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From language to pictorial representations

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Abstract

Representing spatio-temporal events using pictures or schematic representations is a difficult challenge, since static representations are meant to convey dynamic processes. A case in point is the representation of battles, for which historians have devised schematic maps using various conventions. More recently, in the field of geography, the language of choremes has been introduced for the representation of geographical change. This paper describes work in progress on the automatic pictorial representation of events extracted from natural language texts. The general purpose of the research consists in generating schematic visual pictures of spatio-temporal processes described in natural language texts. The application currently under development generates schematic representations, based on choremes, of the events described in a short excerpt from Caesar’s “Gallic War” as a testbed.

1. Introduction

Narrative texts tell stories. When reading a story, we make “mental pictures” of the events it describes, including pictures of the spatial environments it involves. Our main questions in this context are the following: Are pictorial representations of these “mental pictures” feasible? Can we generate them from the text in an automatic way? A case in point is the representation of battles, for which historians have devised schematic maps using various conventions which can lead to the production of very elaborate and beautiful representations such as Minard’s maps (Tufte, 2001).

In this paper, we describe a first approach to the problem of the automatic generation of schematic representations. It is based on choremes, and applied to the description of the events described in a short excerpt from Caesar’s “Gallic War” (*De Bello Gallico*). A preliminary description of this work appeared in (Ligozat *et al.*, 2006).

1.1. Caesar’s text

Consider the following excerpt from Caesar’s “De Bello Gallico”:

In eadem causa fuerunt Usipetes et Tenchteri, quos supra diximus; qui complures annos Sueborum vim sustinuerunt, ad extremum tamen agris expulsi et multis locis Germaniae triennium vagati ad Rhenum pervenerunt, quas regiones Menapii incolebant. Hi ad utramque ripam fluminis agros, aedificia vicisque habebant; sed tantae multitudinis adventu perterriti ex iis aedificiis quae trans flumen habuerant demigraverant, et cis Rhenum dispositis praesidiis Germanos transire prohibebant.

An English translation of the text reads as follows:

In the same condition were the Usipetes and the Tenchteri (whom we have mentioned above), who for

many years resisted the power of the Suevi, but being at last driven from their possessions, and having wandered through many parts of Germany, came to the Rhine, to districts which the Menapii inhabited, and where they had lands, houses, and villages on either side of the river. The latter people, alarmed by the arrival of so great a multitude, removed from houses which they had on either side of the river, and having placed guards on this side of the Rhine, proceeded to hinder the Germans from crossing.

2. Understanding and representing

How do we understand Caesar’s narration when we read this text?

It seems intuitively plausible that understanding involves the ability to create and manipulate spatio-temporal representations while reading and interpreting Caesar’s text. If we use such “mental images” in our understanding process, could we, in a similar way, devise a system that would proceed from the natural language text as input and output some graphical or schematic representation?

Representing battles in terms of schematic maps augmented with annotations and symbols (simple geometric figures for armies, arrows for motions, names of generals, and so on) is a standard way of making the spatio-temporal layout of battles graspable to human readers. We think that this type of representation, which can be considered as a particular kind of choreme in the sense of (Brunet, 1980), can be extended to the kinds of events mentioned by Caesar, which involve various groups of people moving around, crossing rivers, advancing and retreating across Gaul, Germany, and Britain.

3. Choosing a graphical representation

The representation we need has to satisfy specific constraints:

- It has to be sufficiently schematic (undetermined, under-specified) to accommodate the vagueness of natural language descriptions. A description in natural language leaves many details unspecified, whereas pictures tend to impose decisions on sizes, locations, orientations, numbers.
- It has to represent both static, structural aspects of a situation, but also dynamic aspects. For instance, crossing a river, regrouping or scattering are dynamic processes.

If we want to go beyond the intuitive idea of representing the “mental picture” a reader builds when reading a text, we have to ask the question of what cognitive structures underly the various modalities of representations used by human beings.

This question has been the topic of previous research, as exposed in (Przytula-Machrouh *et al.*, 2004), in the special case of *route descriptions* in natural language, *i. e.* texts describing how to get from *A* to *B*. We showed how a common abstract structure underlying route description as natural language texts and route directions using schematic representation (sketches) can be posited to underly both types of representations. This abstract structure can be expressed in terms of *elementary scenes*, and we proposed a classification of basic elementary scenes into eight types. Each type corresponds to a specific arrangement of the basic components of scenes, which are *landmarks* and *actions*.

Dealing with Caesar’s descriptions of the events in Gaul, however, raises new difficulties when compared to describing routes. Whereas a route can mainly be conceived as resulting from the action of a virtual traveller, who can be represented as a point on a map, many of the entities (troops, populations) which are involved in the wars can no longer be assimilated to points. Many of them will correspond to two-dimensional objects. Their trajectories in space, consequently, will not be representable by lines. Moreover, the existence of aggregate objects, which can split or merge, also has to be taken into account.

4. The language of choremes

Originating from Brunet’s work in geography (Brunet, 1980), *choremes* are iconic components which can be used to represent specific spatial configurations, as well as prototypical processes in geography. Fig. 1 shows the basic elements of the language as proposed by Brunet. More recently, Klippel (0) has used “wayfinding choremes” for route descriptions. In order to represent the events in Caesar’s account, we defined a first set of basic choremes as shown in Fig. 6. This set will have to be further extended. In its present state, it is a starting point for building a more comprehensive system.

4.1. A choreme-like representation

Returning to our original example, we can think of a schematic representation as shown in Fig. 2 for the text: because of the arrival of the Usipetes and Tenchteri, the Menapii, who dwell on either side of the Rhine, flee and cross the Rhine.

| | Point | Ligne | Aire | Réseau |
|------------------------|----------------------------------|----------------------------|---------------------------------------|-------------------------------|
| Maillage | | | | |
| | chef-lieu | limite administrative | État, région... | centres, limites et polygones |
| Quadrillage | | | | |
| | tête de réseau carrefour | voies de communication | aire de desserte Irrigation, drainage | graphe |
| Gravitation | | | | |
| | points attirés satellites | lignes d'isotropie orbites | auréoles bandes | liaisons préférentielles |
| Contact | | | | |
| | point de passage, d'entrée, etc. | rupture, interface | aires en contact | base tête de pont |
| Tropisme | | | | |
| | centre d'attraction | ligne de partage | surfaces de tendance | dissymétrie |
| Dynamique territoriale | | | | |
| | évolutions ponctuelles | axes de propagation | aires d'extension ou de régression | fixeur du changement |
| Hierarchie | | | | |
| | semis urbain | habitat dispersé | limites administratives | sous-ensemble réseau maillé |

Figure 1: The table of choremes

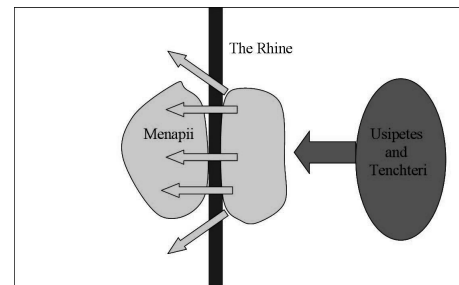


Figure 2: A symbolic representation

5. Putting it all together

The main steps of a process of representation are as follows: First, starting from the text (actually an English translation of the original Latin), the system generates a text annotated with XML tags based on a simple ontology covering the main entities appearing in the text. Then it uses a structured description of the elements to be included in the map and of the choremes to relate the annotated text to (a sequence of) schematic maps enriched by choremes. The intermediate level is expressed using the UML formalism as a basis for an object-oriented implementation.

5.1. Outline of the process

The system currently under development proceeds in two phases:

- From the text to an abstract specification.
- From the abstract specification to a visual representation. The objective in this part is to build a graphical representation of the spatio-temporal processes described in a abstracted manner, and to show the representation on the screen to the user via an interactive application. The abstract specification language used is called ASTL (Abstracted Spatio-Temporal Language). Basically, it describes landmarks and spatio-temporal processes organized into units called (elementary) scenes (the formalism is based on Przytula *et al.*, (0)).

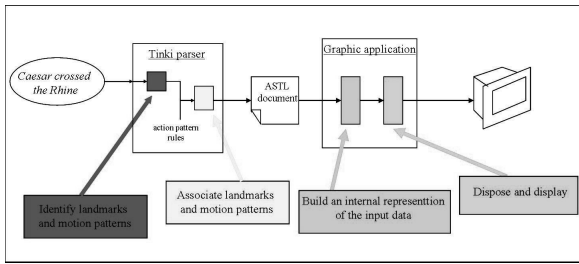


Figure 3: The overall architecture

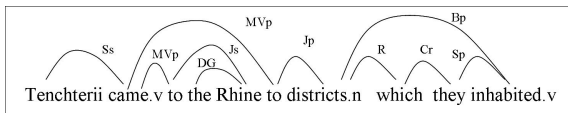


Figure 4: The tree-tagger analysis of a sentence

5.2. The overall architecture

The overall architecture of the system is represented in Fig. 3: the Tinksi parser provides a document written in the ASTL language, using action pattern rules to associate landmarks and motion patterns. The resulting representation as an ASTL document – an XML file – is then fed to the Graphic application component, which first builds an internal representation of the input data, then computes locations for the corresponding graphic objects and displays them.

We now describe the main steps of the process in more detail.

5.3. From the text to its ASTL representation

A special-purpose parser called Tinksi is used to build the abstract representation. It has three main tasks:

- Finding and categorizing the references to spatial entities (*landmarks*) and spatio-temporal processes (*action patterns*) in the text.
- Assigning types to the landmarks.
- Assigning specific action patterns to the spatial entities.

The parser uses the Link grammar and Tree Tagger as external tools. It is written in the Python language.

Fig. 4 represents the structure associated to the sentence:

The Tenchterii came to the Rhine to districts which they inhabited.

5.4. Problems of interpretation

In the first phase of the processing, the text is filtered for spatio-temporal information: only those elements which have a relevance for the description of spatio-temporal events are retained for further analysis.

The properly linguistic analysis of the text then begins. It has to deal with various issues. Among the problems encountered in this part of the process of interpreting the text are the questions of complex sentences and of co-reference.

In the current version of the system, complex sentences are restricted to sentences with one main clause and relative clauses. More complex ones are eliminated using a preprocessing phase.

The problem of co-reference corresponds to the problem of relating pronouns to their antecedents, such as deciding that “they” in “they had lands, houses and villages” refer to “the Menapii”. Again, since co-reference is not a central goal of the project, we use as input a text where co-references have been solved. For example, the pre-processed text has “the Menapii had lands, houses and villages”.

5.5. The abstract representation language (ASTL)

The language describes spatiotemporal objects in terms of landmarks and scenes. Its general structure is as below (left); an example of a specific scene is shown on the right.

```

<spatiotemporal>
  <landmark>
    . . .
  </landmark>
  <scene>
    . . .
  </scene>
</spatiotemporal>

<scene>
  <flavoredtext>
    Tenchteri crossed Rhine
  </flavoredtext>
  <cross>
    <actor>
      <name> Tenchteri </name>
    </actor>
    <position id='I' />
  </cross>
</scene>

```

The general structure

A scene

The action patterns associated to **come** and **cross** are as follows:

```

<come>
  <actor>
    <name> Caesar
  </name>
  </actor>
</come>

<cross>
  <actor>
    <name> Caesar </name>
  </actor>
  <position-id = ref('Rhine') />
  <localization relativeto=ref('Rhine')
    type='leftside' />
  </position>
</cross>

```

6. Building a graphical representation

We start from a map of the region where the action takes place. This map can be described in terms of map objects. On the other hand, the analysis of the text, as described by the XML annotations, results in the task of representing a process which can be described in terms of (generalized) elementary scenes.

The pictorial avatars of elementary scenes (elementary scenes are abstract conceptual entities) can in turn be expressed in terms of pictorial objects (including symbols like arrows). The goal of this part of the representation process is to describe how the map has to be enriched by pictorial/graphical objects (choremes) in order to obtain the final enriched schematic map.

Using the data structures produced by the parsing operation, the graphical representation of each spatio-temporal process is drawn on the screen. Each process is contained in a well-defined scene of the ASTL specification. The application offers a still view of the process by considering only those processes that belong to the current scene. The dynamic aspects of the representation are taken into account by the use of a set of choremes.

6.1. Building the pictorial objects

Fig. 5 shows the UML class diagram of the objects.

The internal representation is built as follows:

- the input is a file containing the data in ASTL;
- a SAX XML parser parses the input;
- each opening tag results in a class (or field of a class)

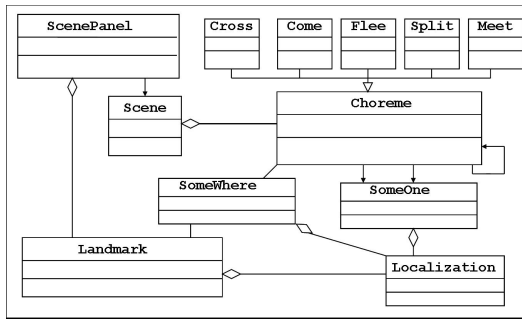


Figure 5: The visualization component

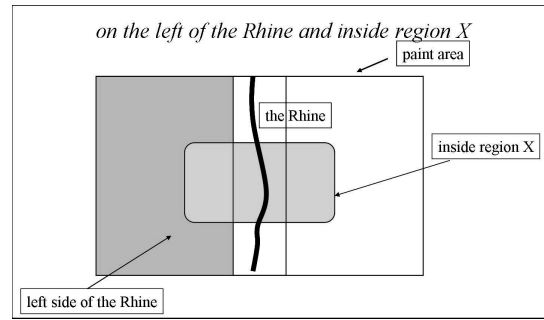


Figure 8: A composed localization

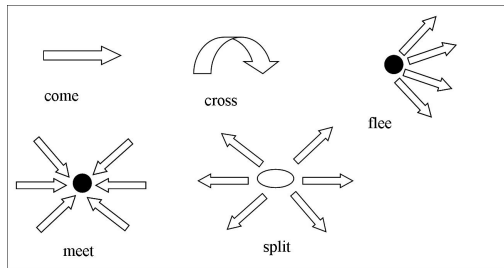


Figure 6: Choremes

being instantiated and initialized;

- each closing tag results in affecting the object to its parent object;
- a **scene** vector is built at the end of the parsing operation.

6.2. Drawing the objects

Some of the basic choremes used at this stage are represented in Fig. 6. They allow to express simple motions of integral objects (**come**, **cross**) as well as processes of aggregation (**meet**) or disjunction (**flee**, **split**).

The task of the drawing system uses the **ScenePanel** class, which offers a canvas as a receptacle for spatio-temporal objects, as well as methods for transforming a **Localization** object into a graphical object with space coordinates.

The localization system computes localizations for the landmarks and choremes. Its operation is illustrated in Fig. 7 and on Fig. 8 on two examples: a simple localization as in “on the left of the Rhine”, and a composed one, as in “on the left of the Rhine and inside region X”.

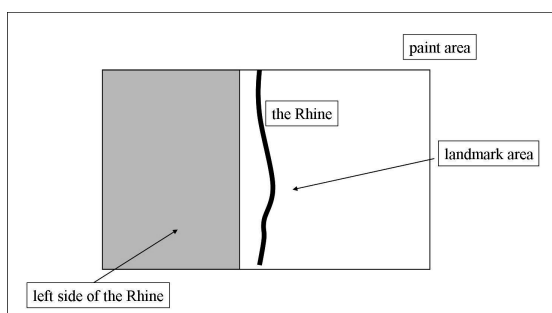


Figure 7: A simple localization

7. Conclusions and perspectives

In its present state, the system can accommodate the representation of parts of the text with a simple syntactic structure. Extending the coverage is a first goal of the current work.

The graphical representation module uses a limited set of choremes which allows the representation of situations with a limited number of action patterns. Extending the system will involve more sophisticated methods for computing the placement and determining the sizes of the graphical objects.

Finally, it can be expected that static representations will not be sufficient for representing complex sequences of events (although the role of symbolic artifacts should not be underestimated: think for instance of the maps representing the initial phases of Napoleon’s attack of Russia in 1812). The static representations may then have to be considered as snapshots in sequences of representations. This could also result in animated schematic maps.

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