Journal of Visualization, Vol. 12, No. 2 (2009) 181-188

Regular Paper

Story Visualization of Literary Works

How a Computer Reads Shakespeare's Plays

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Received 9 March 2008
Revised 9 October 2008

Abstract: With the rapid advance in information technology, the applicability of computers has moved from the scientific field towards simulating human intelligence. We are already familiar with using computers to produce music and art and for language translation. A further use is in understanding traditional man-made products; best exemplified by literary works. In this study, we focus on enabling a computer to visualize the meaning of stories. Four world-famous plays by William Shakespeare have been chosen to demonstrate how the visualization scheme works in grasping the meaning of the stories. The scheme employs primitive keyword detection and ellipsoidal differential equations to create a visual imagery of the story. This methodology ensures uniqueness in the visualization of an individual work. In addition, color palettes obtained from pictures relevant to each story are used to enrich the consistency between the visual sense and the meaning of the story.

Keywords: Visualization, Literature, Shakespeare, Story analysis, Computer interpretation

1. Introduction

Computers have already accomplished a variety of human intellectual works, such as music composition, art painting, and language translation. Nevertheless, the problem of understanding and interpreting literary works has hitherto mostly been ignored. In anticipation of future development in this area, we have tried to create a story visualization system for literary works. A pointer as to how this can be accomplished is found in language education; babies and small children grasp the meaning of long complex sentences by focusing on keywords that they already understand (Chatera and Vitanyi, 2007). The overall meaning of the story is then roughly reconstructed by combining these keywords (Yoon and Park, 2005). The problems that remain are [A] how to reconstruct a story systematically from scattered keywords, and [B] how to present the meaning of the story to a third party. Addressing these two issues is the focus of this study.

The difficulty of the first issue [A] depends on the complexity of the story. Several trials with robots and human interface machines have successfully implemented dialogues with humans by making use of pattern recognition in the conversation (Meng and Wong, 2004; Chen, 2007). Such software development is now underway in artificial intelligence research, beginning with corpus classification (Singh and Dey, 2005), topic mining (Lee et al., 2007; Kuhn et al., 2007) and language compilation (Pons-Porrata et al., 2007). Another approach to analyzing a long story is to introduce advanced mathematics into the text data. By applying a wavelet transform to a numerated keyword distribution, scenario changes can successfully be detected throughout the story (Inami et al., 2007).

The second problem [B] is concerned with the presentation of the results. This is a common issue in visualization and is dealt with extensively in this journal. Fluid flows in nature are sometimes observed as beautiful images (Hertzberg and Sweetman, 2005) and as such, can be recognized as an art form (Fujisawa et al., 2007; Burge, 2007). A difference arises in that a story includes emotional substance for the readers, while natural science excludes this. Therefore, tragedy and comedy must be visualized in such a way that the reader feels the appropriate sadness and happiness when viewing the visualized results. A similar effect is found in music visualization (Ohmi, 2007).

A first attempt towards story visualization in this study considers the two issues discussed above. As the target of visualization, we have chosen Shakespeare's plays, as these are some of the most famous historical literary works and moreover, the structure of the sentences has been investigated in great detail. Although the results presented in this paper might seem primitive to literature researchers, we are confident that this initial step is necessary to pioneer future development. Possible achievements before the end of this century may include having a robot enjoying reading a human letter, or attempting to write a literary work. Visualizing a story, which is the aim of this study, will hopefully form the basis of these systems to be realized in the future.

2. Method of Literature Analysis

2.1 Target of visualization

Famous dramatic works by William Shakespeare (1564-1616) have been chosen to demonstrate story visualization. These works have been universally loved throughout the centuries and across many countries. Shakespeare established the literal essence of drama, poetry, and novels by making the best use of vocabulary. In using his works, we believe that an analysis of literary works reaches the heart of the problem. Shakespeare's works have several common features. a) The plot advances strictly according to time because of the nature of a play. b) Several characters create intrinsic human relationships between one another to deepen the story. c) The theme is clearly defined by love, hatred, life, and death. d) Various expressions are used repeatedly to convey an actor's sentiments to the reader/audience strongly and precisely. e) The structure of sentences and phrases mostly obeys a particular rule including rhyme, i.e., morphological artifice. Iambic pentameter provides the reader/audience with a unique and rhythmical impression. Of the five distinguishing factors given above, this study deals with a), b), and c) since these three constitute the trend of the stories. To compute the literature data, we utilized the electronic library of the complete works of Shakespeare (available on T-Time ver. 5.5.7.6, Voyager Japan Inc.).

2.2 Keyword detection

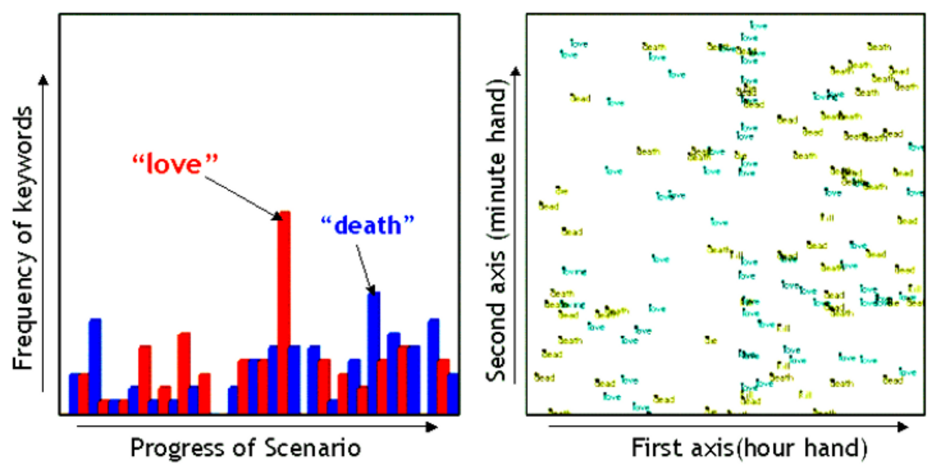
Detection of keywords is the simplest, yet most important method of capturing the meaning of a story. A single keyword does not make much sense, but the distribution of a few keywords generates organized meaning. When a pair of keywords with contrasting meaning is investigated, the outline of the story can be extracted. Such a statistical approach to Shakespeare's plays was first reported by Spurgeon (1935). More recently, Foster (1997) employed a computer to count keywords in these plays. We basically follow these approaches, but construct original software to create a visual distribution of the keywords. It is worth noting that Shakespeare's plays create their own worldview that is barely expressed by alternative meanings only. This matter is highly sophisticated, and thus we define this study as only focusing on the pattern of the story structure.

The computational procedure to detect keywords is as follows. 1) Load the whole text of the target literature. The data format is two-byte ASCI code. 2) Count the number of alphabetic characters to identify the computer memory required. For example, *Othello* consists of 362,858 characters. 3) Decompose all the text into words and assign these to a single word array together with the location of the word in the text. *Othello* contains 35,965 words in total. 4) Search the keywords and memorize the locations in the text by scanning the word array. The computation time for these four steps is only 0.5 sec in the case of *Othello*. Table 1 gives a small section of the list of words and associated counts in *Othello*. Using this list of words, keywords of interest are selected.

The distribution of the detected keywords can be expressed as a one-dimensional profile along the time axis of the story, and also as a two-dimensional map when the second axis is defined. Figure 1 presents a comparison of the two types of representation in the case of *Othello*, where (a) shows the frequency of the word "love" (red bars), and "death/kill" (blue bars) along the progression of scenes, while (b) shows their scattered distributions in a two-dimensional time space. Here, the abscissa represents a longer time evolution like the hour hand, while the ordinate represents shorter time as does the minute hand. These keywords are distributed in space as in PTV-data (Murai et al., 2008), but contrary to PTV, the ordinate is arbitrary and can be given by an alternative axis such as character, gender, or class. One reason for the current method of using multi-dimensionality is that it warrants a homogeneous two-dimensionality, thus presenting the perfect platform on which the visual imagery can be painted. In other words, the canvas for the visualization is provided before the theme of the visualization is decided.

Table 1. List of words and counts in *Othello* obtained using the current software

Character	Count	Positive	Count	Negative	Count	Other	Count
Othello	1435	love	76	bear	19	heart	25
Iago	335	heaven	44	fear	18	light	22
Cassio	234	honest	37	devil	18	fair	21
Desdemona	226	noble	21	poor	16	handkerchief	21
Emilia	118	sweet	20	wrong	15	friend	18
Roderigo	97	faith	16	blood	13	confess	11
Moor	51	honesty	9	kill	13	kiss	9
Brabantio	47	Faith	9	murder	12	passion	8
Lodovico	31	fortune	9	hell	12		
Montano	31	honour	9	death	12		
Bianca	29	Heaven	8	patience	10		
Cyprus	27	courtesy	5	jealous	10		
Gratiano	14	dream	5	bloody	8		
		loving	4	revenge	8		
				fool	8		
				doubt	8		
				jealousy	6		



(a) (b)

Fig. 1. Two types of keyword distribution: (a) one-dimensional frequency along progression of scenes, and (b) two-dimensional map. The target is the complete text of *Othello* (1604).

2.3 Laplace interpolation

After a scattered distribution of keywords has been obtained, the Laplace equation is applied to create a continuous distribution on two-dimensional coordinates. The Laplace equation is defined as

$$\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial y^2}=0 \quad \to \phi_{i,j}=\frac{1}{4}\left(\phi_{i+1,j}+\phi_{i-1,j}+\phi_{i,j+1}+\phi_{i,j-1}\right), \tag{1}$$

where ϕ is an arbitrary scalar distribution on the x-y plane. The second equation given above is the differentiated form on a computational discrete plane (i-j) under the condition that the two grid sizes in the x- and y-directions are the same. When this equation is applied, at least two contrasting keywords must be chosen to define the range of the numerical value of ϕ. For example, when two keywords "happy" and "sad" are selected, the value of ϕ is given as ϕ=1 and ϕ= -1, respectively. This type of meaning-to-value conversion has been investigated in both robotics and linguistics. In addition, it is most important to use the Laplace equation for visualizing the story, as this equation produces a linearly interpolated harmonic distribution and always derives a unique solution for given boundary conditions. This guarantees the uniqueness of the result, and ensures that artificial or personal aspects are totally excluded in the sequence. Furthermore, the existence of a single keyword propagates throughout the whole of the story domain. Hence longer term relationships in the story that exist beyond scenes can also be captured. A mathematical discussion on the Laplace equation applied to scattered information is given in (Ido and Murai, 2006).

The text code computation and visualization are implemented by a single program written in Visual Basic Ver. 6 (Microsoft Windows XP) that runs on an ordinary personal computer (Dell, Optiplex GX260, 3.07GHz-512MB). No subjective process is included in the visualization. The total computation time, from reading the text data to completing the visualization, is less than 20 sec for any of Shakespeare's works.

3. Results and Discussions

We have performed the visualization of four plays by Shakespeare. Before giving the results, let us explain the presentation thereof. Figure 2 shows three types of representation for *Othello* in which a scalar function is defined to be positive for happiness (red) and negative for sadness (blue). Happiness is detected by the keywords "love," "dream," and "honour," while sadness is denoted by "kill," "hell," "blood," "death," and "die." The solid arrow shows the direction of the progression of scenes in the hour hand scale, while the dotted arrow indicates that of the minute hand scale.

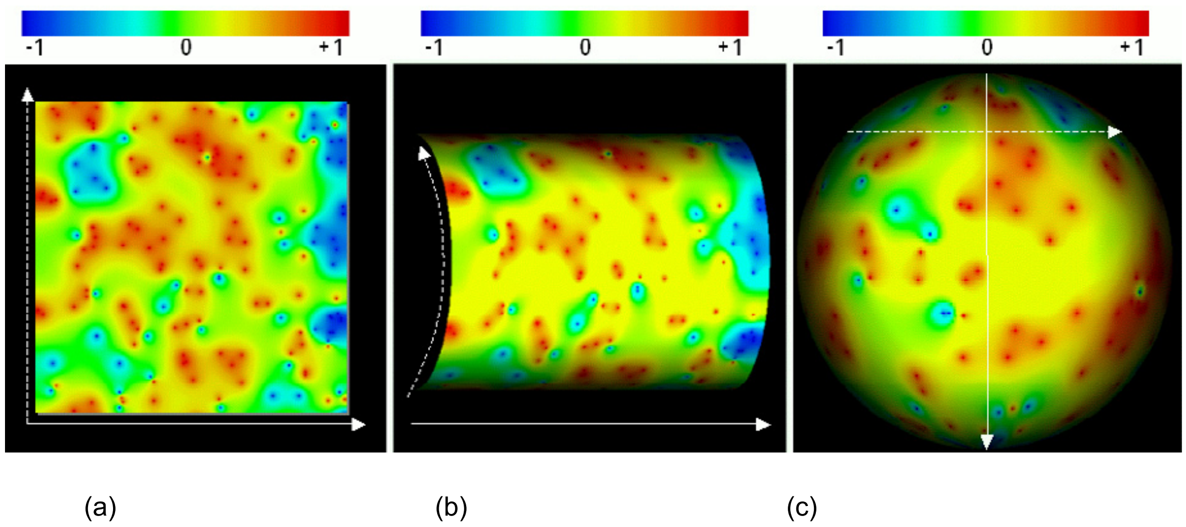


Fig. 2. Three types of story visualization: (a) square domain, (b) cylindrical surface, and (c) spherical surface. Red and blue regions correspond, respectively, to happiness and sadness in *Othello* (1604).

The standard expression using the square domain (a) is the easiest method for grasping the combination of two contrasting impressions. However the top and bottom boundaries should be connected to each other since the vertical axis represents the minute hand time scale with a cyclic property. Painting the distribution on a cylindrical surface (b) allows us to eliminate this problem. This method of expression has a higher correlation to the structure of the plays than (a). Furthermore the cylindrical expression allows readers to imagine the story as a scroll. It should be noted that the value of the keyword function is drawn on the front half of the cylindrical surface so that no hidden part exists. The third case (c) is a reflection of the data onto a spherical surface like a planet. This "planet" is intrinsic and particular to *Othello*. It is interesting that when a spherical representation is applied, each literary work has its own unique planet. A disadvantage of this representation is that the beginning and ending of a story are compressed into small areas, which is contrary to the structure of plays. After comparing these three methods, the authors decided that cylindrical coordinates best represent the visualized results of a story.

The results of the story visualization of four plays are given below. While a standard rainbow color chart is employed in Fig. 2, we have produced original color palettes to enrich the feelings that the readers experience from the results. These color palettes have been taken from the color charts used in famous paintings relevant to Shakespeare's plays. In a broad sense, these paintings have been identified with visual imageries for the individual plays. Thus the combination of the keyword distribution and the color essence in the paintings creates not only information of the structure of the story, but also an expectation of the emotional effect on the reader.

3.1 Othello

Figure 3 shows the visualized results of the tragedy *Othello*, the color palette of which has been obtained from a picture by Théodore Chassériau. The color palette has been defined by color evolution from one point to another in the picture using original image handling software. The hue in the painting includes pastel blue and dark red, which correspond to the general sense of pleasure and distress, respectively. *Othello* is known as a story of conflict within the heart of the main character Othello. The first half of the story deals with Othello's love for his young wife Desdemona, while the latter half deals with his strong jealousy towards her, which is contrived by his subordinate Iago. The visualization is created using the keywords "love" as the positive, and "jealousy" and "handkerchief" as negatives. The result matches the outline of the story as seen in the sky-blue spots on the left side and the red spread on the right half. At the end of the story, a red region appears again, indicating the death of the characters.

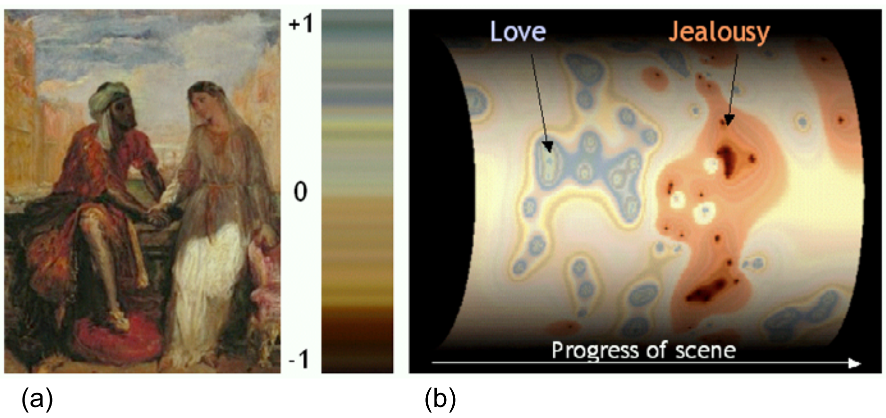


Fig. 3. Story visualization for *Othello*: (a) of the painting *Othello and Desdemona in Venice* by Théodore Chassériau (1819-1856), and (b) the story visualized with "love" as positive and "jealousy" as negative.

A different pattern emerges when different keywords are used; that is, the individual plays have multiple imageries that depend on the theme of visualization. Since the visualizing target is a literary work, we believe that the solution need not be unique, but is allowed to include subjective contributions. In this paper, after considering more than ten combinations of keywords for each of

Shakespeare's works, we present only a single story visualization result for each of the plays, that expresses functionally the structure of the story.

3.2 Hamlet

Figure 4 shows the visualized result of *Hamlet*, which is one of the most popular tragedies in the world. The story is about Hamlet's hatred for the king, his uncle, who killed his father and then married his mother. The color palette has been taken from a picture by John W. Waterhouse, that features the flesh color of Hamlet's fiancé, Ophelia, highlighted on a dark background. In Fig. 4 (b), the positive region shown in white corresponds to his love and admiration for his dead father, detected by the keyword, "father." The white area that appears at the beginning of the story matches the scenes in which his dead father appears to him as a ghost. Contrarily, the story advances to the dramatic discord within his heart when he learns that the present king murdered his father. These scenes are expressed as dark colors by the keyword, "king." White spots are interspersed in the latter half of the story when he compares the king to his father during his revenge. Consequently, the turmoil in Hamlet's heart is well expressed by the visualization of two contrasting characters set as keywords.

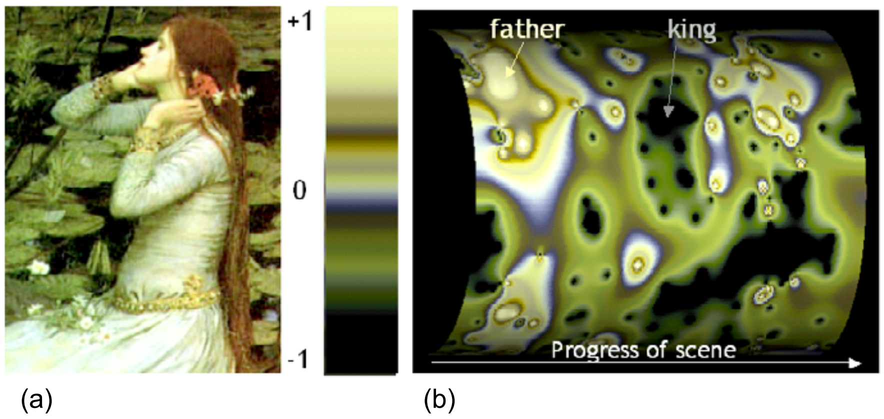


Fig. 4. Story visualization for *Hamlet*: (a) a picture of Ophelia by John W. Waterhouse (1894), and (b) the story visualized with "father" as positive and "king" as negative.

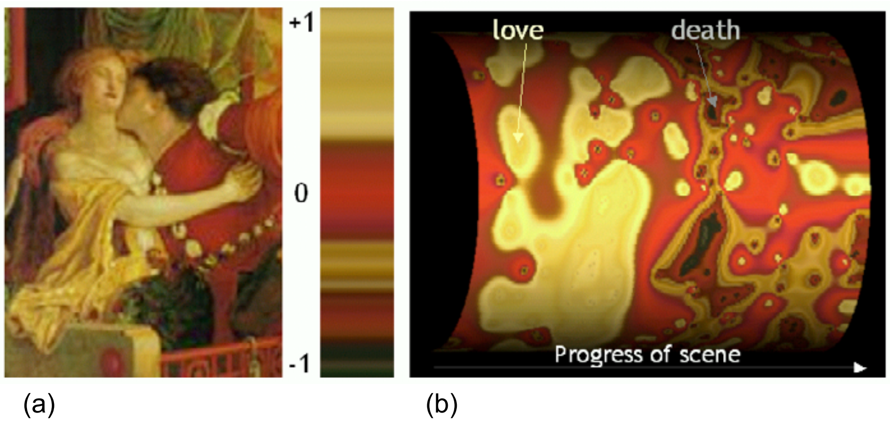


Fig. 5. Story visualization for *Romeo and Juliet*: (a) the painting *Romeo and Juliet* by Ford Madox Brown (1821-1893), and (b) the story visualized with "affection" as positive and "death" as negative.

3.3 Romeo and Juliet

Not requiring any introduction, *Romeo and Juliet* is one of Shakespeare's masterpieces. A number of films representing young love and based on this play were produced in the 20th century. This story tells of the affection between Romeo and Juliet, and of the competition between the two households to which they belong. Figure 5 shows the visualized result, based on a painting by Ford Madox Brown. The primary red and bright yellow colors used in the painting express well the strength and purity of their love. The positive keywords are defined by "love" and "affection"; the negative keywords by "kill," "die," "dead" and "death." The bright gold color in the first half shows the scenes from the outset of their love until their marriage. In the middle of the story, a black area appears, corresponding to the death of Juliet's cousin, Tybalt, who was killed by Romeo as revenge for his friend's death. The end of the story has both gold and black areas since both leading characters eventually die because of their strong love.

3.4 King Lear

Shakespeare's *King Lear* is a tragedy played out by King Lear and his three daughters. The story depicts the theme of filial love and duty. Figure 6 shows the visualized result of the story, for which a painting by William Dyce was chosen. The sharp change in color in the painting matches the dramatic change in Lear's destiny. The result expresses the frequency of two of the male characters, Kent as the positive and Oswald as the negative. The keywords can be defined by characters like these because the two men play opposing roles. Kent supports the honest behavior of the youngest daughter, Cordelia, while Oswald is his rival as the butler of the oldest daughter, Goneril. At the beginning of the story, Cordelia rebels against Lear, her father and king, for having been disowned. Kent protects her from Lear but both are banished from the country. This part is shown in bright colors in the visualization. Thereafter, Oswald and the other daughters treat Lear harshly by ignoring their promises to him, as depicted by the wooden color. A bright area appears again in the middle of the story, corresponding to the scene in which a disguised Kent returns to Lear. The story ends with Cordelia's death while attempting to help Lear. The resulting visualization imitates the outline of the story admirably.

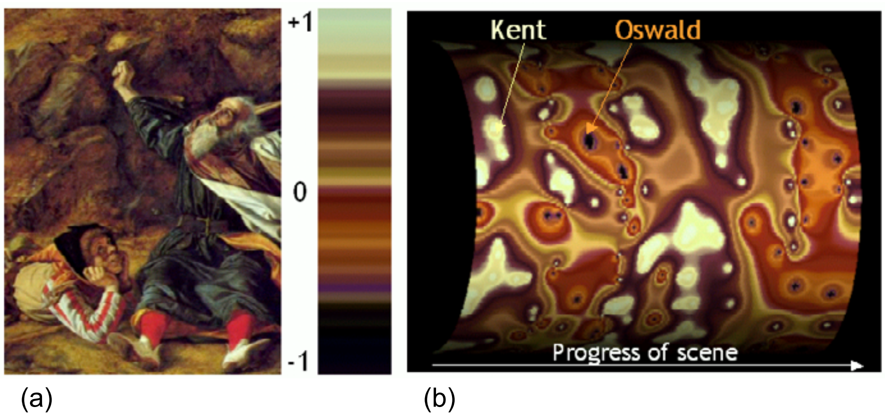


Fig. 6. Story visualization for *King Lear*: (a) a picture of King Lear and the Fool in the Storm by William Dyce (1851), and (b) the story visualized with "Kent" as positive and "Oswald" as negative.

As shown above, the visualization of individual stories produces colorful pictures enabling us to capture the meaning visually. It is obvious that additional analysis can be performed with this tool. For instance, we expect to identify differences and correlations between the plays. From an informatics point of view, a Fourier analysis will show the speed and rhythm of the story. Taking the gradient vector of the scalar field may silhouette the mutual interaction between two events or characters. Furthermore, other mathematical approaches are available, such as calculating the entropy of the story, the eigenvalue of the scenario, and a streamline of the story flow. If various model equations are applied to the data, we expect to extract further latent information hidden in the story. These extensions are to be included in the next stage of the study.

4. Summary

This paper focuses on a methodology for story visualization. For demonstration purposes, we have chosen some of the world's most famous theatrical works, by William Shakespeare. Our proposal for the visualization is to detect keywords in the text to derive the structural pattern of the story. The pattern is expressed by a continuous scalar distribution that is uniquely determined by a Laplace equation. The numerical distribution is converted to a color picture using an original color chart that is relevant to the story. The visualized results are generally consistent with the real story. Thus the story originally described by the text is successfully visualized by visual imagery. As this study advances, the authors expect that more sophisticated visualization will be achieved by applying a variety of mathematical functions to the plays. In parallel in the next stage, we aim to apply this tool to all of Shakespeare's plays, not only the tragedies, but also the comedies, histories, and romances.

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