Sketching in Knowledge Creation and Management

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INTRODUCTION

A sketch is a schematic representation of an image containing a set of objects or concepts. When people need to express and communicate a new idea, they often sketch a rough picture to represent it. Drawing a sketch helps to develop and explore new ideas and enables useful reflection on an idea, elaborating possible alternatives and promoting its evolution. The development of different interaction and communication tools has produced new attention to more natural interaction and communication modalities, including sketching. Hand-drawn sketching is easy and intuitive to use to communicate with others, and human-computer interaction is also simplified.

Because the knowledge to be represented and managed in human-computer interaction is typically multidimensional, for example, spatial and temporal data, images, video, and so forth, it can be managed by a representation having the same dimensions. A sketch can be very useful for representing concepts and complex information because it is typically multidimensional and people naturally use sketching as a medium for concisely representing the reality of interest.

Sketches are characterized by vagueness, incompleteness, and ambiguity. It is therefore essential to solve ambiguities caused by hand-drawn sketching. These may be produced by various factors, such as the variability of hand-drawn input and different interpretations for the same input. In addition, the drawing tools used may introduce noise.

This article considers sketch interpretation based on drawing behaviour in different contexts. One behaviour type is characterized by the objectives and features common to all the users, while another is related to the specific context in which the sketch was designed, taking into account complex information on the application domain, the interaction tool, and the user's skill in drawing sketches.

BACKGROUND

Some cognitive scientists highlight the relevance of sketching for the external representation of ideas and problems. In particular, some works (Verstijnen, 1997) have studied the importance of sketching for expressing new ideas in the creative process. Drawing a sketch does not require a high level of precision. However, simple corrections or drawing the sketch from a different point of view can entail its complete redesign. Familiar objects are most frequently drawn using a part-by-part strategy: this in accordance with the user preference to complete one object before drawing a second one. This analysis confirms the results of studies carried out by Kavakli, Scrivener, and Ball (1998). In fact, sketches are drawn using a part-by-part approach 73% to 90% of the time. They observed the connection between the functional aspect of each part of an object and its drawing. In particular, drawing multifunctional parts of objects implies a non-part-by-part drawing. Another work (Scrivener, Tseng, & Ball, 2002) considers a particular context: (a) when the user draws an object from memory, and (b) when the user draws an object by copying it. In the first case, the drawing strategy is part by part if the object's geometry is identified. If its geometry is confused, and consequently the function of each part is also confused, then the object is drawn using a non-part-by-part strategy.

Some applications manage only a few types of graphical objects, such as sketch-based geographical query languages (Blaser & Egenhofer, 2000), a sketch-based user interface editor like SILK (Landay & Myers, 2001), or sketch-based diagrammatic systems and query languages. Several systems have been designed to recognize formal sketches in a specific diagrammatic notation. These were specifically designed for UML, finite-state machines, flowcharts, networks, program class structures, and others (Blostein, Lank, & Zanibbi, 2000; Kanungo, Haralick, & Dori, 1995; Lank, Thorley, Chen, & Blostein, 2001; Zanibbi, Blostein, & Cordy, 2002). In this type of applica-

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Figure 1. Some examples of sketches in different application domains

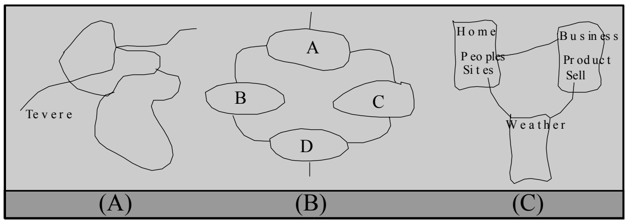
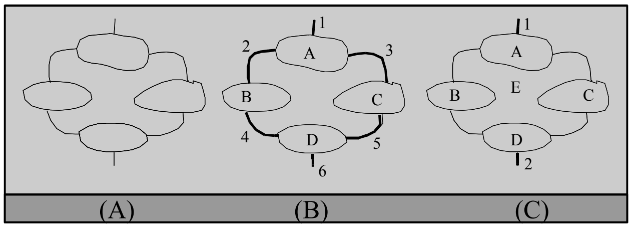


Figure 2. A sketch and some possible interpretations



tion, it is usually necessary to manage several types of graphical objects describing the diagrams and their spatial relationships. Other applications need to manage very complex objects. This is the case of languages for image retrieval and tools for computer-aided design (CAD; Lin, Thomsen, & Landay, 2002).

The developed applications are usually not sufficiently general. They normally involve specific sketches (i.e., one kind of diagram only) and do not consider the possibility of deletion or modification. Some other applications enable these operations, but they must be performed by the user through a graphical command or symbol.

Sometimes, one kind of information lacking in an image can be associated to the sketching process: the sequence of drawing actions defining the sketch. This is because a sketch contains both static and dynamic information. The first refers to the image produced by the sketching process, while the second refers to the drawing actions. Techniques and methodologies defined for image interpretation can also be used effectively to interpret sketches (Mussio, Bruno, & Esposito, 1994). The drawing actions provide further suggestions to correctly interpret the sketch and solve its ambiguities. Ferri and Grifoni (2003), Kavakli et al. (1998), Scrivener, Ball, and Tseng (2000), and Scrivener et al. (2002) have carried out studies on this subject.

It is also possible to consider another aspect of sketching: the drawing behaviour of different users. One behaviour type is characterized by objectives and features common to all users, while another is related to the specific context in which the sketch was designed. The context takes account of complex information on the application domain, the interaction tool, the user's skill in drawing sketches, and so on. The first kind of behaviour (context independent) produces a sketch interpretation independent of the user. The second (context dependent) produces a sketch interpretation according to the user characteristics. This is why some sketching behaviours are connected with user categories.

MAIN FOCUS OF THE ARTICLE

The ambiguity of sketches can determine a mismatching with a single corresponding interpretation. Sketches can therefore have multiple interpretations. This occurs because, on one hand, a unique space is used to express different kinds of information, and on the other, signs on the sketch may not completely represent the semantics of the information relating to them. The information provided by the sketch may thus be insufficient to identify a unique interpretation. Ambiguities may also be caused by noise from tools and sensors, or by cotermination failure (where pen strokes do not meet at their end points; Mahoney & Fromherz, 2002). The context is often very useful to correctly interpret and disambiguate the sketch.

The context may consider a set of operative variables that influence users' drawing strategies and behaviour (application domain, information devices, interaction tools, user goals, etc.). The system's ability to identify the context could be useful for the sketch's correct interpretation. Such information can be used to interpret the user's drawing strategy and behaviour.

In the following section, sketch ambiguity is presented and discussed using one of the operative variables influencing the user's drawing strategy and behaviour: the application domain.

The Sketch and Different Application Domains

Depending on the application domain, sketches can have different characteristics and needs in representing concepts, objects, and relationships. Figure 1 shows three sketches concerning the related domains: geographical (Figure 1A), diagram representation (Figure 1B), and hypertext representation (Figure 1C).

The sketch in Figure 2A representing a diagram has various interpretations, two of which are shown in Figures 2B and 2C. Figure 2B considers the sketch as formed by 10 graphical components: four closed shapes (A, B, C,

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