RST as Narrative Structure for Node-Based Editors

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ABSTRACT

Despite Narrative Visualisation's (NarVis) proliferation in academic circles, a narrative structure designed to suit the individual challenges and needs of the discipline is yet to mature. We present both a structure and tool for NarVis that remediates narrative form and concepts using Rhetorical Structure Theory (RST). Through RST, we develop a dynamic narrative structure that avoids many of the trappings of traditional narratives.

Our RST-based structure has been implemented as a node-based editor, itself part of a broader tool for generating dynamic narrative visualisations. We discuss this tool's theoretical foundations, its implementation, and demonstrate it through a narrative about COVID-19. This paper marks an important step towards establishing a clearer view of the narrative elements of NarVis.

CCS CONCEPTS

• **Human-centered Computing** → Visualization; Visualization systems and tools; • **Human-centered computing** → Interaction design; • **Applied computing** → Arts and humanities.

KEYWORDS

Narrative Visualisation, Computational Linguistics, Narratology

ACM Reference Format:
Cameron Edmond*, Maxime Cordeil, Rob Lawther, and Tomasz Bednarz. 2021. RST as Narrative Structure for Node-Based Editors. In *The 14th International Symposium on Visual Information Communication and Interaction (VINCI '21), September 06–08, 2021, Potsdam, Germany*. ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3481549.3481556

1 INTRODUCTION

The field of Narrative Visualisation (NarVis) or Data Storytelling has proliferated in recent years within academic communities as a methodology by which data visualisers can more effectively communicate their data [26]. Despite its history, there is little in the way of a formal "narrative" structure for NarVis. Advocation for a single narrative structure risks repeating many of the problems narrative and folklore studies have grappled with in the past [4]. However, all new mediums eventually develop their own formal techniques and frameworks. Evidence of this exists within film [9], graphic novels [18] and videogames [19]. By a similar token, we suggest that establishing a unique narrative structure for NarVis may allow for greater experimentation and expression within the NarVis field. Our emphasis is on de-coupling the field from the narrative traditions it currently works within.

We have looked outside the field of narratology and narrative structures and instead engaged with computational linguistics, adopting elements of Rhetorical Structure Theory (RST) [29]. Through streamlining RST and remediating it into our bespoke NarVis platform, we present a dynamic narrative structure suited for use in narrative visualisations. Our integration of RST into the NarVis discipline is also a novel theoretical contribution. This paper includes an overview of this narrative structure and details of tool development, followed by a discussion of the sample NarVis presentation we have crafted with our tool, shown in Figure 1 and accessible from https://youtu.be/0y6gvQQudV0.

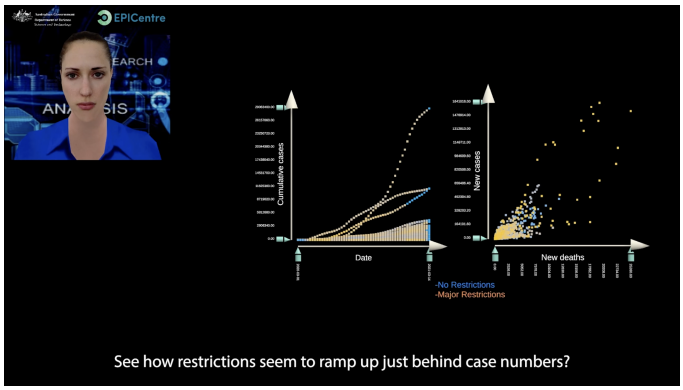

Figure 1: A scene from our narrative, made using our NarVis tool. A virtual adviser (right) narrates over visualisations (left).

2 RELATED WORK

Data Storytelling with visualisations has emerged in the past decade as an essential and powerful tool to convey complex information to an audience [17]. Data Storytelling often relies on linear narratives and visualisations to immerse users in a given context. Experimental

VINCI '21, September 06–08, 2021, Potsdam, Germany

ACM ISBN 978-1-4503-8647-0/21/09…$15.00
https://doi.org/10.1145/3481549.3481556

and impactful examples include *The Fallen of World War II* [11] and *Is the NASDAQ in Another Bubble?* [14].

Our work on NarVis' structural elements draws on our prior investigation into the relationship between the narrative and visual elements of NarVis media [7]. We iterate on this work by investigating the structure that the narrative itself may take.

While the NarVis field is populated with tools [24], only a handful consider narrative structure. NBVT allows the authoring of narrative visualisations based on digital library content, utilising a sophisticated narrative ontology [20] based on the Event Calculus theory of Artificial Intelligence [2], an action-and-change based form of reasoning that can be presented narratively [22]. Where NBVT focuses on narratives with minor visual cues, our work is invested in entwining narrative with traditional data visualisation.

Most of this paper's lineage is found in its use of RST, a descriptive linguistic approach for understanding textual organisation. RST focuses on the relationship between a text's "discourse elements" [21]. Texts are defined by the relations between their different discourse elements.

RST use cases are diverse [29]. Sahan [27] interrogated the use of RST on journalistic stories to teach language. Abdalla et al. [1] used RST to systemically analyse how Alzheimer's Disease manifests in speech. Kraus and Feuerrigel [16] used RST to create discourse-aware neural networks for sentiment analysis. Much like these works, we adapt RST for our own use. We also streamline the RST structure to avoid overwhelming users.

3 NARRATIVE STRUCTURE

When crafting our narrative structure, we considered the benefits and pitfalls of using traditional narratology. Much of the NarVis discipline loosely adopts narrative forms from fiction. Gershon and Page [10] present storytelling as rooted in literary texts, evident in their references to novellas and films. Kaplan and Dahlstrom [13] lean even further into the realms of traditional narratology, discussing how entertainment media communicates science through storytelling. The pair interweave their inquiry with narrative examples written as traditional, text-based narratives that include dialogue, focalisation, drama and characterisation.

The uncritical alignment of NarVis with traditional narrative structures is concerning. Film and literary structures often come with implicit inclusion of Campbell's Monomyth [4]. The Monomyth refers to a meta-narrative Campbell states all stories follow. Despite its widespread use, Campbell's narrative structure has been rejected by folklore, mythology and narrative scholars due to its far-right ideologies and lack of academic weight [8]. Even scholars that accept Campbell's work suggest it is outdated [12] [6]. Many advocates for NarVis [10] [13] view the vagueness and interpretive flexibility of narratives as a reason to use them in data communication. Vagueness and ambiguity may lead to incorrect conclusions, which is opposed to data communication's purpose.

Other work within the discipline advocates for a more NarVis-centric narrative. Segal and Heer [28] are often credited with laying the theoretical foundations for NarVis, and advocate for a more visualisation-minded take on narrative structures, barely mentioning traditional narratives. Obie et al. [24] have proposed a loose structure for "visual data stories", formulating methods to make narrative elements compliment visualisations.

With these arguments and positions in mind, we looked beyond traditional narrative structures, leading us to RST. RST is a linguistic framework, not a narrative structure. However, RST is applied to many different areas. As the NarVis narrative is a beast that exists 'between worlds', a more adaptive structure seems apt.

The RST framework provides a methodology for categorising the elements of a text not in terms of story structure, but instead by their relationship to each other [29]. RST suggests a text is made up of a "nucleus", such as a short statement, and "satellites", which are other textual elements that relate to the nucleus. Satellites may provide background information, an elaboration, or an opposing view. Complex texts may feature many nuclei.

By emphasising the relationship between textual elements, RST affords the writer a more dynamic, networked view of their text. Rather than having to force their data-driven findings into a narrative structure that may not fit, they are instead asked to consider their narrative from the perspective of what information is most important (the core nucleus of their NarVis presentation), followed by considering other elements such as what background information may be important (where data was collected from, how it was collected, etcetera), or what information may essentially be elaborations but not part of the core findings (seemingly non-significant outliers, or results that indicate further work in a different direction). Conceptualising one's narrative in this way ensures that the goal of clear data communication remains at the forefront of narrative creation, rather than falling to the maxim of "not letting the truth get in the way of a good story". As our discussion of our tool development will show, our exact structure evolved over the course of development.

Our RST tool is part of a larger toolkit for authoring narrative visualisations, the Narrative Visual Analytics Toolbox (NarVAT). NarVAT was developed in collaboration with Defence Science Technology Group (DSTG), and utilised our RST tool to link together and play back visualisations. Through RST, we were able to integrate DSTG's Intelligent Multimedia Presentation plug-in (IMMP), which had previously been designed to deliver multimedia, RST narratives through a digital human/virtual adviser [30]. While the original RST structure includes 32 relations, DSTG modified it to suit their technical specifications. We further iterated on this list, resulting in the RST structure detailed in Table 1

4 TOOL DEVELOPMENT

NarVAT offers NarVis creation and playback within one program. We identified the following requirements:

- An intuitive, "WYSIWYG" node-based editor.
- Clear communication of the RST structure to the user.
- Visualisation tool integration for authoring and playback.

The tool features three components: a node-based narrative editor (Figure 2), a visualisation editor, and a virtual presenter. Our node editor uses the xNode plugin,0F[1] a visual scripting tool we modified to suit RST. All components were integrated with the Multimodal High-End Visualisation System (HEVS) our team developed [3].

[1] https://github.com/Siccity/xNode

Table 1: Used RST relations list.

Relation	Description
Initialisation	Indicates a nucleus is the first in a narrative.
Preparation	Provides narrative information to prepare the user, such as why data was gathered.
Background	Provides situational information, such as data collection method or conditions.
Cause	Factors that caused the insight, such as context or additional correlations.
Continuation	Refers to another nucleus with its own satellites.
Elaboration	Provides additional information, such as future lines of inquiry, concessions, or contrasts.
Conclusion	Summarises the information.

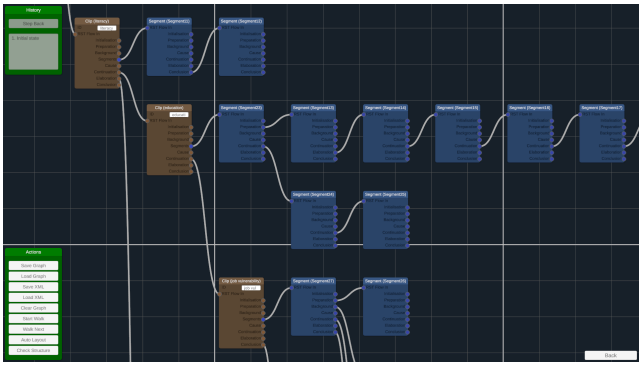

Figure 2: The RST tool. Brown nodes are clips, blue nodes are individual segments.

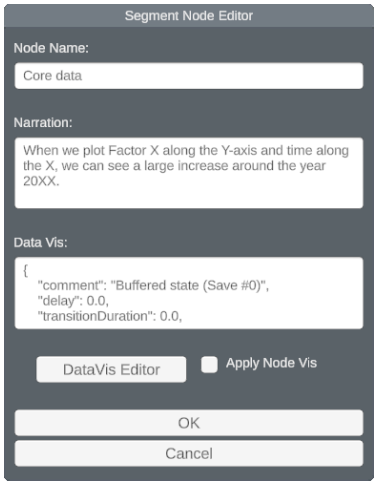

Figure 3: The properties of a node in our RST tool.

Nodes are created from a right-click menu and double-left-clicked to edit. Illustrated in Figure 3, the node properties are:

- **Node Name:** The name of the node itself.
- **Narration:** The textual element of the node. This is what the virtual presenter will read out.
- **Data Vis:** The associated visualisation in JSON. This includes graphs, annotations and camera positioning.

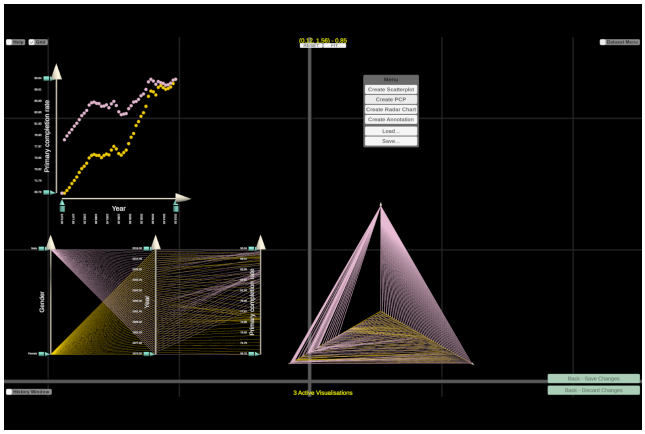

Figure 4: A screenshot showing a user experimenting with different visualizations.

4.1 NarVAT integration

Our visualisation tool was built using the Immersive Analytics Toolkit (IATK) [5].1F[2] IATK provided us an infrastructure for creating graphs within the Unity engine, which we expanded.2F[3] The currently available visualisations are scatterplots, parallel coordinate plots and radial charts, as shown in Figure 4. Through the use of heatmapping, shapes and filtering, NarVis authors can create additional plots.

The states of the data visualisations are saved as part of the node's data. Playback of the narrative is handled through an implementation of DSTG's IMMP. IMMP works to take the RST-narrative, and each node's corresponding data, from NarVAT and save it as an XML. When the user plays back their narrative, IMMP sends narration to the virtual adviser and the visualisation state to the data visualiser. As the presenter speaks the narration, the visualisations are recreated in real-time, unfolding in front of the user. Authors can choose to hide the presenter. Figure 5 shows a breakdown of this process. As NarVAT also creates a JSON output, the user can run their visualisations and narrative data through a tool other than IMMP if they wish.

It is in the playback with the virtual presenter that the real utility of RST comes to the fore. Our inclusion of a virtual adviser is informed by the positive impact a human presenter has on data

[2]https://github.com/MaximeCordeil/IATK
[3]A full discussion of our visualisation tool is outside the scope of this paper.

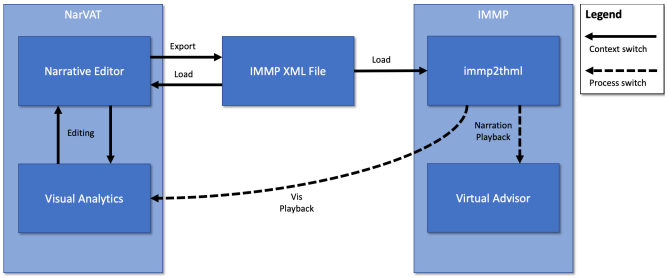

Figure 5: A diagram showing how our platform integrates with DSTG's IMMP plug-in and Virtual Adviser.

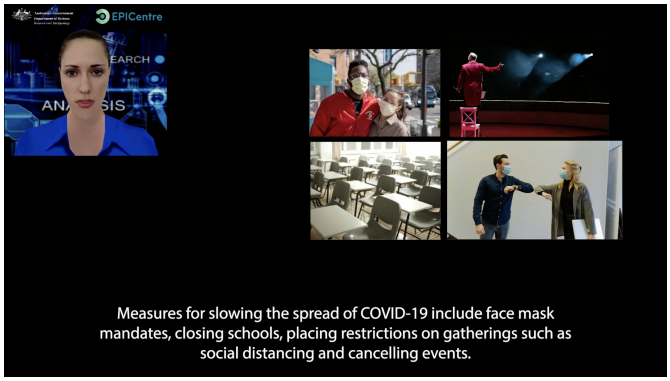

Figure 6: A scene from our narrative. The presenter discusses COVID-19 prevention methods, with annotations on the right.

presentations [23]. Our presenter is spatially integrated with the data [15]. Users are able to specify the length of time the narrative may run for in seconds. The virtual presenter then calculates the length of time each node will take to speak based on the text. If the presentation is too long, the virtual presenter will "prune" the nodes, based on the relation they have been assigned. Nodes considered more important will be kept, while those with less importance will be cut until the desired length is reached. Importance, in descending order, is: ***Continuation, Conclusion, Preparation, Cause, Background and Elaboration***. This order could be modified if the relations were altered.

Through our weighting, authors can freely create expansive presentations and then have them automatically edited to fit constraints. These constraints may be due to the audience demographic (specialists versus general audience), or the urgency of delivery (a rescue mission briefing versus a day-long workshop). All crucial information should be contained in the "continuation" nodes, so the presentation will still be useful.

4.2 Structural changes

As part of our integration with the rest of the NarVAT tool, there was a necessary alteration to our structure. DSTG's IMMP tool looks for RST relations, but within larger narrative "containers" known as clips. These clips encompassed multiple nuclei to allow for integration with multimedia elements. As such, our tool required the introduction of a "clip" node. The clip node is far simpler than other nodes. In practice, the clip node only features two relations: a "segments" relation that leads to a nucleus, and a "continuation" relation that leads to the next clip in the series. While this may seem like a minor addition, it introduces a deviation from our dynamic RST structure. Although authors using our tool still must think predominantly in terms of RST relations, they now have a more familiar, narrative-like element to help anchor and organise their narrative visualisation. Clips become something like "acts" or "chapters" to their narrative, placing a narratological restriction on what is otherwise an arguably non-narrative form. Through our use of RST, the potential pitfalls of traditional narrative structures are avoided. However, through the inclusion of clips, the structural fortitude of narratives is maintained.

5 NARRATIVE CONSTRUCTION

To demonstrate our tool's effectiveness, we have attached a short NarVis presentation as supplementary material, seen in Figure 5. The narrative was created by one of our authors. The presentation discusses global responses to COVID-19. This narrative was chosen due to the complexities of the data. Our presentation attempts to highlight how it may often appear that nations with high restrictions actually have more COVID-19 cases, but this is likely due to spikes in cases being followed by reactive restrictions, which stops further spread.

The presentation, depicted In Figure 6, used data from The World Health Organization [31] and The Oxford Martin School [25]. Although the RST structure at first appears slightly confusing, the intuitive nature of the node editor made experimentation easy. The integration of the visualisation editor meant the author could switch between narrative and visuals and quickly iterate. Additionally, by focusing on the importance and relevance of particular pieces of data or information rather than the narrative's dramatic potential, we were able to ensure the most important pieces of information were clearly communicated.3F[4]

6 CONCLUSION

Our RST tool re-thinks narrative elements of the NarVis discipline. We have proposed that the narrative structure of NarVis must be tailored to the objectives and forms of the medium, rather than simply co-opting other structures. We have also demonstrated the versatility of the RST model by applying it to the generation of narrative, something it was not explicitly designed for. The resulting RST tool affords NarVis authors a way to create narratives that remain anchored to narratology via clip nodes, but also allows them to focus on the importance of data by organising their narrative around the relationships between different segments.

We do not claim that the RST model presented here should be the only one used by NarVis practitioners. Instead, we offer a bespoke model for the NarVis discipline, allowing others in the NarVis field to re-think the relationship between narrative and visualisation

[4]The narrative was constructed to test and demonstrate the tool, not inform about COVID-19. Its insights should not be taken as a thorough analysis of the data.

in a way that privileges data clarity, rather than bootstrapping on potentially harmful narrative structures. This paper and the RST tool it describes offers a framework upon which the narrative of the NarVis medium may grow.

ACKNOWLEDGMENTS

The authors acknowledge senior software engineer Conan Bourke for his work on the visualisation tool. We also acknowledge our DSTG collaborators, in particular Steven Wark and Marcin Nowina-Krowicki for their insights and hard work.

FUNDING

This work was supported by funding from Australia's Defence Science and Technology Group (DSTG) [RG190540-A-Simulation and Visualisation Using Data Farming for Joint Operating].

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