Narrative as a Complex Network : A Study of Victor Hugo's Les Misérables

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ABSTRACT
Propelled by the recent advances in digitization of books and computational methods for automated text analysis, we are witnessing a promising opportunity for a serious scientific study of narratives. The importance of such an endeavor stems from the fact that a good story, albeit often fictional and artificial, is composed of highly believable characters who interact and experience a sequence of events together in a realistic world setting, and thus a better understanding of narratives may yield new insights for comprehending various social phenomena as well as literature. Here we present a scientific framework for modeling narrative as complex networks, which allows us to study how the narrative structure is reflected in the network of characters and how they allow us to understand the dynamics of narrative progression. This demonstrates the type of complexity that must be addressed by the scientific framework for narratives.

Author Keywords
Network analysis; Narratology; Social network; Network growth; Narrative; Network humanities

ACM Classification Keywords
J.5 Literature; C.2.1 Network topology; I.2.7 Text analysis;

INTRODUCTION
In recent years, advances in quantitative methodologies for the modeling and analyses of large-scale heterogeneous data have made possible the understanding of various complex social, technological, and biological systems from novel perspectives. And the horizon is expanding from such traditional complex systems to other fields including culture and humanities to find answers to new and long-standing problems, helped by the advent of large-scale data sets. For example, massive digitization of books (e.g., Project Gutenberg [14] and Google Books) have allowed scholars to perform high-throughput analyses of language and literature, collective memory, the adoption of technology, censorship, and historical epidemiology [19]. The global nature of web and the social media are also enabling massive transnational studies of contemporary cultural phenomena: Dodds et al. have recently studied the sentimentality of ten more popular human languages using data from various sources such as books, subtitles, song lyrics etc. [9]. Park et al. studied complex network of western classical composers constructed from a comprehensive recordings data from ArkivMusic [4] and revealed its basic properties and growth dynamics [22]. Schich et al. analyzed the network of notable individuals and showed the emergent processes in cultural history [25].

Among many data analysis frameworks, one that has attracted significant attention in recent years is network science. Network science attempts to uncover the underlying principles of a complex system from the patterns and the nature of the connections or interactions among its components [15]. By focusing on the interconnected nature of things, network science has made great strides in enabling a deep understanding of not only the systems easily recognizable as a network such as the Worldwide Web [2, 3] and the Internet backbone [8], but also those that have been intensively studied in other traditional domains such as biology, management, and sociology [6, 7, 13, 17].

In this paper we also aim to utilize the network framework to study a system that has not yet been widely studied by the framework although, as we argue later, we believe it can benefit hugely from a network treatment: narratives or stories. Narratives, or stories as they are called more colloquially, have long been studied by narratologists who tried to reveal universal patterns therein as they realized the importance of the narratives in how we perceive and portray the events and the world around us. A narrative is, at its core, a series of events, real or fictional, presented to the reader or the listener. Therefore the connection between the elements of the events -- people (characters), things (devices), environment etc. are very important in the construction of a well-written, engaging narrative. It is this importance of the connections between the elements that render narratives an appropriate topic for network science. While still in its infancy, there have been a number of notable works in the past several years that do highlight the importance of networks for understanding narratives. The community structure of the co-appearance network of characters from Victor Hugo's Les Misérables [21], the network of characters from William Shakespeare's Hamlet constructed from word exchange [20], and the social networks of characters from 19th-century British novels and serials from conversations [10] are such examples.

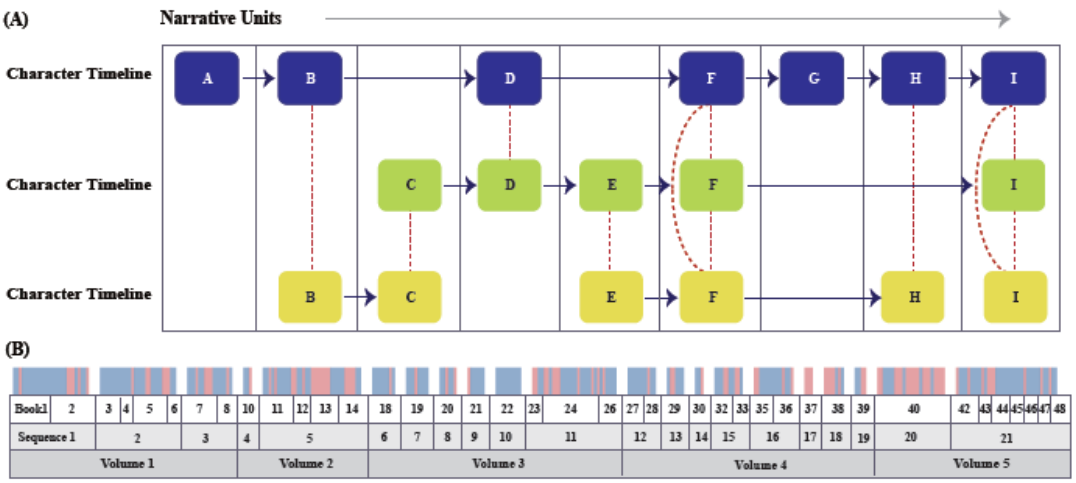

Fig. 1. (A) Character-centric diagrammatic representation of a narrative. A narrative is composed of character timelines, a record of the character's appearances in each narrative unit. Characters interact when they appear in a unit together. (B) Narrative units are not uniquely defined. One possibility is to use the author's designation (i.e. the Volumes, Books, or Chapters of Les Misérables). Here we introduce the concept of Sequence based on character composition, defined in the text

Background theory in narratology

The New Oxford American Dictionary defines a narrative as "a spoken or written account of connected events." In literary studies, a good narrative is said to involve a coherent message or overarching theme consisting of a continuant or consistent subjects, and constitute a whole from beginning to end. As such, the events described in a narrative often make a coherent point or relate to a single communicative goal. The essential building blocks of a narrative are said to be characters (also called agents or actants), events, and the causal and temporal relationships that weave them [5, 24]. A narrative is often broken down into smaller units such as acts, chapters etc. organized around a central theme or conflict [1].

Of the aforementioned building blocks of a narrative, characters are often the most central since the progression of the narrative is realized via their actions, transformations, and interactions with other characters. These constitute the plot of the narrative - its backbone, so to speak - referring to the main events being presented as an interrelated sequence. There have historically been many attempts to characterize the plot structure of narrative plot by extracting common and oft-observed patterns. The oldest and the most prototypical one is Aristotle's three-act plot structure theory: Act One is the setup where the central theme and question are raised, followed by two major turning points that form Acts Two and Three before the narrative concludes with a climax and a final resolution. Variant forms of it such as a four-act plot structure theory exist as well [11, 27].

While the three- and four-act structure theories may be useful, there are naturally many ways in which they can be extended to be able to help us understand the huge volume of narrative or stories that exist in literature. That is, in fact, not only possible but also necessary: the themes may be different from narrative to narrative, and each narrative may contain more than three events and many more characters, resulting in the level of complexity that requires dividing the narrative into more than a flat structure composed of mere three or four smaller units. An interesting work in this direction is by Propp who, while trying to describe Russian folktales using formalism based on symbolic notation, proposed two layers of a narrative, the fabula and the sjuzet [23]. The fabula refers to the entirety of all the events that occur in the story world, while the sjuzet is its subset that are explicitly presented to the reader. For instance, when a narrative is depicting character A engaged in some action (e.g., fixing a lunch) it forms the sjuzet, while the rest of the characters in the story world and their actions are not. Although they are not presented to us explicitly as they are happening, they are still important for the consistency of the story world. They can therefore be said to be always interacting with the sjuzet implicitly, and how they influence and reflect the narrative development is very important for understanding the structure of the narrative.

Character-centric network representation: Interacting timelines

Given that it is often the characters that advance a narrative through their actions and interactions, it is appropriate to represent the structure of narrative as a collection of character appearance and interactions. Since there are many characters appearing concurrently in the narrative, we represent the narrative as a set of interacting **timelines** of the characters, shown in Fig. 1 (A). A character's timeline shows their appearance in each stage of the narrative and interactions with others. What we consider as an appearance of a character and an interaction with others is up to not only the narrative format but also the modeler's choice. It is easy to do for a dialog-driven script for a movie or a play since the point of a character's appearance and their dialog partners are clearly marked. In a novel,

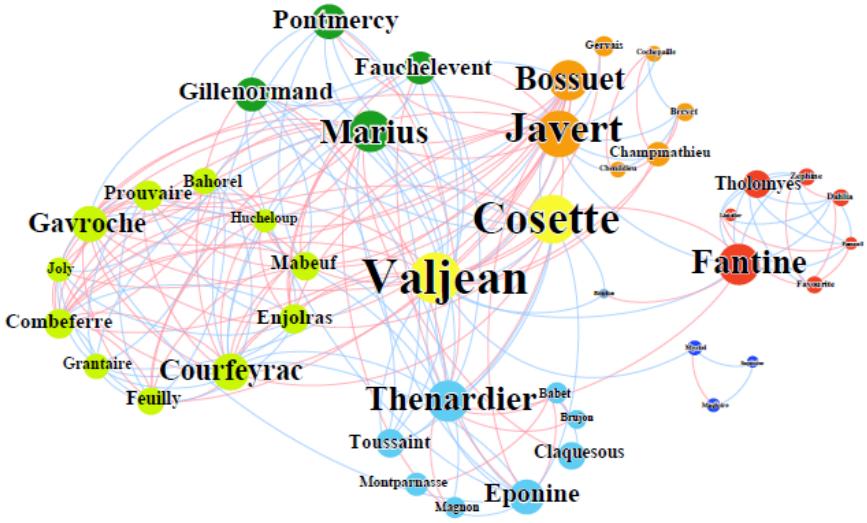

Fig. 2 The character network of Les Misérables. The node radius is proportional to its degree (the number of its neighbors), an indicator of the character's importance of activity in the narrative.

however, there can be ambiguities in determining the exact point of action or interaction by characters. For our analysis of the Les Misérables we choose to define a ``narrative unit" or ``sequence", and consider two characters to be interacting when they appear in the unit together. In this sense, we mean an interaction to mean not only an explicit conversation or contact but also being experiencing a common event and sentiments such as happiness or sadness. This latter kind requires an advanced text analysis and is thus out of the scope of this work, but will be performed in a future study. In Fig. 1 (B) we show the many levels of narrative units in Les Misérables. The **Volume**, **Book**, and **Chapter** (not shown due to their high count) are the designations by the author (Victor Hugo), while the **Sequence** is a grouping of the Books based on character composition; the exact method will be explained later. Each one could be used as the narrative sequence in Fig. 1 (A), although we use the Sequence in this paper.

DATA AND METHODOLOGY

We analyze the English translation of Victor Hugo's Les Misérables [16], freely available on Project Gutenberg [14]. Based on the Paris Uprising of 1832 CE, it is considered a classic that vividly conveys the social conditions of a tumultuous era and insights into the human psyche via richly developed characters and many intersecting plots and subplots. The main plot follows fugitive Jean Valjean who transforms into a force for good in a chaotic France while constantly being haunted by the constant shadow of his criminal past [29]. In the process he interacts with a wide range of characters some helpful or friendly, and others antagonistic and dangerous to him. The partial list of the major characters is as follows. *Fantine:* A young woman appearing in the beginning of the novel who is abandoned along with daughter Cosette. She leaves Cosette in the care of the Thenadiers who abuse her and keep demanding money. Valjean rescues Fantine when Javert, an inspector, arrests her on charge of assaulting a man.

i. *Cosette* (friendly): Valjean's adoptive daughter who once served the Thenardiers. Under the loving care of Valjean, she grows into a beautiful woman and falls in love with Marius.

ii. *Marius* (friendly): A young student associated with "The Friends of the ABC," a group that leads the Paris revolt. He falls in love with Cosette but fights in the barricade after parting with her. He is later rescued by Valjean, and marris Cosette.

iii. *Javert* (hostile): A police inspector who relentlessly pursues Valjean. After being saved by Valjean at the barricades and realizing the immorality of the system he has dedicated himself to, he commits suicide.

iv. *Thenadier* (hostile): A cruel, wretched man who abuses little Cosette. A lifetime schemer of robbery, fraud, and murder, he conspires to rob Valjean until being thwarted by Marius and arrested by Javert. He becomes a slave trader in the United States, and passes information on Valjean's true identity

Dividing a narrative into meaningful units has a long history. Narratologists, notably Tzvetan and Todorov, tried to define the smallest unit of story dividing narrative into **propositions** and **sequences** [26]. They proposed that at a minimum five propositions of Equilibrium, Disruption, Recognition, Attempt to Repair the Disruption, and Reinstatement of the Equilibrium compose a sequence, as the smallest plot, that make up the bare minimum of a completed story. Each proposition has an actant, a verb, and an adjective, each representing the character, event, and setting - the very basic element of story.

Les Misérables consists of 365 Chapters, 48 Books (collection of chapters), and 5 Volumes (collection of

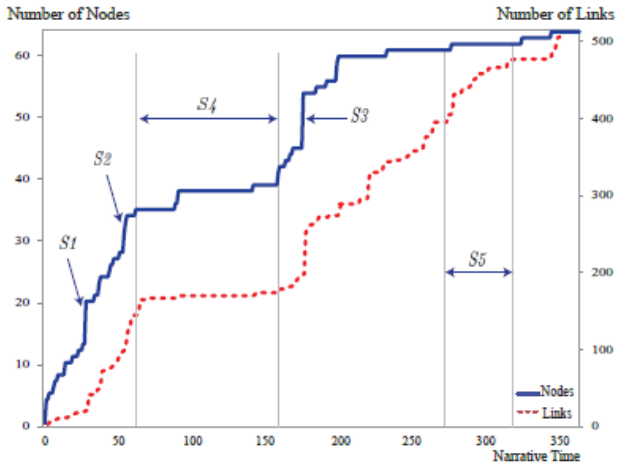

Fig. 3. The growth of the number of characters n and the number of edges m. The growth is nonlinear (i.e. growing at a uniform rate), indicating that different points of the narratives serve different purposes in the growth of the network. We note five stages S1 to S5 that show the relationship between narrative structure and patterns of network growth

books). One may accepted them as narrative subunits, as they do correspond to specific topics of themes of the novel. For instance, the five volumes are titled "Fantine," "Cosette," "Marius," "The Idyll in the Rue Plumet and the Epic in the Rue St. Denis," and "Jean Valjean," showing what they are primarily about. We find, however, using the volume as the narrative unit unsatisfactory for a couple of reasons. First, five units appear too few to properly capture the structure of a long novel known for many intersecting plots. Second, choosing to use the finer chapter or book as the unit still may not properly capture the novel's structure, since each plot or storyline may span different numbers of chapters or books. In this paper we propose way to bundle them into based on the changes in the characters in adjoining chapters, which we call "Sequences." Our character-based sequence determination method is as follows. Of the three elements of story, because the characters are the most straightforward to detect in a digitized text and play the most significant role in narrative progression, we assume that two consecutive bodies of text containing similar characters to be highly relevant to each other, parts of a common story arc or event. Specifically, we start from the 40 books (excluding 8 of them containing no characters) of Les Misérables, we calculate the similarity between consecutive books with regard to character composition (we used the cosine similarity, but other measures such as the Jaccard similarity could be used), and bundle consecutive books that are more similar than a prescribed threshold. Taking the threshold to be the average (equal to 0.481) of the similarities we end up with 21 narrative units (see Fig. 1 (B)).

NETWORK OF CHARACTERS: TOPOLOGY AND GROWTH

Our analysis focuses on the importance of the characters in a narrative since plot is defined as a chain of interaction centered around protagonists. In fact, one can easily see from many well written stories that it is often the adventures, tribulations, and the success or failure of the characters that make up principal component of a narrative itself. Therefore, structure of relationship represented in the characters network may indicate the state of certain characters showing the scope of the relationships they are involved in and their characteristics. Moreover, because interactions with different characters - allies and enemies - causes the changes or transitions that move a story forward, dynamics of relationships is the driving force of the character's developments and, consequently, the narrative as a whole.

Our network of Les Misérables contains 63 characters after very minor ones are excluded. The simplest network between these characters can be constructed by drawing an edge between two characters if they have appeared in a chapter together [21], resulting in m=504 edges. This means that 25.8% of the character pairs are connected (called the connectance of the network). See Fig. 2 The mean geodesic path length (a geodesic is the shortest path between two nodes) is 1.85, while the network diameter (the longest geodesic in the network) is 4 (between the pair of Babet and Geborand, and 17 other pairs of relatively minor characters) and the clustering coefficient is 0.77. The network is therefore denser and more compact than typical social networks [18, 28] [30]

From the perspective of the narrative flow, what interests usis how the network grows over time and what the patterns can teach us about the narrative. This is because the network is essentially coupled to the narrative flow: starting from an empty network in the beginning of the narrative, the network grows as new characters are introduced and interact with others until the end of the narrative. The temporal growth of the network is intimately connected to the concept of narrative stages. A common classification of narrative stages is Exposition, Rising Action, Climax, Falling Action and Resolution [12]. The Exposition stage introduces the characters and the space they inhabit. Once the motives and allegiances of the characters are presented, in the Rising Action the characters begin to struggle against each other until all conflicts are resolved throughout the last three stages. Based on this stage distinction, therefore, we can assume that n and m would not simply increase linearly in time but nonlinearly according to the nature of the distinct stages. In Fig. 3 we show the growth of n and m along the narrative time (measured in chapters). As expected, the growth is not linear, especially for the number of nodes n; the characters are introduced early, and there are specific points where many multiple characters are introduced simultaneously (noted S1, S2, and S3 in Fig. 3)

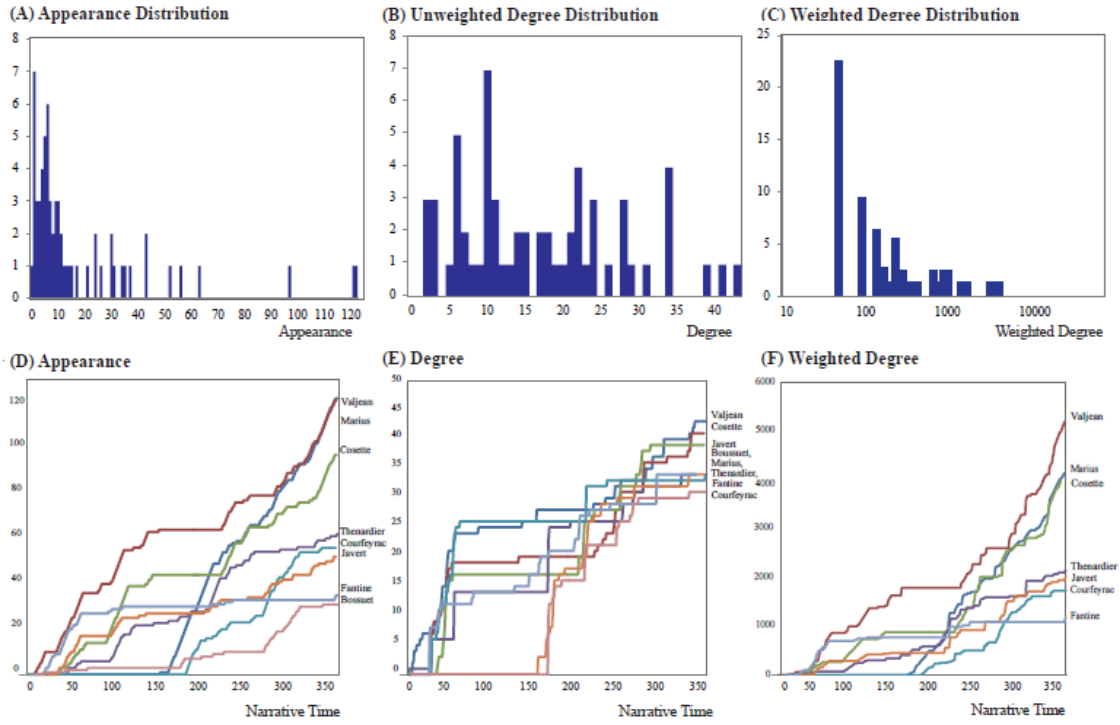

Fig. 4 (A) Appearance and (B) unweighted, (C) weighted version of degree distribution of characters in Les Misérables . Some of characters have high values in three distributions, while many of characters shows relatively small numbers. (D) Appearance of characters. The three most frequently appearing characters are Marius (122), Valjean (121), and Cosette (97). (E) Unweightd degree of characters. The three highest-degree characters are Valjean (43), Cosette (41), and Javert (39). (F) Weightd degree of characters. The three highest-weighted degree characters are Valjean (5203), Marius (4148), and Cosette (3977).

that suggest they are Exposition stages. An inspection of the actual story confirms our hypothesis:

- S1: Fantine's friends are introduced while her happy days are depicted.
- S2: Valjean's former fellow prison inmates appear during the trial of the fake Valjean.
- S3: “The Friends of ABC” (young progressives) are introduced, debating on various issues of the day.

There is also a stretch of chapters *S4* where the network shows little growth. This part largely coincides with volume 2 (“Cosette”) of the novel which contains chapter with no narrative progression (the author digresses to discuss the battle of Waterloo, religion, the vagrant children of Paris etc.) or one that is not driven by new interactions between characters, being mainly about Valjean and Cosette fleeing form the pursuit of Thenadier and avoiding people in general. Finally, near the end of the narrative at *S5*, it is the number of edges m that lead the growth of the network while n shows little increase. This - new edges are being created between existing nodes without the addition to new ones - implies a convergence of the characters into a common environment; the environment is in fact the barricade where nearly all major characters converge.

The network growth pattern shown Fig. 4 is aggregate. To understand the narrative structures based on the character network in more detail, we now study the centrality of each character. We introduce three measures: Appearance a, unweighted degree k, and weighted degree w. The simplest way to quantify the centrality of a character in a narrative is the number of narrative units (chapters in this case) in which a character appears. We call it the character's **appearance** a. We show the final histogram of n(a) measured in chapters in Fig. 4 (A). It has a skewed distribution with many characters appearing in a handful of chapters and a few characters appearing in many chapters, for instance Marius in 122, Valjean in 121, and Cosette 97, whereas the mean and the median are 19.3 and 9 respectively, nearly an order of magnitude smaller than the most frequent characters. In Fig. 4 (D) we show the temporal growth of each character's cumulative appearance. Although Marius and Valjean are similar in the total appearances (122 and 121, respectively), how they are reached is very different. Valjean first appears in the beginning of the novel and then with regularity until a noticeable absence between chapters 160 and 233 (showing a plateau). During Valjean's absence, Marius, making his first appearance in chapter 170, takes the center stage in the novel and appears in almost every chapter until he overtakes Valjean in appearance. This is a direct reflection of the structure of Les Misérables: the first part is mainly

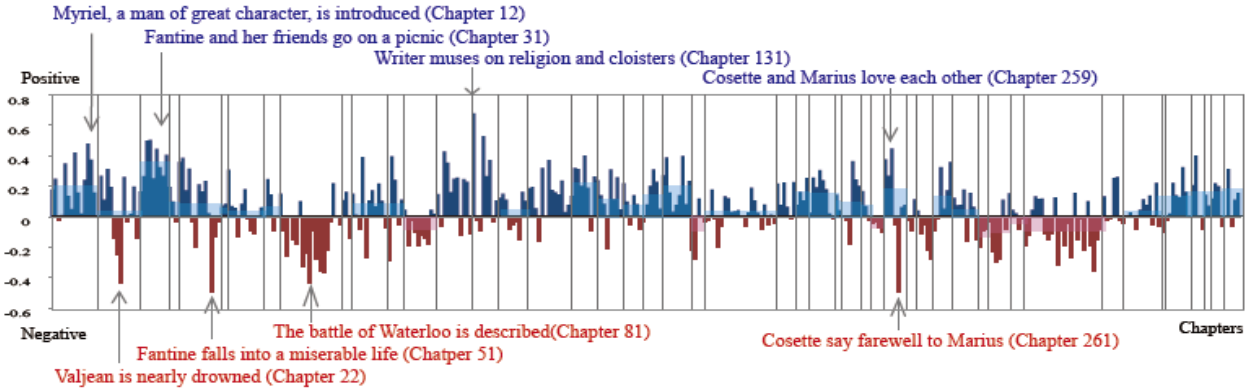

Fig. 5 Sentiment polarity indices of the chapters of Les Misérables. The 48 books of Les Misérables (collections of chapters) of the novel are separated by gray vertical bars. Each Book is colored (blue for positive and red for negative) according to the average polarity index of the chapters it includes. The sentiments of chapters appear to match their content moderately well; for eight select chapters (four positive and four negative) we show their contents: positive chapters depict uplifting characters or events (e.g., introduction of Myriel, a man of great character in Chapter 12) and happy events (e.g., Fantine going on a picnic, Cosette and Marius falling in love etc.), while negative chapters depict pain and suffering (e.g., Valjean nearly drowning in Chapter 22, Fantine living miserably in Chapter 51, war in Chapter 81, and lovers parting etc.).

about Valjean (with Marius absent), the second part is mainly about Marius (with Valjean absent), and the final part features both as major characters.

In the degree, on the other hand, differs significantly with appearance: Here the three highest-degree nodes are Valjean 43, Cosette 41, and Javert 39, whereas Marius is down to 34. This means that nature of the social sphere around a character cannot be sufficiently captured by appearance alone; in this particular case, this shows us that Valjean is a well-travelled character linking many different spheres of the story world, whereas Marius associates with a narrow pool of characters (namely the young fellow rebels) and his lone love interest Cosette. The weighted degree, the total number of times a character meets others, shown in Fig. 4 (E) and (F) is in a sense a combination of the two. Here Valjean is again the leading character, followed by Marius, Cosette, Thenadier, and Javert.

Simple centrality measures such as the degree introduced here typically measure the importance of a node in a single context, losing information on the nature of the connections. In a narrative where the relationships between people can be of very different qualitative types - friendly or hostile, for instance - and they matter to the drama, we ought to incorporate them into the network analysis as well.

QUALIFYING THE NATURE OF INTERACTIONS VIA SENTIMENT ANALYSIS

ur analysis so far has not distinguished the types of relationships. While it renders the analysis simpler and allows us to identify important nodes using straightforward centrality measures, it incurs loss of information on the nature of interactions between characters, which could lead to a more meaningful understanding of the narrative. For instance, the vast difference in nature between Valjean's relationships to Cosette and Javert - the former helpful and sympathetic, the latter hostile and antagonistic - are at the center of Les Misérables's storyline, driving the narrative and influencing the actions of the characters. While there have been found some relation and character types occurring in narratives [27, 23] here we apply a modern computational linguistic tool called Sentiment (Mood) Analysis to identify the nature of character relationships from the text of a narrative, and explore what we can learn about the narrative structures from them.

Sentiment Analysis, also called Mood Analysis or Opinion Mining, is a computational method for determining the qualities of a given text based on the words it contains. The origin of the technique can be traced to an attempt in the 1990s to which we combine into a single chapter polarity index $\sigma_i \equiv \left(\log_{10} \frac{\pi_i+1}{v_i+1}\right)$ σ_i is is larger (smaller) than 0 when it is more positive (negative), and equal to 0 when neutral ($\pi_i = v_i$). We then end up with the set $\sum\{\sigma_1 \dots \sigma_c\}$, where $c = 365$ is the number of chapters in Les Misérables, of chapter polarity indices. In Fig. 5 we show the polarity values $\{\sigma\}$ of the chapters. The sentiments of chapters appear to match their content moderately well; for eight select chapters (four positive and four negative) we show their contents: positive chapters depict uplifting characters or events (e.g., introduction of Myriel, a man of great character in Chapter 12) and happy events (e.g., Fantine going on a picnic, Cosette and Marius falling in love etc.), while negative chapters depict pain and suffering (e.g., Valjean nearly drowning in Chapter 22, Fantine living miserably in Chapter 51, war in Chapter 81, and lovers parting etc.). To quantify the sentimental qualities of relationships, we define the expected sentiment $\bar{\sigma}(\alpha)$ of chapters in which the character appears. Then we define the co-sentiment of character pair (α, β) as

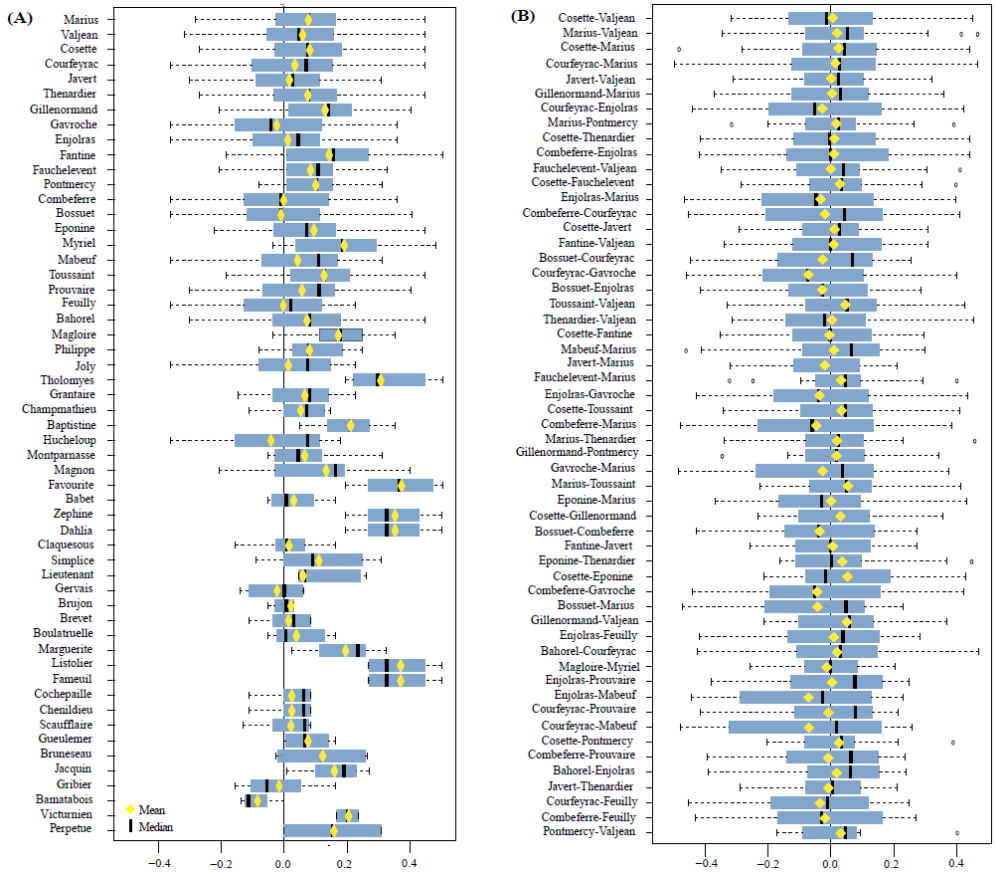

Fig. 6. (A) The sentiment polarity indices for the characters of Les Misérables. The yellow diamond indicates the mean, and the black bar indicates the median value for the chapters in which the character appears in. The blue box contains 25% of the chapters in which the character appears below the median, and 25% above the median. Notably, the leading characters (higher in the plot) show a wide range of sentimental values, unlike the marginal characters (lower) who tend to be more consistently sentimentally positive. (B) Co-sentiment polarity indices of character pairs. Cosette and Marius who develop into lovers are indeed happier on average when together than by themselves. But the fluctuations are sizable, demonstrating the sentimental complexity in character relationships.

$$\Gamma(\alpha, \beta) = \bar{\sigma}(\alpha, \beta) - \frac{\bar{\sigma}(\alpha) + \bar{\sigma}(\beta)}{2}$$

which is the difference between the average sentiment of chapters where α and β co-appear and the average of each character's expected sentiment. Thus, it is positive if α and β experience more emotionally positive events when together than by themselves, and vice versa.

The average chapter polarity is 0.060.01. While obviously a mix of tragic and happy story elements, Les Misérables nonetheless boasts an overall positive sentiment. This is likely to be another case of the so-called Pollyanna effect that refers to a universal positivity bias in human language. Given this fact, it is not surprising that for many of the characters the mean polarity values are positive (see Fig. 6 (A), where the characters are sorted according to appearance a), and Javert, an often joyless person, indeed is more negative than Marius, Valjean, and Cosette. Another notable point is that the leading characters (higher in the plot) show a wide range of sentimental values, unlike the marginal characters (lower) who tend to be more consistently sentimentally positive. This again highlights the role of leading characters as carriers of the narrative progression with respect to its sentimental states, in contrast to short-lived, marginal characters characterized by constant sentiments. The role of sentiments in the network of characters can be studied by exploring the co-sentiments Γ of character pairs, shown in Fig. 6 (B) for 63 most frequently co-appearing pairs, and in Fig. 3 where the colors of edges are colored according to this quantity (blue for net positive, and red for net negative). They appear reasonable in many cases: Cosette and Marius who develop into lovers are indeed happier on average when together than by themselves, evidenced by the net positive Γ. But also in this we see that the fluctuations are sizable, demonstrating the sentimental complexity in character relationships, just as in real life. For instance, Cosette and Marius show the happiest sentiment when they meet and fall in love, but precisely because of their love they can also experience a very negative mood when they part and one gets gravely injured later at the barricades. Also, Javert and Valjean, as hostile as their relationship is throughout the narrative, show a net positive co-sentiment, helped by the

scene where Javert lets Valjean go and carry Marius to safety.

The sentimental nature of the relationships also reflects the narrative structure, and using the information allows us to understand the narrative in more detail, as expected. However, the wide fluctuations in the sentiment polarity indices again tell us that we need to explore the dynamical changes in the sentimental nature of relationships as the narrative progresses. This topic will be further explored in a future study.

DISCUSSION

In this paper we tried to establish a network framework for studying a narrative. By modeling a narrative flow as a growing dynamic network of characters, we demonstrated what the evolving network patterns reveal about the narrative structure. We also introduced a method to quantify the qualitative, sentimental nature of character relationships, which showed us the complexity of relationships, as in real life. While this work is the first part of a longer exposition, we believe that this work contains some useful and fundamental ideas for bringing the methods of complex networks towards understanding narratives. Given the ubiquity and the importance of narratives and good storytelling, we hope our work can contribute to the development of many useful theories and applications in understanding them.

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