.

Attraction and rejection forces and fields depend on the dominants, on the manipulated object and on the manipulation meaning (e.g. copy, move and merge). Field boundaries do not necessarily have a shape similar to the object, or a common center. Distorted fields may be defined to establish preferential entering or exiting directions. Thresholds can also be adjusted after the fields are entered.

The model is common to all the elements of the interaction level. Teleports and context views will represent the constraints of the target contexts in their own fields so that manipulation feels similarly. Nevertheless, field shapes and forces do not need to match those of the target. They will be adapted to the size and shape of the teleports or views.

The actors involved in a generic drag and drop manipulation are: the manipulated object, its original dominant (or dominants), the destination dominant and the device of manipulation (see fig.3). Once the manipulation starts, the

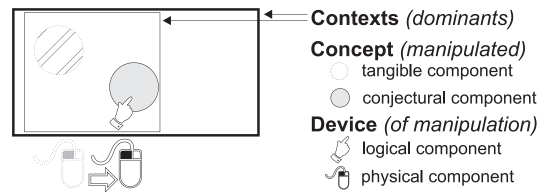

Figure 3. Actors and components.

manipulated object can be separated into **tangible** and **conjectural** components. The tangible component refers to an already existing object, while the conjectural one refers to a prospective occurrence that may be viable or not. The device comprehends a **physical** and a **logical** component. The physical is a mouse, a keyboard, a voice command set, etc. The logical one coincides with the cursors of pointing devices. For other physical devices a logical representation is created.

Feedback dialects, supported by the parent's model, are defined with these objects and components. Their shapes, visual attributes and relative positioning may be changed dynamically, at each manipulation step (even for physical devices e.g. force feedback joysticks). Current user interfaces only change the shape of the logical device and one of the manipulation components (that most of the times coincides with the logical device). Next, we present a metaphor that manages actors in order to provide richer feedback. An alternative is discussed in [7].

3.1. The membrane metaphor

In the membrane metaphor the outline of dominant objects is distorted as if it was a membrane. The distortion is applied until the logical device reaches a threshold. The size of the field and the length of the distorted boundary convey the strength of the constraint.

Fig.4 represents the definition of an association. The exit and enter thresholds are shown as dot-dash ellipses in the origin and destination concepts. The beginning of the fields coincides with the objects' outline. In (a), the concept outline is distorted until the exit threshold is reached. Thereafter, the conjectural component of the association is shown. Its dotted appearance reflects that it will not be created until a destination is found. The small plane indicates that the manipulation is flying over the diagram space in search for another concept. When the logical device enters the rejection field of a destination object (in (c)), the distortion of its outline starts. Once the enter-threshold is reached the distortion ends and the conjectural component changes its style (to a solid arrowhead arc).

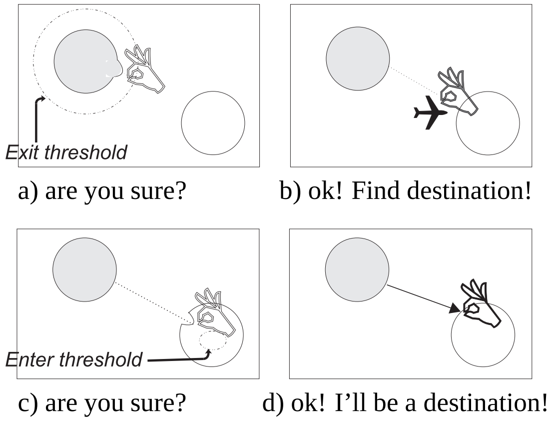

Figure 4. Reluctance to association.

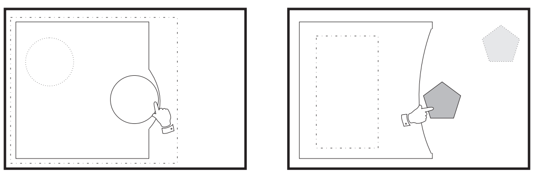

Figure 5. Resistance to re-classification.

Fig.5 depicts a situation showing different influence forces: smaller for attraction (on the left) than for rejection. The length of the distorted area (smaller for attraction) conveys the difference. Finally, fig.6 shows the classification of

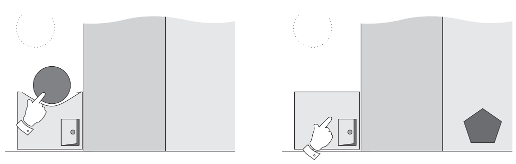

Figure 6. Moving to non adjacent contexts.

a concept on a non-adjacent using a teleport. Its boundary deflects proportionally to the target constraint.

4. Related work

Hardy [2] and KMap [9] provide rather complete solutions for the manipulation and visualization of diagrams while offering access to a rule-based engine. Standard layouts, emphasizing attributes, multiple views and constraints to determine the behavior of nodes and links are available. Visually weaker, DecisionExplorer [3] further approaches the application domain of our work. It is designed for the study of cognitive maps of decision-making processes. Nevertheless, none of the above provides support for effective visual feedback. Feedback dialects are static, very simple and compensated with natural language phrases.

Penz and Carriço [11] and Benford and Fahlén [4] proposed the inclusion of sensitive areas around objects. The models allow objects to ”feel” each other and react accordingly. Rejection fields of the parents' model offer an approach similar to active areas (on the first model) and nimbus (on the second). However, the definition of a dual attraction field and the introduction of forces allow easier construction feedback dialects, not aimed by the other works.

5. Conclusion and future work

The work described here emerges from the requirements identified in the development and usage of cognitive mapping tools [5]. This paper presents the representation, interaction and feedback components required to specify and explore cognitive maps. It proposes an object model dealing with the constraints that result from the uncertainty of knowledge expressed in those maps. Based on the approach a feedback dialect conveying resistance is proposed.

Our current work focuses on the empirical evaluation of the approach, particularly within an ongoing project, named Cognitive Mapping of the Negotiation Processes. Future plans include integration with a group decision support system [1]. The highly interactive nature of these systems will provide a valuable contribution to the evaluation.

References

[1] P. Antunes and N. Guimarães. Structuring elements for group interaction. In *Second CE'95 Conference*, Aug. 1995.
[2] Artificial Intelligence Applications Institute. Hardy, 1997.
[3] Banxia Software. Decision Explorer, 1997.
[4] S. Benford. A spatial model of interaction in large virtual environments. In *ECSCW'93 Conference*, Sept. 1993.
[5] L. Carriço and N. Guimarães. Facilitating analysis and diagnosis in organisations. In *CAiSE'97*, June 1997.
[6] L. Carriço and N. Guimarães. Integrated multiviews. *Journal of Visual Languages and Computing*, 9(3), June 1998.
[7] L. Carriço and N. Guimarães. Manipulating concept maps with constrained regions. In *AVI'98 Conference*, May 1998.
[8] C. Eden and J.-C. Spender, editors. *Managerial and Organizational Cognition*. SAGE Publications, 1998.
[9] B. Gaines and M. Shaw. Concept maps as hypermedia components. *Int. Journal of Human-Computer Studies*, 1995.
[10] A. Huff, editor. *Mapping Strategic Thought*. John Wiley & Sons, Ltd., 1990.
[11] F. Penz and L. Carriço. Objects feeling objects in a multiview object space. In *Vienna Conference on HCI*, 1993.
[12] S. Shum and N. Hammond. Argumentation-based design rationale, 1993. Tech. Report EPC-1993-106, Rank Xerox.

This work was partially developed within the project Cognitive Mapping of the Negotiation Processes, PRAXIS/PCSH/P/PSI/77/96, funded by the PRAXIS XXI program.