StorylineViz: a [Space, Time, Actors, Motion] Segmentation Method for Visual Text Exploration.

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Abstract: Supporting knowledge discovery through visual means is a hot research topic in the field of visual analytics in general, and a key issue in the analysis of textual data sets. In that context, the StorylineViz study aims at developing a generic approach to narrative analysis, supporting the identification of significant patterns inside textual data, and ultimately knowledge discovery and sensemaking. It builds on a text segmentation procedure through which sequences of situations are extracted. A situation is defined by a quadruplet of components: actors, space, time and motion. The approach aims at facilitating visual reasoning on the structure, rhythm, patterns and variations of heterogeneous texts in order to enable comparative analysis, and to summarise how the space/time/actors/motion components are organised inside a given narrative. It encompasses issues that are rooted in Information Sciences - visual analytics, knowledge representation – and issues that more closely relate to Digital Humanities – comparative methods and analytical reasoning on textual content, support in teaching and learning, cultural mediation.

1 INTRODUCTION

A broad picture of the evolution of information sciences over the past decade shows that big data, meaning here big volumes of data, dynamically changing data, as well as high variety, highly heterogeneous data, has paved its way to the top of the research agenda. In parallel, availability of large collections of non-structured textual content, typically found in digital libraries, has fostered the emergence of research works clearly intermingling knowledge discovery issues with visualization issues. Said briefly, there is a move towards bridging the gap between on one hand linguistics-based approaches – *i.e.* for instance spotting markers of cause-effect relations in text corpora, as in (Marshman et al. 2008) – and on the other hand information visualisation approaches – *i.e.* for instance tileBars for document visualisation (Spence, 2001), or basic wordclouds. Hence supporting text analysis through visual means has become a hot research topic in the field of visual analytics (VA), a field described in its early days by Thomas and Cook as "*focusing on analytical reasoning facilitated by interactive visual interfaces*" (Thomas and Cook 2005).

In that context, the StorylineViz study builds on the premise that a narrative can be segmented into successive or parallel ***situations*** differentiated from one another other basing on changes in ***time, space, actors,*** or ***motion***. Situations act as a semantic filter, helping to analyse and compare heterogeneous texts and collections of texts basing on common metrics. (Figure 1)

Ethnology
… Having left his farm for a barn he owned in Saugué, | *he was swept up in an avalanche*, | **eight days later he was still not back home.** | *the family climbed up to the barn.* | **Cows had spent eight days without eating** …
Culture du risque en montagne – Le pays Toy , M. BARRUÉ-PASTOR, dir.

History
… **on the Wednesday he [Sevetus] walked into Geneva,** | *found a room at La Rose* |**, and went to an afternoon service.** | *In church, he was recognized by someone* | **and denounced to the city authorities** …
Europe : A History, N. DAVIES

Literature
Some of us were travelling together. A young man, who did not look very intelligent, spoke to the man next to him for a few moments, | *then he went and sat down.* | **Two hours later I met him again** …
Exercices de style, Litotes, R. QUENEAU, transl. B. WRIGHT

Figure 1: Identification of *situations* in heterogeneous texts.

Appropriate visualisations (in the sense of VA end products) depicting sequences, rhythms, alternations of situations can then help experts and end users perform reasoning tasks on the narrative structure of texts, ranging from stylistic profiling (differences and similarities inside and across writing genres, or inside an author's works) to comparative analysis (different recounts of the same story for instance). (Figure 2)

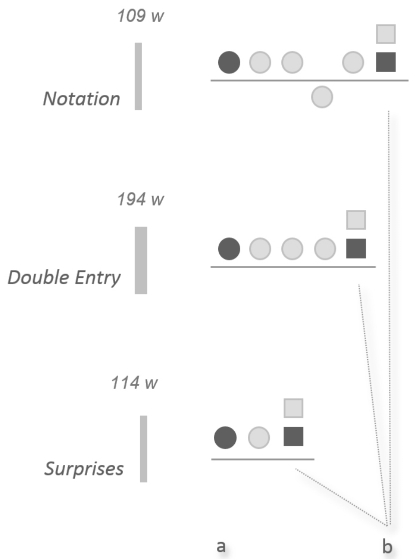

Figure 2: A comparison of how ***situations*** unfold in time and space in three recounts of the same story (from R. Queneau's *Exercises in Style*). Note for instance that only situations (***a***, ***b,*** *first and last symbols*) remain systematically the same across in these three versions.

The research unfolds in two sub-challenges a ***knowledge modelling*** challenge (How can we spot *changes* in space? What exactly makes a *space* to be differentiated form another – a name, a size? Who are actors - human beings only? ...) and a ***visualisaton*** challenge (What visual solutions could help underligning expected or unexpected patterns inside or across texts?).

The paper is structured as follows: section 2 introduces the reason-to-be of this research, its starting point. In section 3 we position our contribution with regards to existing approaches in the fields of visual analytics on one hand, and of text analysis on the other hand. Section 4 details our choices in terms of knowledge modelling, *i.e.* how the *space/time/actors/motion* components are used in the segmentation of textual content. Section 5 then presents a series of experimental visualisations aimed at demonstrating in what the whole approach should be beneficial in terms of knowledge discovery for text analysis. In section 6 we pinpoint strengths and weaknesses of the approach, and in particular challenges ahead if wanting to apply the approach on a large scale. Finally, a short conclusion sums up what we think can be considered as fruitful feedbacks from this study.

2 RESEARCH ISSUE

There is naturally a large range of features researchers may want to extract from text corpora, and analyse through visual means. Some are clearly *structure-related*, like in (Marshman et al. 2008b)'s comparative analysis of lexical knowledge patterns. Others by contrast focus on spotting *topics* like Sabol's topical-temporal maps (Sabol, 2012), a visual metaphor allowing an interactive analysis of how prominent topics in large collection of news releases change over time.

So why did we choose to focus on extracting the ***spatio-temporal content*** of textual data? The idea came as a natural continuation of years of research conducted on the architectural and urban heritage. A significant part of the historical evidence we use is extracted from texts, ranging from inventories to travel diaries. At the end of the day hints are recorded as relevant for a given place, a given time, mentioning a given set of actors. But both place and time are likely to be partially, when not poorly, described (a document will for instance mention something occurring "*on street **A** at the beginning of spring*"). Neither space nor time are consistently defined inside sources, and across sources (varying precision, varying granularity).

The statement of need from which the StorylineViz study originates can be summed up as follows: can we represent in a systematic, synthetic and universal form ***paths*** by their spatial and temporal components? A '*path'* is here understood as a series of situations leading from an initial state to a final state. This series is consistent or not in terms of spatial scale or quality of the information describing situations. It can be continuous or not (*i.e.* including or not temporal breaks). The notion of *path* can be used to interpret, and structure (*i.e.* segment according to division consistent lines) a variety of heterogeneous historical evidence: travel diaries, witness reports, inventories, iconographic material, *etc.*

But this notion of *path* could, when looking from closer, act as a potential semantic filter far beyond its initial field of concern - historical evidence. It is obviously closer to the content of a *narrative* that to highly structured data sets handled in route calculations offered by GPS applications for instance. Hence the attempt we present in this paper to try and see in what such an approach to text segmentation could be fruitful, beyond its initial context of emergence.

StorylineViz should be understood as a proof-of-concept study that aims at developing a generic approach to narrative analysis, supporting the identification and visualisation of significant patterns inside textual data, and ultimately knowledge discovery and sensemaking.

Narratives as seen from that general point of view are strongly heterogeneous (from whole texts to just series of facts, from a book or collection to a few paragraphs). In addition, they can be contradictory or conflicting (different recounts of a series of events) or transformed (typically by translations). As of today they are often categorised (a play, a travel diary, an eye-witness report) and analysed from an expert's point of view (linguistics, literature, history, *etc.*) but hard to synthesize and to compare to one another.

In this contribution we propose an approach in which a narrative is segmented in a series of situations in ***ordinal time*** (*i.e.* only the order of appearance of situations is defined: situation ***A*** occurs before situation ***B***, but neither ***A*** nor ***B*** need to be actually dated). A situation is differentiated from another basing on the variation of one of four parameters: time, space, actors, and motion.

Our approach's core objective is to facilitate visual reasoning on the structure, rhythm, patterns and variations of texts in order to enable comparative analysis and to summarise in a clear-cut manner how the space/time/actors/motion components are organised inside and across narratives. (Figure 3)

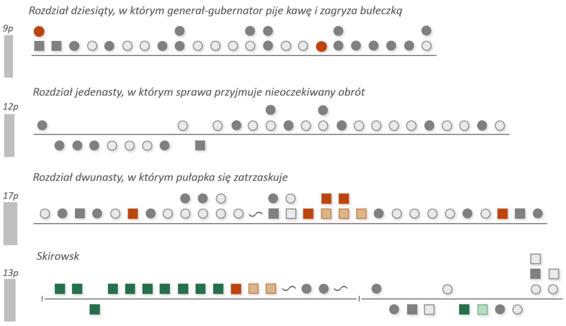

Figure 3: Visualisation of the spatio-temporal content of a Fandorin mystery by Boris Akunin (partial view): each line corresponds to a chapter, each situation is represented by one or several symbol distributed along the line. Notice similarities and differences between these four chapters highlighted for example by the colour of graphic signs (type of space – orange and green correspond to "large" spaces – urban areas or open land whereas greys correspond to spaces in and around a given building) or by their shape (circles correspond to *nested* spaces, *i.e. actors are inside vehicles or objects that can move or be moved).*

Quantitative and qualitative parameters can then be taken into account, allowing the association of causal or contextual indicators. The segmentation procedure is seen as a common ground between varieties of narratives. It aims at facilitating analytical *focus+context* views of complex narratives, comparisons inside collections, and more generally visual reasoning on structure, rhythm, patterns and variations. If proven workable the approach opens a number of application scenarios, among which:

- Comparing oral or written recounts of the same series of events as made witnesses of the same series of events.
- Supporting the identification of trends and patterns in writing genres in an edutainment-like approach.
- Combining the segmentation procedure and its visualisation with a cartographic platform in order to analyse emblematic "travel diaries".
- Allowing for a synthetic and systematic comparison of urban tracks, tourist routes, *etc*. (type and number of situations on a particular course, patterns of regular alternations or not, *etc*.).
- Analysing the changes over time of a route from point A to point B (situations added, retrieved or modified).
- Uncovering differences in the interpretation of texts by different readers.

At the end of the day, the approach can also be seen as an attempt to step out of discipline-specific frameworks so as to promote sort-of "universal", comparison-enhancing, metrics of narratives.

3 SCIENTIFIC CONTEXT

Open access to massive textual content, typically as found in digital libraries, has fostered the emergence of research works intermingling knowledge management, visualization, and language processing issues. In this contribution we focus on large non-structured texts. Unlike when handling structured data sets, working on large texts, today often made available in large open access repositories such as *Gallica*, introduces specific challenges. (Oelke, 2010) summarizes some of them: quantity (amount of words), polysemy (of words, references, literary imagery), flexibility (of rules in natural languages), interpretation (use of a predefined knowledge of the world by humans).

Our study proposes an approach that centres on semantic aspects, applicable across collections of texts. It builds on the idea that visualisation can help users explore, analyse and cross-examine textual documents. This idea is backed by research works covering a wide range of issues: (Oelke et al, 2010) VisRA tool focuses on readability analysis, (Koch et al, 2014) VarifocalReader focuses on multi-layer visualisation/navigation and interactive annotation, (Vuillemot et al, 2009) POSvis on relationships and co-occurences in the flow of a text (Wanner et al, 2011) approach digs in the notion of opinion and sentiment in book rating, ...

Those examples share a common mantra: *human analysis of textual content, sensemaking in large and/or complex textual data sets, can be facilitated by adapted abstract visualisations*. They also share a common statement: *full automatic algorithms can hit their limit when facing complex texts*.

Accordingly, our study does relate to the above research works in terms of scientific context, but it clearly leaves aside the NLP (Natural Language Processing) issues. We shall in this contribution focus on the knowledge modelling step on one hand, and on the visualisation step on the other hand. Mainstream research works at the intersection of VA and NLP have been investigating approaches that strongly rely on a line per line, word per word analysis of texts: statistical approaches (*e.g.* occurrences of words, lengths, word types), Named Entities Recognition (NER) related approaches (*e.g.* user selections of words, ontologies, opinion indicators), machine-learning approaches (*e.g.* extraction of significant linguistic patterns). In all these cases, language itself - *i.e.* the occurrences, positions, lengths, relations of words and sentences - is at the heart of a discipline specific analysis.

By contrast our approach builds on a segmentation bias that is:

- neutral - allowing for a discipline-independent cross-examination of texts,
- unrelated to text features such as lengths (a new situation can occur inside one sentence, or after three pages),
- focusing on supporting visual comparisons of rhythms and sequences, at user-chosen aggregation levels.

As will be discussed in section 6, we do acknowledge that the language processing step remains at this stage of our research an unaddressed issue. The segmentation of texts used in the study has been done manually: it could be seen as a weakness in terms of significance and reusability of the approach.

We believe that before any attempt at "automatizing" language processing it is key to formalise a robust, insight-gaining, unambiguous segmentation protocol, and to evaluate in what the visualisations can be beneficial. Accordingly we consider that our study can contribute to pinpointing a new research path, at a time when the focus is often put on the processing of massive data sets.

4 METHOD

We introduce a text analysis method that builds on the identification of quadruplets of components: ***actors, space, time and motion.*** These components are used to segment a narrative and translate it into sequences of situations in ordinal time (only the order of events considered). (Figure 4)

movement indicator
space
time
actors present / actors mentioned

... On the order of the honourable *mayor* **and** *the council of Cracow,* **at the request of a pious priest,** *prior* **of the St Mark monastery in Krakow, located at the Sławkowska street,** we sworn *wiertelnicy* were walking to the monastery. |

There, already mentioned prior **showed** us a yard **on a cemetery of the monastery, on which** we **saw such a building:** |

firstly small wooden chamber **plastered with clay, which is sprinkled with earth from the bottom** ...

Figure 4: Segmentation into situations - four indicators (*Actum feria sexta ante Fabiani et Sebastiani* [19I] *anno Domini 1596*).

The way each component is defined and structured is detailed in the following sub-sections. At the end of the analysis phase the text under scrutiny is entirely transformed into sequences of situations as they occur in the narrative. Sequences are then translated into a visual language.

- **a change in space**
  e.g. Kate in a hospital room | *She went out into the corridor.*
- **any break in the continuity of the story**
  e.g. She was unconscious as they carefully laid her back in her bed. | *She woke a few hours later with a wintry sun seeping through the window.*
- **a change among actors (e.g. *actors coming in or out*)**
  e.g. Dirk went in. | *Another policeman was standing in the hall and looked at Dirk blankly.*
- **a move from a static to a dynamic situation, when at least one of the actors is in motion**
  e.g. he stood there for a second or two longer | *then he turned and stalked grimly back into the den of the beast.*

Figure 5: A segmentation procedure ending in the identification of independent situations basing on changes in space, time, actors or motion: example of application to D. Adams' *The Long Dark Tea-Time of the Soul*.

4.1 The Concept of *'Situation'*

A situation is basically a sort-of token, resulting from the segmentation procedure. However we are here far from a segmentation at the word or sentence level: situations are determined by changes of values in a quadruplet of descriptors (space, time, actors, and motion). A change of one of the four descriptors introduces a new situation. (Figure 5)
Situations occurring in the past of the story (*e.g.* reminiscences - narrating past experiences) are differentiated from those occurring in the course of the story.

Situations are identified at this stage through a manual annotation and segmentation process - a dozen of texts ranging from literature to ethnology have been tested, covering three languages. Each situation is associated manually with a value for each of the descriptors, and with a short paraphrase summarising "what happens". The four values are translated into an alphanumeric code comprising indicators for each of four parameters and separators that allow for a processing of the information, *i.e.* for a transfer into fields of an RBBMS dataset which in return is queried in order to produce the visualisations. (Figure 6)

```
110#01;4:2_private car inside a train Petersburg-Moscow|v;.4:2',3',4m',f1',5m'
,6m'_article in "Will the Nation"|110#01x;2:2_ private car inside a train
Petersburg-Moscow, Chrapow is sliping |11x;0:2,7_officer enters and wakes
Chrapow|110#12;1:7,8_officers in a waiting room |110#12;0:8,f2_one officer
moves to the third room|110#12;0:8,f3_in the vestibule passes by two
policemen|110;1:8,f2_the train pulls into the platform/14;0:9,10_two people
go down the platform toward the train|02;1:8,7'_von Seidlitz inside the
carriage/04;0:9,10_ newly arrived presents himself as Fandorin|12x;0:8,10_
von Seidlitz invites him to the carriage|12x;1:8,10,f2_Fandorin leaves his coat
in the room in which they sat bodyguards|12x;1:8,10,7_von Seidlitz and
Fandorin enters to the waiting room|02x;1:8,10,7_ Modzelewski checks the
documents of newly arrived
```

Figure 6: Example of the alphanumeric code resulting from the annotation phase (in red, the code corresponding to the motion indicator - 0 static 1 dynamic – example from *The Death of Achilles* by B. Akunin).

Situations can also be grouped by predefined sequences such as chapters (or any other main division of a document).

4.2 Space Parameter

The space parameter defines where the action takes place (*i.e. Where does the action begin? Does it continue in the same location? Are the subsequently cited places well identified or in vaguely mentioned locations? Are there many quick changes of space?*). But 'space' as geographers, historians, architects, or ethnologists picture it is far from being one and only one notion. It can be described quantitatively (positions, size, exact morphology) or qualitatively (through linguistic indicators, or a relation to a Named Entity, for instance a toponymy like in (Kergosien et al., 2014).

In the context of this study we need to spot in the flow of a narrative the moments when a change of space occurs, and therefore leads to a new situation (whether spaces are associated with a given named entity - *e.g. Paris*, or are present in the flow of part-of-speech – *e.g. in the second cellar*). Detecting such changes implies defining unambiguous lines of division between spaces. To do so, we reinterpret the concept of scale, in accordance with previous research on spatio-temporal information retrieval (Blaise & Dudek, 2005, 2008, 2012). What is meant by scale is not a map's numerical ratio, but the idea that spaces can be classified according to alternative spatial granularities.

Our model of space includes 16 indicators (3 non-spatial descriptors and 13 scale identifiers). The non-spatial descriptors concern the situations where space is not clearly assessed (metaphorical descriptions, undefined space, space is not present) – in other words non-spatial descriptors help dealing with incomplete, ill-defined, or simply missing spatial information. The thirteen scale identifiers are organised into six groups (*e.g.* in and around a building, public spaces, open land). An additional parameter is taken into consideration: primary vs. nested spaces. ***Primary spaces*** correspond to 'simple' situations (*e.g.* Jane is in her room, Jane is walking in the garden). ***Nested situations*** appear when actors are inside vehicles or objects that can move or be moved inside a primary space (*e.g.* Jane is travelling by train.).

4.3 Time Parameter

The time parameter corresponds to the when question: it explains the story's development over time (*e.g.* continuous progression from present to future, regressive present-to-past development, multiple changes of time, *etc*.). The time model builds on the notion of ordinal time (Aigner et al., 2011): situations are analysed from the point of view of an order of appearance (before/after) in the flow of the narration, but neither quantified nor anchored. (Figure 7)

initial situation >
<u>Having left his farm</u> for a barn he owned in Saugué […]

new situation, short lapse of time >
<u>He was swept up</u> in an avalanche […]

new situation, longer lapse of time >
<u>Eight days later</u> he was still not back home […]

Cultures du risque en montagne M. Parrué-Pastor (dir.) L'Harmattan

Figure 7: Change of situations - temporal disruptions.

A qualitative assessment of time continuity is associated to each situation change (lapse of time separating a situation from the next one).

Successive situations are identified in the order of the narration (as the story unfolds) as belonging to the ***present*** of the story or its ***past*** (things having occurred "before the present of the story"). Situations can also be tagged as being ***parallel*** (occurring at the 'same' time). (Figure 8)

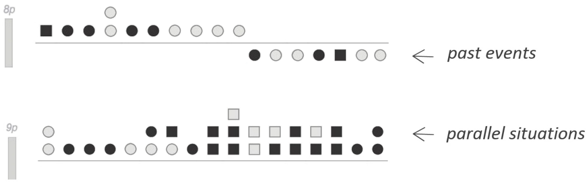

Figure 8: Top, ***past situations*** are represented below the horizontal line. Bottom, ***parallel situations*** are represented by graphic elements "piled" one over the other above the horizontal line.

Additional indicators are used to further describe parallel situations (actors mutually aware of one another or not, typically), or to identify customary behaviours (occurring repeatedly).

4.4 Actors

Actors are yet another trigger of situation change. They may be individuals, well defined groups of people, but can they also be indistinctly specified groups (*e.g.* a crowd), things (*e.g.* thinking machines), or animals? We here need to disambiguate the very concept of actor: are ants mentioned in B. Werber's *Empire of the ants* actors?

Our strategy is to consider actors as a being or a consistent group of beings, real or imaginary creatures or entities, fitted with the ability to make choices and to act. Actors may be human beings, but also gods (*e.g.* Zeus, Dionysus), thinking machines, androids, animals (*e.g.* the wolf in Little Red Riding Hood), and so on. The description of actors is then fine-tuned. Actors physically engaged in a situation (*i.e.* present) are distinguished from actors that are only mentioned (*e.g.* in a conversation, in thoughts), individual actors are distinguished from consistent groups either identified (*e.g.* the Celts) or not (*e.g.* a crowd). (Figure 9)

Figure 9: Actors appearing in each situation of S. Lem's *Trurl's Machine*. Situations are read from left to right. Here Trurl and Klapaucius, the two engineers (bottom part of the lines showing actors as silhouettes) are being chased by Trurl's machine gone mad (top part of these lines, one silhouette alone). A reference to past events is made (orange square below the horizontal grey line), and that past situation concerns two actors not present but mentioned (white silhouettes).

Finally, major events concerning actors can also open up on a situation change – a severe injury, or a death of an actor needs to be reported.

4.5 Motion

Finally, motion is also a key element in the definition of a situation (only the motion of actors is considered). Motion is important to state since it helps unveiling spatial and temporal continuities or discontinuities in the narrative. An intensive use of motion indicators in a text may characterise writing genres (*e.g.* logbooks), may underline recurrent stylistic elements (*e.g.* a speed chase with the police), stylistic characteristics of an author, differentiate acts inside one play, help understanding changes in space, and so on.

Naturally we need to be clear on what we mean by motion. The strategy is to focus on movements that introduce a change of location but not necessarily a change of space (*e.g.* someone is walking down a street). From the point of view of this criterion situations may then be classified as ***static*** or ***dynamic***. A ***dynamic situation*** implies the motion of at least one of the actors, motion understood as moving in space (*e.g.* walking, marching, strolling, running, driving a car…). (Figure 10)

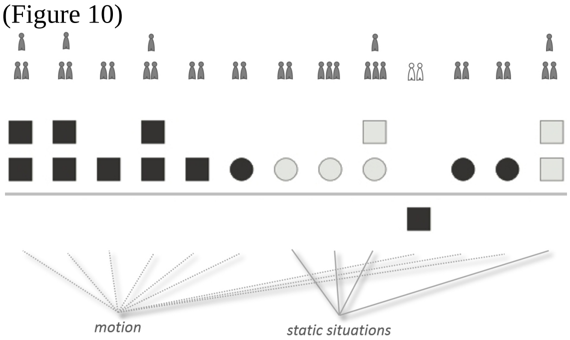

Figure 10: A partial view of *motion analysis visualisation* corresponding to S. Lem's *Trurl's Machine*. Light grey elements indicate static situations (*e.g.* the engineers discuss with the mayor of a town in which they sought refuge).

5 VISUAL SOLUTIONS

Our approach bases on the idea that interactive visual interfaces can help various target users perform reasoning tasks in application fields ranging from expert analysis to education or cultural mediation. Accordingly visualisation, as defined by R. Spence (*i.e.* a cognitive activity) is a key component of the study, both in the understanding of a given narrative's "spatio-temporal profile" and in fostering comparisons inside collections of texts. Depending on the parameters a user may choose to privilege (*space/time/actors/motion*), different visualisations are proposed. We detail them in the following sub-sections. All of these visualisations share some common design principles:

- Situations are represented one by one and aligned as they occur in the original text (left to right, or top-down).
- Each situation is represented by an interactive symbol (a multidimensional icon). Shape, colour and position are used to transfer visually the information on each situation.
- A rephrasing of the actual text corresponding to each situation is available on user demand.
- Parallel situations, *i.e.* situations co-occurring in time, are grouped and represented together.
- Actors are visualised on user demand, with colours differentiating the nature or type of actors (actors present, mentioned, injured, or groups of actors).

Situations are grouped by sequences (chapters or other grouping mechanism adequate for a particular writing genre) in order to grab more easily an understanding of the text's structural features.

5.1 Spatial Sequences Visualisation

In the ***spatial sequences*** visualisation situations are represented in ordinal time from left to right along horizontal bars. Each horizontal bar corresponds to a sequence of situations. All reminiscences are situated below horizontal bars (Fig. 11 ***b₁,b₂,b₃***). Colour and shapes are used to differentiate the occurrences of various spatial scales.

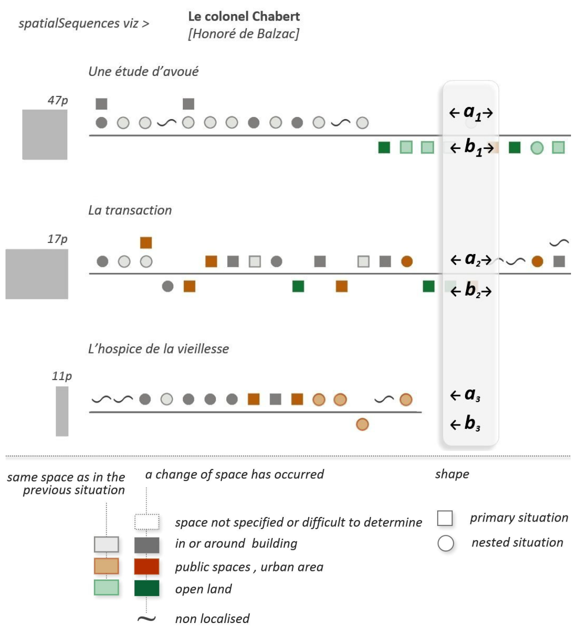

Figure 11: Organisation and legend of the *spatial sequences visualisation*. Bottom, legend of the visualisation. Colours correspond to ranges of scales. Squares and circles differentiate nested spatial configurations (*e.g.* driving a car in a city) from primary spatial configurations (*e.g.* walking in a city). Top, a partial view of the *spatial sequences visualisation* corresponding to Balzac's *Colonel Chabert*. Note for instance the contrast between spatial location of present (***a₁***) and past (***b₁***) of the story in chapter one (colours), or the quasi-absence of past events in chapter 3 (***b₃***).

5.2 Motion Analysis Visualisation

The ***motion analysis*** visualisation uses the same general organisation as the previous: situations are represented in ordinal time from left to right along a horizontal bar.

But here the focus is put on the motion component of the model: colours and transparency representing different types of space are replaced by black-and-white motion indicators.

This visualisation is used to differentiate static and dynamic situations, thereby better underlining in particular rhythms inside a text. (Figures 10, 12)

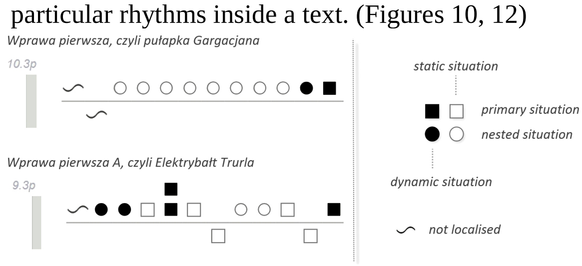

Figure 12: Organisation and legend of the *motion analysis visualisation*. Left, a partial view of the visualisation corresponding to S.Lem's *Cyberiad*. Note for instance the

long sequence of static, nested situations in chapter 1. Right, legend of the visualisation.

5.3 Temporal Continuity

The ***temporal continuity*** visualisation focuses on assessing visually to which extent the story unfolds without interruption in time. (Figure 13)

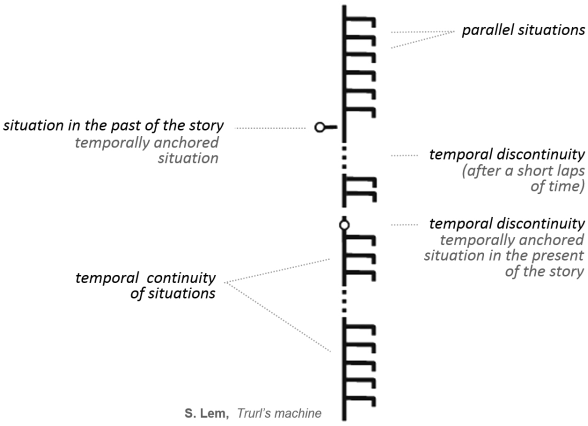

Figure 13: The temporal continuity visualisation applied to S. Lem's *Trurl's Machine*. The visualisation shows an intensive use of parallel situations, and spots three lapses of time disrupting the temporal continuity.

A typical example of time continuity is the classical *unity of time rule* for drama.

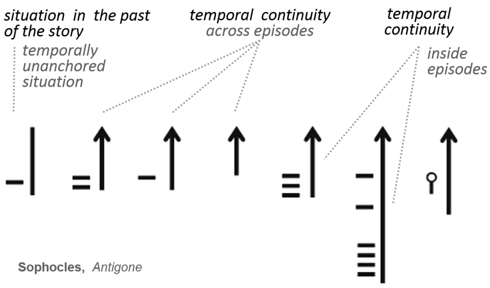

Figure 14: The temporal continuity visualisation applied to Sophocles' *Antigone*, the visualisation illustrates the *unity of time* pattern.

Each sequence (*i.e.* chapter, episode, *etc*.) is here represented as a vertical line. A line topped with an arrow shows a temporal continuity with a previous situation. Small horizontal lines distributed on the left side of the vertical line correspond to situations occurring in the past of the story. Parallel situations are identified by symbols positioned on the right side of the vertical line. The vertical line is disrupted by various symbols in cases of temporal discontinuity (different symbols are used to represent short lapses of time, jumps in time, temporally unanchored events, *etc*.).

5.4 Spatio-temporal Continuity

The ***spatio-temporal continuity*** visualisation builds on the same design as the previous, but adds symbols representing the space parameter. Whereas in the spatial sequences visualisation (section 5.1) we only deliver an indication about the group of scales corresponding to a situation, we here allow for a visual coding of each of the thirteen individual scales. Fine-grain differences can be made for instance to differentiate a situation occurring inside a building from a situation occurring in a building's courtyard, or in a flat forming part of the building. (Figure 15)

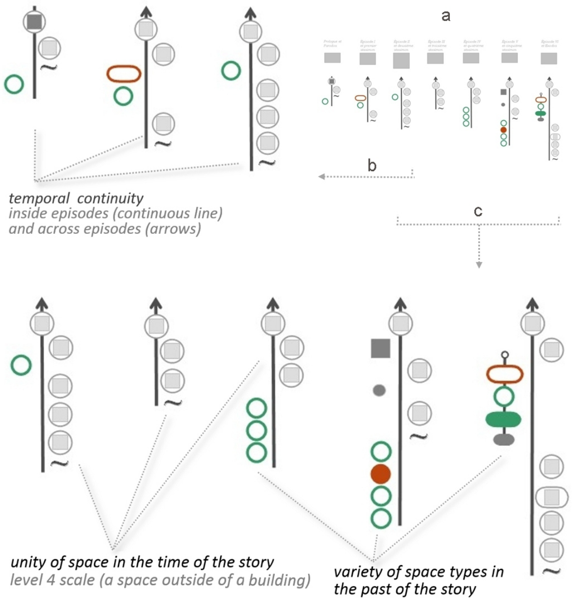

Figure 15: *Spatio-temporal continuity* visualisation corresponding to *Antigone* of Sophocles (**a** – entire visualisation, ***b,c*** - fragments). Note contrast in terms of space between the past of the story (symbols on the left of the vertical lines) and the present of the story (symbols situated on the vertical time-line and on the right of it). Note also that in the present of the story space remains unchanged (*in front of the palace*).

5.5 Implementation and Evaluation

The approach has been tested on different types of text: a play (Sophocles), crime stories (A.Christie, B.Akunin), science fiction and fantasy (S.Lem, T.Pratchett, D.Adams), French literature (H.Balzac, R.Queneau), reports of interviews (*e.g.* ethnological research) or historical texts (*e.g.* 16th century textual building inventories).

The corpus includes textual content written in English, French and Polish. One of the reasons of this choice was to check that the approach is workable in different languages. Another reason was to test the impact of a given natural language - *i.e.* test if the segmentation of a given textual content, once translated into another language, remains fully consistent with the original.

As mentioned in section 4.1 the annotation step results in alphanumeric codes associated to each situation. These codes, along with bibliographic data and other general information concerning the texts, are stored in an RDBMS structure. They are interpreted on the fly (Perl scripts) to produce SVG (Scalable Vector Graphic) interactive visualisations available inside standard web browsers.

5.6 Evaluation

An early "feasibility" evaluation was carried out with a group of non-experts (twelve students in mechanical engineering) in order to get a first feedback on the ***knowledge modelling bias*** (segmentation into sequences of situations). We asked testers to depict an everyday series of actions, such as their home to work routine, using the graphical codes. We then asked then to complement the description of each individual situation with one or several qualitative parameters of their choice. Some recurrent parameters emerged, such as sound, amount of light, mood, *etc*. What this evaluation procedure did usefully underline is that the logic behind the segmentation protocol is easily understood, and somewhat intuitive.

Yet there is a clear difference between asking testers to analyse one of their own everyday routine in terms of series of situations and having them uncover these situations from a textual content using predefined segmentation rules. In a second round we therefore implemented a more demanding evaluation setup, with this time eight testers from different countries (Marie Curie fellows focusing on reality-based 3D modelling – no native speakers of English) working on two extracts from novels written in English. The testers were first introduced to the approach, and shown the whole set of segmentation rules. Following, they were asked to work on a first text that they had to segment under supervision. This step was needed to make sure that the protocol was clear enough for them. These two phases lasted for an hour and a half. Testers were then left for one hour with a 1000 words text that they had to segment on their own, *i.e.* on one hand they had to ***spot situation changes*** and on the other hand they had to ***qualify each situation*** with regards to space (what scale?) to time (any disruption?) actors (who is concerned?) and motion (do actors move?).

Before analysing the results, it has to be said clearly that the length of the text, the amount of testers, and the time devoted to the evaluation (two hours and a half all included) are certainly not sufficient in order to draw firm conclusions. This evaluation, however, did help us spotting significant trends (including weaknesses) and ultimately helps understanding where to go next.

A central issue we wanted to raise was whether or not ***situations***, can easily and unambiguously be differentiated from one another. We analysed both the raw, quantitative results (number of situations spotted, types of scales identified, quantity of switches between static and dynamic situations, *etc.*) and the oral remarks made by the testers at the end of the evaluation.

Results show that generally speaking the concept of situation is quite easy to use – testers had no particular difficulty in spotting different situations and tagging them with values for the four parameters. But if the mechanism was found clear, we spotted a number of ambiguities deriving from two different issues: comprehension and individual interpretation of the segmentation rules on one hand, and inherent "fuzziness" of texts on the other hand.

5.6.1 Comprehension Issues

The evaluation showed us that the testers had some difficulties with time discretisation and scale identification. Although testers globally understood the rules, they did not have enough time to get familiar with them before the test - they somehow discovered them as they progressed in the segmentation of the text.

We also noticed different individual interpretations of the segmentation rules: *e.g.* what does '*after an instant*' really mean? Testers disagreed on this very notion. What kind of space is '*a railway station'*? A building, a building and its surroundings, an inside, an outside? Here again each tester pictured what '*a railway station'* is his own way.

A certain number of segmentation rules as we had verbalised them turned out to be either too loosely defined, or too interpretative – typically the notion of ***parallel situations*** that encompasses someone spying on others from behind a window to a phone call connecting two people located in different parts of the world. One type of parallel situations appeared as particularly confusing, when several groups of people are in the same space but act independently of one another - in this case the rule itself needs rethinking.

Finally, some testers questioned the segmentation rules themselves when the rules, according to them, did not let them stick close enough to the text. In the text proposed *Kate* is driven to the airport in a taxi – but no mention is made of the taxi driver in the initial situation. Those testers considered that putative actors – here the taxi driver – should be mentioned, although according the segmentation rules they were given only actors mentioned in the text should be specified.

Briefly speaking, the evaluation showed that segmentation rules and definitions of scales, temporal disruptions, motion and actors need to be further clarified and illustrated by examples in order to pin down the concepts and reduce existing ambiguities. More generally the above comprehension issues underline the fact that more time should be spent on explaining the segmentation rules prior to the evaluation itself. Moreover applying correctly the segmentation rules requires a thorough understanding of how space and time are discretised – which implies a steep learning curve.

At this stage the approach requires from readers and annotators a good understanding of the segmentation rules, but also keeping a certain "distance" with the text in order to avoid confusing what is really written, with what one may deduce, understand or imagine. What we asked the testers to do – segmenting of a text into an alphanumeric code using a set of segmentation rules and of discrete values – requires from annotators skills and capabilities. It is a demanding task that limits the circle of people who can be expected to carry out the annotation step. What remains to be verified is the level of readability of the visualisation we proposed.

5.6.2 Inherent Fuzziness of Texts

There are a number of factors that impact the way space, time, actors and motion are verbalised by authors. Texts are written with a significant amount of *unsaid*, or *half-said* elements – voluntary omission of details, figures of speech, *etc*.

Consider this yet straightforward example: "*She set off in search of first a newspaper and then some coffee. She was then unable to find a working phone"*. Should the reader here consider time as continuous, or as interrupted for a short while, for a long while? The author does not say openly whether there is a time disruption or not. The same can happen when mentioning spaces, actors, or even motion. Texts are the way they are, and readers will anyway interpret and understand them differently, whatever semantic-based segmentation rules one may write – a feature of what Alfred Korzybski named *verbal levels* (Korzybski, 1951).

The evaluation showed the inherent fuzziness of texts can be seen as an obstacle, but can also be seen as a potential object of study, an opportunity for instance to use the segmentation rules in order to localise areas where readers interpret a text differently.

Interpreting the evaluation's results should however be done with caution. The segmentation's learning curve is definitely steep: further evaluation efforts are therefore clearly needed (for example finding a match between a text and a visualisation in a setup where several possibilities are shown). It also underlined unexpected potential benefits of the approach, in its current state of development:

- It helps comparing how different people understand and interpret the spatio-temporal content of a text.
- It enhances debate, and helps uncovering precisely (in the flow of the text) where alternative interpretations occur, and why.
- It facilitates the communication by one individual of *his own* understanding of a text by supporting (through visual means) his discourse on rhythms of a narrative in a context + focus manner;
- It could be used to weigh and compare the level of interpretation required from readers depending on the text or author.

6 LIMITATIONS AND PERSPECTIVES

As mentioned in the introduction, we report in this paper a ***proof-of-concept study*** that aims at developing a generic approach to narrative analysis. Accordingly there are a number of limitations that we can quote, but that we will not detail, and notably the following:

- We consider that the corpus of texts used as test cases is representative in terms of variety, heterogeneity, but it definitely is a partial corpus.
- The evaluation phase should clearly be deepened – notably with regards to fine-tuned usage scenarios.
- The comprehensibility of the segmentation rules for a wider public should be better assessed, as well as the learning curve.
- The implementation is a robust one, but it certainly could be rethought or improved.

But beyond these general remarks, there are two major lines of development, discussed hereafter, that we think need to be mentioned and that somehow underline potential perspectives.

6.1 Visual Reasoning: Still a Challenge

Our approach bases on the idea that the combination of a non-standard segmentation procedure with appropriate visualisations can offer users new opportunities to perform reasoning tasks, and uncover pieces of knowledge inside textual content. But such a statement can only be corroborated (or invalidated) if the experimental setup proposed to testers is fully satisfactory. The visualisations we ended on do show the idea is worth exploring, but the implementation is at this stage not fully satisfactory. For instance support for a visual cross-examination of texts "*within the eyespan*" (Tufte, 2001) needs to be improved. Accordingly we consider that our study needs to be extended and deepened in order to state without doubt that the approach is indeed, generic, workable across various types of texts, and fruitful in terms of knowledge discovery.

6.2 The Impact of Manual Annotation

Even more significant in terms of limitation of the research's potential impact is the fact that the annotation process - *i.e.* the segmentation of texts – is to this day a manual process. This clearly undermines perspectives of application of such an approach on a large scale. But on the other hand it also opens a clear perspective (and challenge) for this research. The approach hits the limits of existing NLP based methods. Hence rounds of discussion we are at this stage having with VA and NLP partners to try and investigate how the approach could be developed on a large scale. Even if a fully automated annotation process would turn out to be out of reach, working on semi-automatic procedures in the context of the emergent crowdsourcing paradigm would clearly open tangible large-scale application perspectives. Furthermore, human annotation is by itself a meaningful activity, opening perspectives, as mentioned in section 5, in terms of communication and comparative analysis of text interpretation. Both going towards more automation in the segmentation process, and sticking to a human process, can therefore be considered as lines of development of the approach.

his contribution introduces a generic approach to narrative analysis: the approach's main claim is that *extracting the spatio-temporal content of a narrative and visualising it in ordinal time as a series of situations can help spotting and exploring significant patterns, trends, exceptions across various types of texts*.

It builds on a knowledge modelling effort and on explorative visual analyses. The approach should lead to a multipurpose visualisation framework helping to reshape the way we understand, summarise, and explain a narrative.

Our approach encompasses issues that are rooted in Information Sciences - Visual Analytics, Knowledge Representation – and issues that more closely relate to Digital Humanities – comparative methods and analytical reasoning on textual content, support in teaching and learning, time and space perception modelling, *etc*.

Although the corpus on which the approach has been tested remains partial, the experimentation does show the approach is workable across various types of texts, and in each case does uncover patterns suitable for comparison. The evaluation carried out paved the way towards usage scenarios that would focus more on assessing differences between reading experiences than on the "automatization" of the segmentation.

Beyond the segmentation issue, the approach investigates the potential services of visualisation as a non-verbal means to communicate an understanding of a text, in particular of how space and time unfold inside narratives. A number of the patterns unveiled are somehow expected (*e.g.* the rigorous storyline of Sophocles' *Antigone* - unity of action, time and place, or a recurrent element in Agatha Christie's crime stories – a concluding chapter with all actors in one space discussing the whole sequence of past events that lead to the crime.)

Finer-grained findings revealed a number of other characteristics for example varying proportion of elements situated in the past of narration in various texts, specific motion characteristics of chapters, authors using extensively parallel situations as a mean to reinforce the suspense, and so on. In all cases

To conclude, visualisations produced until now show an interesting interpretative potential. They could be used for example to support teaching and learning activities, helping learners to quickly get a hold on patterns, trends, exceptions, and to carry out comparative analyses across texts (for instance using the approach in order to support pupils with learning disabilities such as *dyslexia*). We consider that, at this stage, the approach has proven workable, but will need further improvement loops (more case studies, more rounds of evaluation) before becoming fully operable.

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