LITERARY GEOGRAPHIES

Visualising Time and Space in *The Voyage of the Dawn Treader* and *The Magician's Nephew*

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Abstract:
Drawing on innovations in literary visualisation developed by the *Chronotopic Cartographies* project led by Sally Bushell at Lancaster University, this paper introduces two methods for visualising the spatial structure of literary texts both drawing upon the same underlying code and spatial schema. Using analysis of two 'secondary world' fantasies (that is, texts in which the events of a story occur in a space entirely divorced from reality) from C. S. Lewis's Chronicles of Narnia series, *The Magician's Nephew* and *The Voyage of the Dawn Treader*, the paper compares two methods of visualising spatial graphs of each text. The first is two-dimensional and synchronic, showing the spatial structure of the text as a whole; the second three-dimensional and diachronic, seeking to show how that spatial structure changes over time. In so doing we shall show the ways in which these different modes of visualisation invite new modes of interpretation, and reveal similarities and disparities between the two texts that would not otherwise be evident.

Keywords: C. S. Lewis; visualisation; spatial narratology; digital literary scholarship.

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C. S. Lewis's *Chronicles of Narnia* series has been enormously influential on children's literature. In the words of the preface to The *Magician's Nephew* (the first book following the chronology of the series, although written later), the books concern 'all of the comings and goings between this world and the world of Narnia' (Lewis 2009: 1), Narnia being another world or alternate reality, parallel to our own, which is visited via magical means by the children who are the protagonists of the books. This trope, inaugurated in these texts, remains a popular device in children's fiction and fantasy, appearing in contemporary works such as J. K. Rowling's *Harry Potter* series or Philip Pullman's *His Dark Materials*.

This essay discusses two of the Narnia novels: the aforementioned *Magician's Nephew* and *The Voyage of the Dawn Treader* in relation to the question of the visualisation of spatial and temporal literary form. In so doing, it draws upon learning from the *Chronotopic Cartographies* project into the question of the visualisation of time and space in the literary text. The project used a combination of XML markup, network graphs, and data visualisation techniques to create non-referential maps of literary works. It sought to free the spatial analysis of the literary text from the conventions imposed by geographic or cartographic conventions.

The two Narnia books presented here are examples of the necessity of this approach, and are employed to illustrate the value and effectiveness of this digital mapping method. Whilst both texts have sections set in the 'real' world, the majority of each takes place (in the case of *Dawn Treader*) in Narnia or (in the case of *Magician's Nephew*) in a combination of Narnia and a number of other discrete alternate realities. As such, visualisation of the spatial forms of these texts, and the insights that these visualisations enable, would not be possible using standard geographical approaches that only map to the real. Moreover, the two books, whilst both quest narratives (in the broadest sense), occupy different genres. *Voyage of the Dawn Treader* draws on sea voyage fiction and the medieval Celtic *immram* to describe a journey at sea (Swank 2019: 75). As such, were the narrative to be mapped geographically, it would be linear, with a defined start and end point to the voyage. *The Magician's Nephew*, conversely, whilst also a quest, has no defined start and destination, and draws instead on fairy tales, Milton and biblical sources for its narrative, with a much less linear spatial structure.[1] We therefore present two visualisation techniques to explore the spatial structures of the two books. The first, developed by the *Chronotopic Cartographies* team at Lancaster University, is entirely two-dimensional and shows the spatial structure of the novels synchronically. The second, developed by Andrew Rirchardson at Northumbria University, working as a CI on the project draws on the code from the first project but uses 3d graphics and animation to make visible the temporal structure of the books in addition to their spatial structure.[2] The two visualisation styles allow different qualities of each text—their similarities and disparities—to be shown, and offer complementary affordances for their interpretation.

This paper therefore begins with a brief overview of the *Chronotopic Cartographies* method and a discussion of the 2d visualisations and the interpretations that they facilitate. It emphasises particularly the way in which the 2d visualisations serve to illustrate the importance of liminal or bridging spaces between both narrative episodes and the separate

'worlds' of the books. It then moves on to describe the method by which the 3d visualisations were created and the design decisions entailed. Next there is an exploration of how the addition of temporal visualisation highlights the differing ways the liminal spaces function in each text, with implications on questions of genre. Finally, the paper opens out to discuss limitations of the model in terms of the question of dimensionality: that is, not only the familiar distinction between the two 'times' of the narrative (*fabula* and *syuzhet*), but also the problems that the multiple 'worlds' of the Narnia books raise for literary mapping and visualisation more broadly.

2d Visualisations

The Chronotopic Cartographies visualisation method is described in detail in Bushell et al. (2022a, 2022b) and in Sally Bushell's (2023) Introduction to this special issue of *Literary Geographies*. However, in order to proceed, a brief explanation of the methods used are necessary. The aim of the research was to develop methods to visualise, or spatialise, the structure of works of fiction in abstraction from real-world geographies. This was to address a fundamental issue with approaches to digital literary mapping which have used technologies such as Geographic Information Systems (GIS) to interrogate the relationship between the 'real' world and literary space. The issue with these approaches, whilst they are of great explanatory value, is firstly that they implicitly or explicitly presuppose a representational relationship between the literary text and real world geographies. Secondly, such approaches render texts which contain either no real-world or imprecise real-world references un-mappable, and therefore outside of the scope of spatial literary analysis.

The approach taken by *Chronotopic Cartographies* has been to abstract literary space from real geographies by modelling texts as *graphs*. A graph in this sense is a mathematical representation of a network consisting of 'nodes', or the points on the network, and 'edges', which are the connections between them. These structures are very useful in a number of domains as they allow the relationships between different types of entities to be modelled and represented. Within the digital humanities, they are most often used for modelling the relationships between social groups. For example, the relationship between two people might be represented as a very simple graph, with two nodes and a single edge: Tolkien —> was friends with —> Lewis. Adding further nodes and edges to this graph would enable the relationships between groups of people to be modelled. From this one could infer, for example, that if someone on this network was highly connected to many other people, they were an 'important' member of that group, as seen, for example, in the Carnegie-Mellon University project *Six Degrees of Francis Bacon* (Warren et al. 2018).

Graphs allow literary spaces (that is, the locations mentioned or the places where events are described as occurring) and the ways those spaces are connected to be modelled and visualised without necessarily relating them to real-world coordinates.[3] This approach has the advantage of, first, not presupposing a representative relationship between literature and the real world, and, second, allowing the visualisation of the spatio-

narratological qualities of any literary text, whether or not that text has real-world reference. The resultant web of spaces and the connections between them constitutes a 'ground' or 'map' of the text: in effect, we move here from literary *topography* to literary *topology* (Bushell et al. 2022a).

The principal visualisation type created for the project is two-dimensional and synchronic: that is, it shows the spaces of the text as a whole, as would a conventional cartographic map. Creating these visualisations is a three stage process: XML markup, graph generation, and visualisation. In the first stage, a text is annotated using a custom XML schema designed to identify spatial 'blocks' in a text, how they are connected with one another, and the linguistic elements which compose the spatial references within them.[4] This data model describes three principal entities. The first of these, *topoi*, correspond loosely with the notion of 'setting' and refer back to the Bakhtinian concept which underpins the project as a whole – the 'chronotope' (Bakhtin 1981). *Connections* represent the spatial (or narratological) links between topoi. *Toporefs* are words or phrases which indicate spatiality *within* a topos but which do not themselves constitute a separate topos in and of themselves. In order to capture the full narratological structure, the entire text is treated as 'spatial', with every passage contained within a topos. Each of these entities is assigned one or more attributes. In the case of topoi, each is assigned a chronotopic archetype, derived from Bakhtin. In the case of the connections which link the frames, the nature of the connection is given, that is,. directly spatially connected; indirectly spatially connected; a narrative 'jump' from one place to another; or one of various metatextual relations. Attributes for toporefs designate whether they compose spatial references within the purview of the current frame or without it.

When a text is fully marked up, the resultant XML file is processed using the Python libraries BeautifulSoup (for XML tree traversal) and NetworkX (for graph generation).[5] This results in a network graph representing the topoi and toporefs of a text, represented as nodes on the network, and the connections or relations between them, represented as edges. Each topos is also given a 'length' attribute – the number of alphanumeric characters it contains –which indicates the portion of the text dedicated to that topos.

Once the graph has been created, it is then laid out using either NetworkX's built-in layout algorithms or with Gephi, an open-source package for working with network graphs. The graph is then further processed using a custom Python library for styling, written to overcome some of the shortcomings of Gephi's built-in graphical capabilities. In particular, it was decided that symbology was more appropriate for representing chronotopic archetypes than colour as these represent qualitatively different types of space rather than continuous values; secondly, the significance and number of the different types of connection between frames called for easily-distinguished line styles (double lines, dotted and dashed) which could not be created in Gephi. Each node is scaled according to the 'length' attribute, indicating the proportion of the text dedicated to it. The final product of the processing is a series of images, each representing different aspects of the underlying spatial graph modelled in the XML file.

The Magician's Nephew

The first visualisations presented here are those of *The Magician's Nephew*. Though it represents the beginning of the Narnia arc narrative, this book was published towards the end of the series, and provides the context (and a retrospective explanation) for the stories which preceded it. Figure 1 shows the spatial structure of the book in terms of its topoi and the connections between them. (For the purposes of the argument explored here and for visual clarity toporefs are not included in the visualisations in this essay). So as to explicate the relationship between the plot of the book and the visualisation, we provide a relatively detailed summary of the narrative and how it is shown in Figure 1.

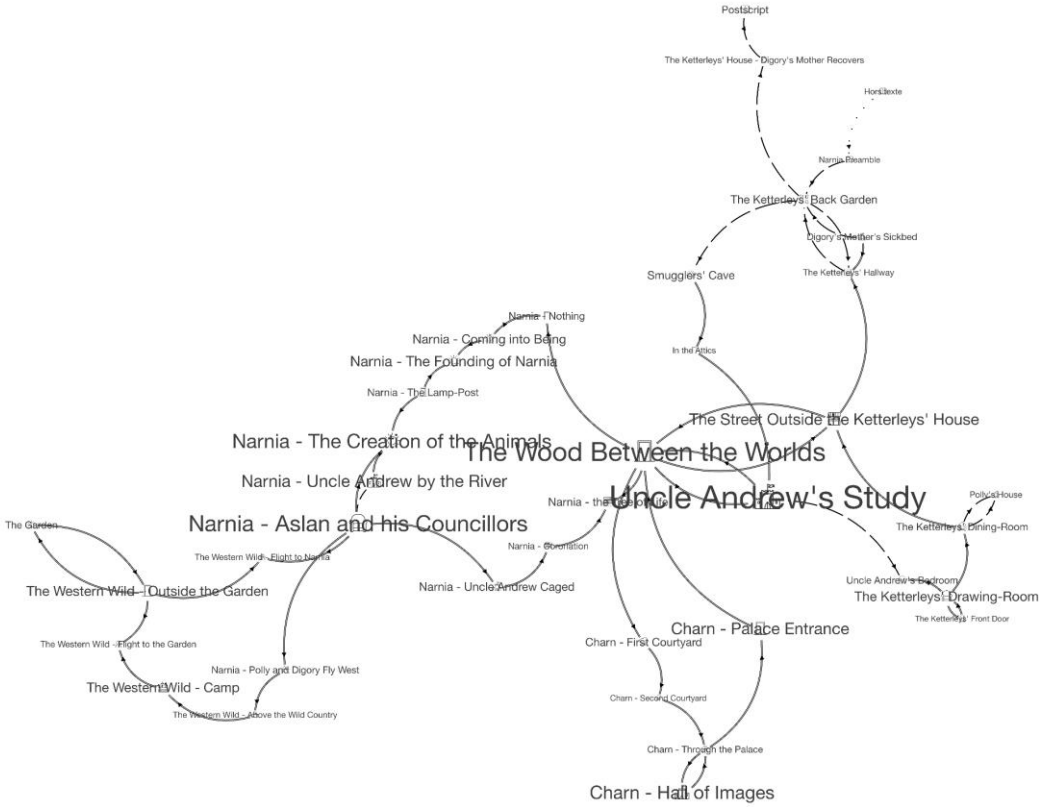

Figure 1. The Magician's Nephew: Topoi Map.

The book describes the adventures of two children, Polly and Digory, neighbours in an unnamed suburb in Edwardian London. Digory's mother, it is implied, is terminally ill, and, as his father is in India, she and Digory are living with his aunt and uncle, Letty and Andrew Ketterley. Polly has made a den in the attic of her house which she calls the 'Smuggler's Cave', and, exploring the lofts beyond, the children surmise that their houses must be connected through their roof spaces. They enter a door in the attics which they think leads to Digory's house, but instead they find themselves in Uncle Andrew's study. Uncle Andrew, it transpires, is a magician. Using magical dust from a box of relics from Atlantis, Uncle Andrew has created a pair of rings which enable the wearer to travel between 'worlds', or universes. A cruel and cowardly man, Andrew tricks Polly into touching one of the rings, causing her immediately to vanish. Digory is then forced to go after her, bringing with him a second ring which will allow them to return home. Visualised, these first spaces can be seen towards the top of Figure 1, forming a line from the (a-spatial) *hors texte* and preamble which establish the link between *The Magician's Nephew* and the rest of the series, and the spaces of the back garden, the smugglers' cave, the attics, and Uncle Andrew's study.

On vanishing from the study, Digory finds himself emerging from a pool of water into a wood. Close by is Polly, and many other pools of water. Between them they deduce that this place—the Wood Between the Worlds, seen at the centre of Figure 1—is an interstitial realm which allows access to many others, each pool being a gateway to another world. Rather than returning home, Polly and Digory decide to jump into another pool and arrive in the world of Charn, a deserted, lifeless city. Here proceeds the second portion of the narrative, seen as the loop at the bottom of Figure 1, starting and ending at the Wood Between the Worlds and moving through courtyards and palaces of Charn. In their explorations, Polly and Digory discover a room of statues (the Hall of Images). In the centre is a bell, which Digory strikes. This causes one of the statues to come to life and the palace to start collapsing around them. The awakened statue is Jadis, a former Empress of Charn, who, at the height of a civil war, spoke the 'deplorable word' causing all life on Charn to be extinguished, and who as punishment was frozen in a form of suspended animation ever since. Whilst they attempt to escape the collapsing palace, Jadis discovers the rings and tricks Digory into touching one, returning all three of them to the Wood Between the Worlds, and then to Earth.

A faintly farcical series of events ensues, in which Jadis enlists the help of Uncle Andrew to conquer our 'young' world, and which can be seen in Figure 1 to the centre right. Again, this segment begins and ends at the Wood Between the Worlds, looping through Uncle Andrew's study, various rooms in the Ketterley's house, and departing from the street outside. Despite her superhuman strength and magical abilities, Polly and Digory are able to return Jadis to the Wood Between the Worlds, bringing Uncle Andrew with them. However, rather than returning her to Charn they enter another pool and become witnesses to the birth of a new world: Narnia.

The final portion of the narrative, beginning in 'Nothing' and then looping, in a figure-of-eight through Narnia and the 'Western Wilds', takes up the whole left-hand

portion of Figure 1. Narnia is sung into being by Aslan, a lion, who, in the allegorical system of the novels, is analogous to the biblical Jesus. Jadis, terrified by Aslan, escapes into Narnia, and there discovers a magical apple tree, which on eating its fruit, grants her immortality. Aslan charges Digory with having introduced evil (in the form of Jadis) to the world of Narnia, and, to atone for this, asks him to retrieve the fruit of this same tree and plant its seed in Narnia. This he does, resisting Jadis's temptation to eat the fruit for himself. The tree grows immediately in the magical Narnian soil, and its fruit, now loathsome to Jadis, will keep the country safe from her evil, at least temporarily. Having atoned for his misdeed, Aslan allows Digory to take an apple from the tree and the children and Uncle Andrew are returned by magical means to London. Digory gives the fruit to his mother, who miraculously recovers, and he plants a seed in Uncle Andrew and Aunt Lettie's back garden. Many years later, Digory becomes a world-renowned professor, and, after the tree died, he had its wood made into a wardrobe. Jadis, meanwhile, is revealed to be the White Witch, the antagonist in the first book of the series, *The Lion, The Witch, and the Wardrobe*. This final portion of the narrative, starting once more from the Wood Between the World, returns to the Ketterley's back garden where the story begins, and can be seen at the top right-hand corner of Figure 1.

The Voyage of the Dawn Treader

We shall return to Figure 1 shortly; however, before we proceed we must first introduce our second visualisation (Figure 2) which shows the spatial structure of *The Voyage of the Dawn Treader*. This book, third in the series though written before *The Magician's Nephew*, relates a sea voyage in the world of Narnia. Lucy and Edmond, the two youngest Pevensie children who are protagonists of the first two books, are sent one summer to stay with their cousin Eustace. Eustace's parents are 'up-to-date' and Eustace himself is portrayed, at least initially, as rude and stupid. In Lucy's bedroom, the children discover a painting of a ship which, as they watch, starts to move, and they are cast into the sea at her bows. Rescued by the crew, they find themselves in the company of Caspian, King of Narnia and a major character in the previous book, *Prince Caspian*. This opening section is visible to the far left of Figure 2 proceeding from the preamble, through Lucy's room, into the sea and on to the main deck of the Dawn Treader. (We note that from this point onwards the story is set almost entirely in Narnia, making the text even less amenable to literary geographic approaches than *The Magician's Nephew*).

Caspian is on a quest to discover what happened to seven lords of Narnia who were sent by his uncle to explore the 'Eastern Seas beyond the Lone Islands'. The book then follows the Dawn Treader and her crew as they proceed to do just that. As such, it has an episodic structure, clearly visible in the spatial graph, which takes the form of a series of loops centred on the cluster of spaces which make up the ship. The first of these, at the bottom right-hand side of the visualisation, is to the Lone Islands, starts and ends on the forecastle of the *Dawn Treader*. The second, to Deathwater Island, composes the first part of the loop at the centre-top of the visualisation, followed by Coriakin's Island, The Island

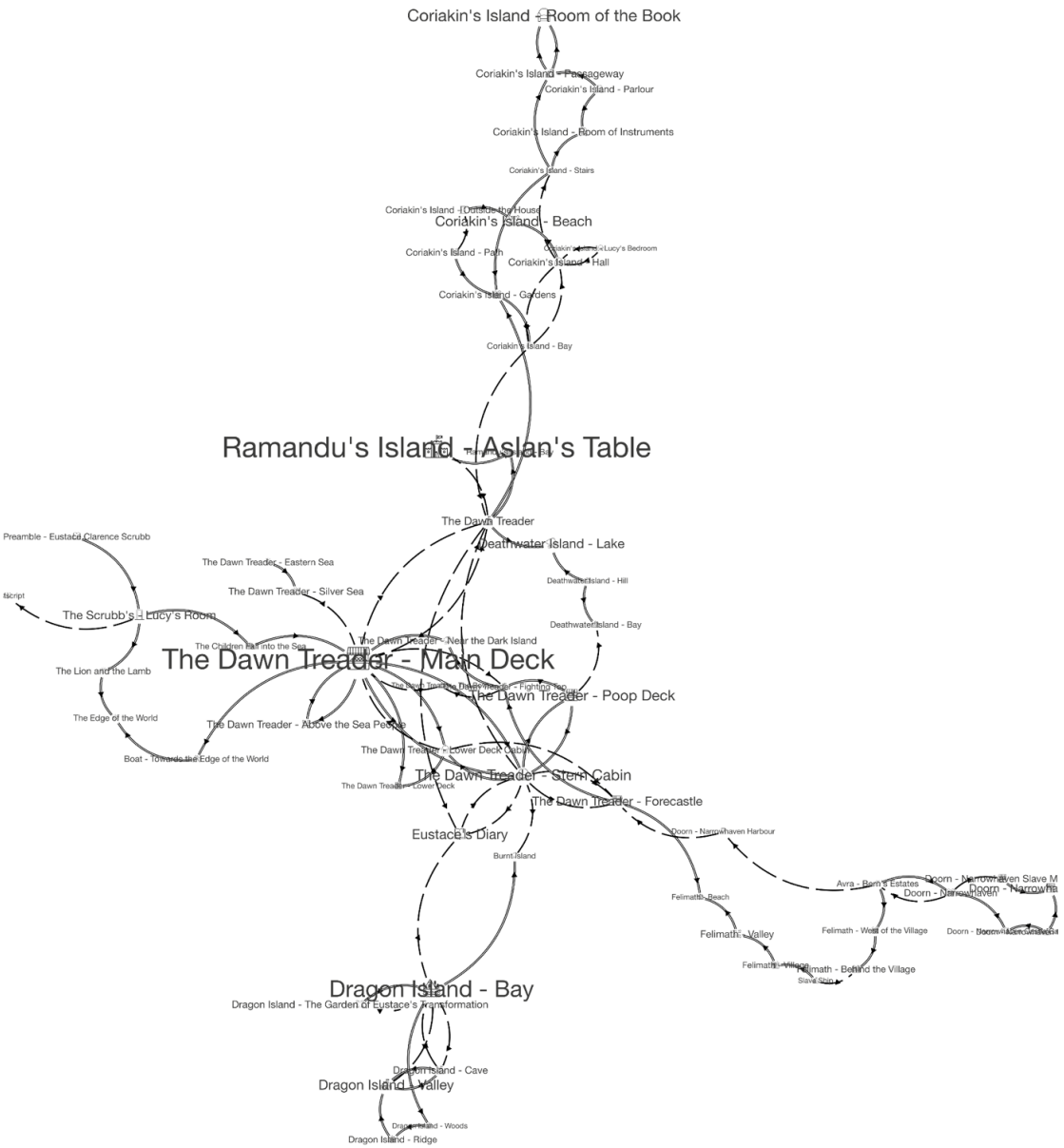

Figure 2. The Voyage of the Dawn Treader: Topoi Map.

Where Dreams Come True (marked on Figure 2 as 'The Dawn Treader – Near the Dark Island', close to the central knot), and then Remadu's Island completing it. The final part of the novel, the journey to the edge of the world, forms the return part of the loop at the far left of the visualisation, which closes in Lucy's bedroom when the children leave Narnia at the end of the book.

The Narnian Chronotope Visualised

Comparing Figures 1 and 2, we see a striking similarity. Whilst Figure 2 is more complex than Figure 1 as a consequence of the ship having a number of sub-spaces, in both graphs the spatial structure is characterised by a central hub surrounded by a number of branches

or petals.[6] The visualisations therefore draw attention to a similarity between the two texts which might otherwise be obscured by the sea-voyage narrative of *The Voyage of the Dawn Treader*: the Wood Between the Worlds and the Dawn Treader itself function as central mediating spaces between the narrative movements of each book.

In *The Magician's Nephew*, we have a three part narrative and spatial structure: London and the discovery of the Wood between the Worlds; the awakening of Jadis and her unfortunate transferral first to London and then to Narnia; and the quest to retrieve the apple in Narnia. This structure is played out across four spatial dimensions or worlds: 'Our World' (realist base narrative) Charn, Narnia, and the Wood between the Worlds. The four worlds are clearly visible in Figure 1: 'Our World' at the top-right hand corner; Charn at the bottom, and Narnia to the left, with the Wood Between the Worlds occupying the central hub. Though comparatively few of the events of the story occur here, it is this space that firstly allows access to the other worlds, but also where the decision *not* to return straight back to earth is taken (from which proceeds Digory ringing the bell, Jadis coming to Earth and thence to Narnia). Though an interstitial and liminal space (and arguably, not really a 'world' at all but the means by which worlds are connected), the Wood is nonetheless fundamental to the unfolding of the plot.

The Voyage of the Dawn Treader, as a sea-voyage story, is at once more spatially complex (in that many more locations are visited) and more simple (in that they are encountered linearly). Whilst both books (in common with all the *Narnia* works) have a moral and didactic purpose, *Dawn Treader* has less work to do on this front than *The Magician's Nephew*. Where the latter book is concerned with the origins of evil and shows the consequences of Digory's idle curiosity and his subsequent atonement for it, most of the characters in *Dawn Treader* do not undergo such profound moral transformations. Instead, as Thomas L. Martin has demonstrated, each episode, in which the fate of one of the seven lords is discovered, represents a moral test that the lord has *failed* but the crew of the Dawn Treader *pass* (Martin 2016: 56). In most of these cases, the moral worth of the crew is not in question. Lucy and Edmund, having previously been tested in *The Lion, the Witch and the Wardrobe* come out of their adventure in Narnia enriched, but not fundamentally changed.[7] Whilst a significant portion of the story is dedicated to Eustace's literal (and figurative) transformation, this occurs in the opening third of the book, and, after this point, he plays a relatively minor role in the story.

The ship, then, occupies the central position on the graph firstly because, as the vehicle which takes the characters from each episode to the next, it is the point to which they must always return. In this sense it is a mediating space much as is the Wood Between the Worlds. However, the ship is also the space which mediates the 'real' world and Narnia, for it is a painting of the Dawn Treader in Lucy's bedroom which provides the magical means by which the children travel there. Where the Wood Between the Worlds can be shown to be a fulcrum point in the plot of *The Magician's Nephew*, the ship does not play the same role for *Voyage of the Dawn Treader*, with most of the key scenes of the book occurring on land. However, it nonetheless fulfils a second mediating function in the text: as a ship with a crew representing the range of classes in Narnian society, it functions often

as the place where decisions are discussed and the meanings of events are determined collectively.[8]

The centrality of these mediating or liminal spaces to the two works points to the conceit at the centre of the *Chronicles of Narnia* series as a whole, and the genre which these texts inaugurate: the bridge between the 'real' and 'fantastic' worlds. Visualised, this spatial structure is shown to be more than an ornament, but fundamental to the narratives of both books. Moreover, when one examines the other nodes on each graph which articulate two or more spatial clusters, we see a similar mediating function. For example, in *Dawn Treader*, the bay of Dragon Island is the gateway to Eustace's transformation; the stairs in Coriakin's house before Lucy is tempted by the visions in his book; or Lucy's bedroom itself, which is the threshold between the real world and Narnia. In *Magician's Nephew* we find 'Aslan and His Councillors', where Aslan tasks Digory to fetch the fruit from the tree and judges his success; outside the garden where Digory resists Jadis's attempts to tempt him to take the fruit for himself; and the Ketterley's back garden where Polly and Digory first meet and where Digory later plants the seed from the fruit of the tree. In Bakhtinian terms, what these visualisations show is the way that these bridging spaces – between the 'real' and 'fantastic' dimensions, but also between key narrative episodes – are at the heart of the Narnian chronotope.

3D Visualisations

The second part of this paper presents an alternative visualisation method for the same texts using interactivity, 3D graphics and animation. Using the same underlying spatial graph and XML markup, these visualisations are able to re-introduce the temporal dimension that is excluded from the 2D visualisations discussed above. In so doing, they demonstrate how the bridging spaces in the two books function differently depending on the generic conventions each story draws upon.

The second element of the research focussed on the *temporal* and *interactive* elements of visualisations, to apply these attributes in order to illustrate the dynamic movement of literary spaces over time, in an environment which affords ways of viewing and exploring the spaces and encourages engaged reading, interpretation and enquiry: that is, visualisations of humanistic data which 'expose and support the activity of interpretation' – the core of humanistic analysis, rather than serve to reify them as 'facts' (Drucker 2013: 1). Visualising the relationship between time and position is complex, there are many different approaches that have been used (Schöttler et al. 2021) and there are a number of different factors to consider for example the 'unit' of time, the measurement of time. Space-time cubes are commonly used approaches for visualising relationships between time and space, but they have their limitations and complexities (Bach et al. 2014). Added to this, the concept of 'time' in literature is an enormously complex one, worthy of its own separate discussion, and there are many different ways of representing and thinking about it (Reuschel and Hurni 2011).

Visualising time and space in a 3d environment is exceptionally challenging (Aigner et al. 2007). Even within conventional geographical representation, visualisations such as the space-time cube (Nöllenburg 2007), whilst they do capture change over time as it occurs in space are difficult for the eye to parse, especially for complex data sets. The problem is essentially one of dimensionality. One must either combine higher-dimensional data sets into lower-dimensional spaces of representation (for example, represent a four-dimensional object in three dimensions, as in the space-time cube), or dispense with one or more dimensions of the data in order to represent the relationships between those dimensions more clearly. This required a different approach to that taken for the primary visualisation, so a practice-led, experimental methodology of 'sandcastle building' (Hinrichs et al. 2019) was adopted. A range of 'creative' coding environments and technologies (D3, Processing, Three.js (Bostock 2021; Processing.org 2021; Threejs.org 2021)) were explored, and a series of experimental prototypes were constructed to test and develop several different visual concepts, models and approaches. Adopting an experimental design-led methodology helped to foster approaches and interactive outcomes which not only informed the development of the final visualisation but also provided a broader contribution to the development of research into the development of new approaches for literary visualisation.

The process of creating the 3d visualisations can be divided into three key stages: XML parsing, 2d graph generation to visualise the *horizontal* spatial relationships between entities, and 3d heat-map generation to visualise the temporal attributes on the *vertical* plane. The source XML is parsed into an object-orientated structure to translate the markup into two principal data entities: *Topos* ('passages'), and *Clusters* ('places'). These data entities are visualised in a 3d environment, initially as a 2d network horizontally along the XZ plane to ground the spatial relationships and then vertically on the Y axis to illustrate and animate temporal changes. The combination of horizontal 'space' and vertical 'time' attributes generated a series of temporal, dynamic landscapes.

XML elements, from the *Chronotopic Cartographies* schema described above, were parsed into groups of interconnected objects: 'Topoi' – abstractions of passages of text, and 'Clusters' – collections of Topoi, abstractions of 'places' within the text (grouped by a shared *framename* attribute). Each of the elements inherited attributes from XML schema, and the object-orientated structure allowed the addition of extra properties and functions. Translating the XML structure into an object-orientated configuration of classes, properties and functions, was a pragmatic design decision which opened up opportunities to visualise passages of text into new visual entities each with their own properties and behaviours, and helped toward the development of the interactive, dynamic and time-based outcomes.

Having created the Topos and Cluster data entities, connections between them are created and a series of network calculations are applied to create a 2d graph defining the spatial (horizontal) relationships between them. Topos and Cluster objects are connected both one another (Topos to Topos and Cluster to Cluster) and to their corresponding 'parent' or 'child' (Topos to Cluster). Topos nodes are connected to their neighbouring

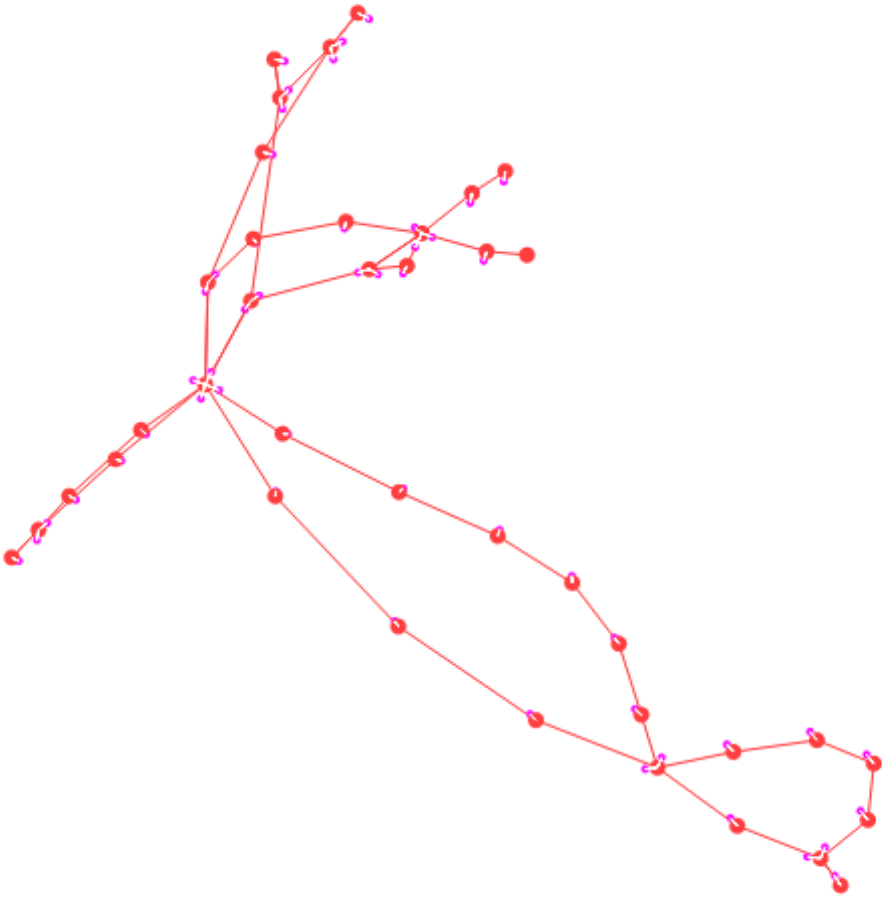

Figure 3. A force-direct network diagram of the Topos objects.

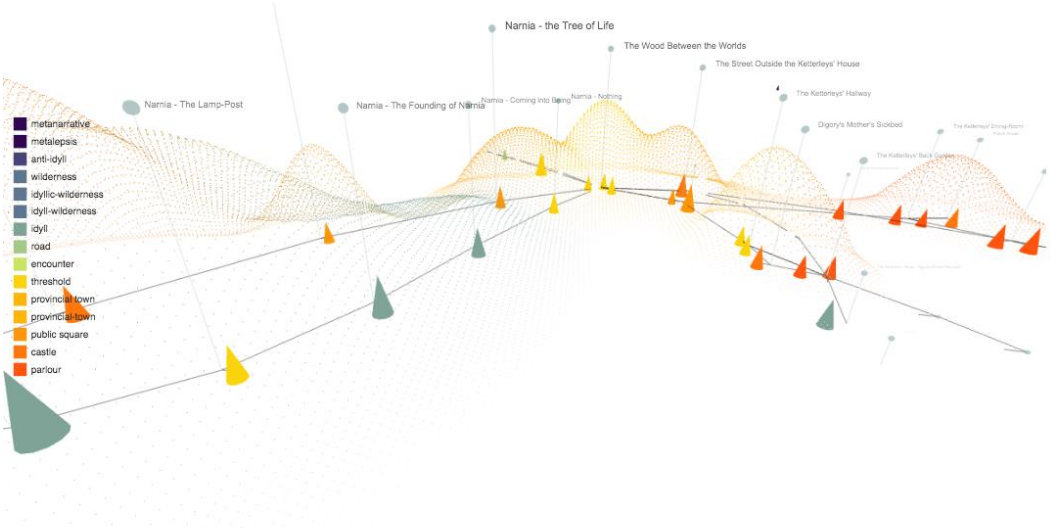

Figure 4. Topos items are visualised as 3d waymarkers.

Topoi in linear, narrative sequence and also to their 'parent' Cluster (via a shared *framename* attribute). Connections between Cluster nodes are generated from an aggregation of all the 'child' Topos connections. Once the connections are established, a series of force-direct calculations, from the D3 framework, are used to attract connected nodes together, and repel unconnected ones. The result is that the Topos objects become spatially organized, positioned by an aggregation of their relative place in the narrative *and* their connection to shared places in the text. Topos objects (*passages*) are given visual form as 3D shapes, which represent waypoints through the connected network with colour attributes which are used to represent the individual chronotype attributes of each passage. Clusters (*places)* are represented as groups of Topos nodes which, when combined, create a visual representation of the overall location, character, size, type and organisation / relationships of literary places in the text. The shapes (e.g. clusters, chains) of the connected pathways in the network reflects something of the underlying literary structure of the text. Hubs or Clusters of connected Topos highlight significant, or often visited, places in the narrative, whilst 'outlier' passages, less connected to other places in the text are moved to the edges. Passages that are clustered together signify closeness, both in terms of narrative and connections with shared places. Chains of regularly spaced passages are indicators of narrative flow, indicative of a directional narrative journey, whilst narratives structured around key or recurring (revisited) places are illustrated by looping network structure. Individual passages closely associated to a specific place are brought close to the centre of a cluster, whilst others, which, through the combination of forces, are 'spread' (placed) between several places are located at mid-points, acting as a bridge between one place and another. This spatial horizontal structure creates a base network and provides the ground upon which vertical, temporal, attributes are built.

Visualising Temporal Attributes (Vertical Y axis)

After defining the ground – the network of horizontal (X Z) relationships between Topos (passages) Clusters (places) – a height (Y axis) attribute is added to the visualisation to illustrate the effect of narrative *time* that is, the 'ebb and flow' of the changing significance of spaces as the narrative moves between places in the text. For the purposes of this project, time is defined simply as the *narrative* sequence: the sequential order of events as told in the text. This definition means that a 'time' value can be easily applied as a chronological numeric value, indicating position of each passage in the overall linear sequence. An additional global 'point in time' value was added to indicate the user's current point in the narrative as he or she moves or selects points from the text.

The combination of individual 'time' attributes applied to each Topos and a single global 'point-in-time' value representing the reader's current position, provided a useful set of data values which were used to visualise temporal changes that occur as the user navigates through the text. Using these values a vertical (Y axis) *'height'* attribute is added to each Topos, to capture the changing temporal distance between each Topos and the

user's current position in the narrative. These temporal distances are visualised as peaks on a 3D heat map which are generated by combining the Topos height value with the number of words in a passage. A 'height map' bitmap image is created by plotting the location of each Topos as a gradient circle on an image canvas – the radius of the circle corresponding to the number of words in the passage, and the alpha value of the centre of the circle being representative of its height value. A gradient blur creates areas of overlap between individual circles and allows them to merge together. The result is a 2d 'heat map' image (Figure 5) which shows areas of activity and is used to generate the 3D terrain. Individual alpha values are converted to vertical height values (vertices) and translated into a 3D surface. Using this process the height of each passage (the proximity) is translated across an undulating terrain of peaks (Figure 6). The 'height' of each Topos peak signifies the proximity, and therefore narrative 'significance', of each passage relative to the reader's point in the text. As the user moves through the work, and passages get nearer to or further from, the readers point in the narrative, so the distance and height values of each Topos change accordingly. Passages closest to the reader's point emerge and grow larger whilst those that get further away shrink, diminish and vanish. The 'readerly experience' of encountering and foregrounding places is visualised as a rise and fall of peaks on a landscape.

The base span of each peak is representative of the amount of words within the passage, and the height of the peak is set to the 'proximity prominence' of the passage to the user point in the narrative. The overall shape and size (breadth and height) of each peak therefore provide further visual cues to the significance of each passage as part of the overall text (allocation of words) as well as its particular prominence to a given point in the narrative: narrow but high shapes, for example represent textually short passages which have prominence to the current point in the narrative, whilst broad but shallow share indicate passages which are more narratively distant but which contain a large / significant portion of text (Figure 7). Just as individual passages create single peaks, groups of clustered passages merge together to form regions of mountain ranges – in effect, *a visual topography of the text* (Figure 8). Passages (peaks) within close spatial and temporal proximity have an influencing factor on those surrounding them and a 'levelling out' effect occurs. Significant places emerge into the landscape as large mountain ranges, generated by collections of passages which share the same common areas of place and time. The result is that greater visual weight is given to clusters of passages which feature prominently at a given temporal and spatial point in the narrative. Thus, rather than viewing passages as stand-alone columns of single quantities of data the effect of creating a landscape which includes overlap, blurring and merging creates a visual impression of the overall character and significance of places more reflective of the interpretative nature of literary study. The effect is to create an interpretive landscape of the text, a dynamic 3D topography from the text.

Figure 5. A 2d heat map of the temporal activity.

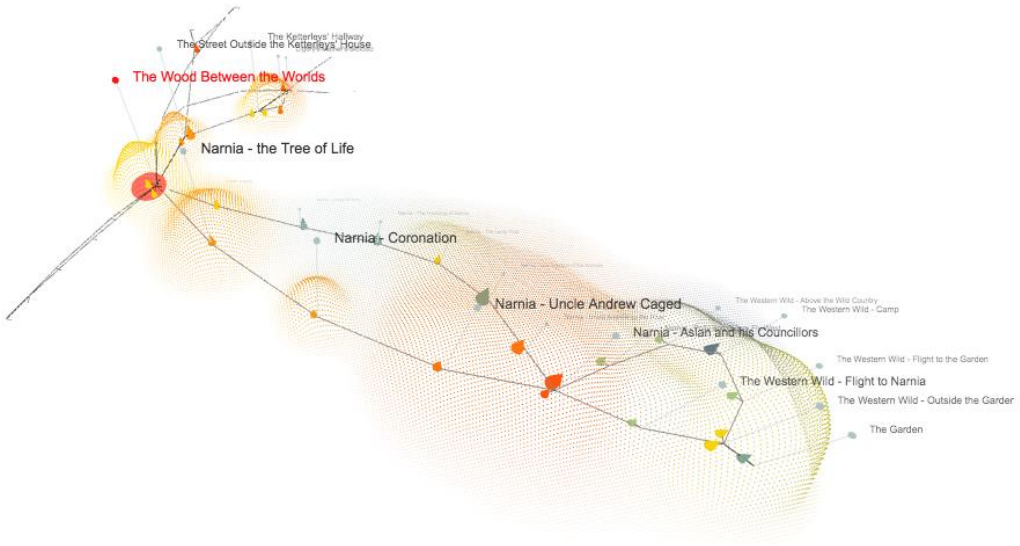

Figure 6. A 3D height map terrain generated from heat map image.

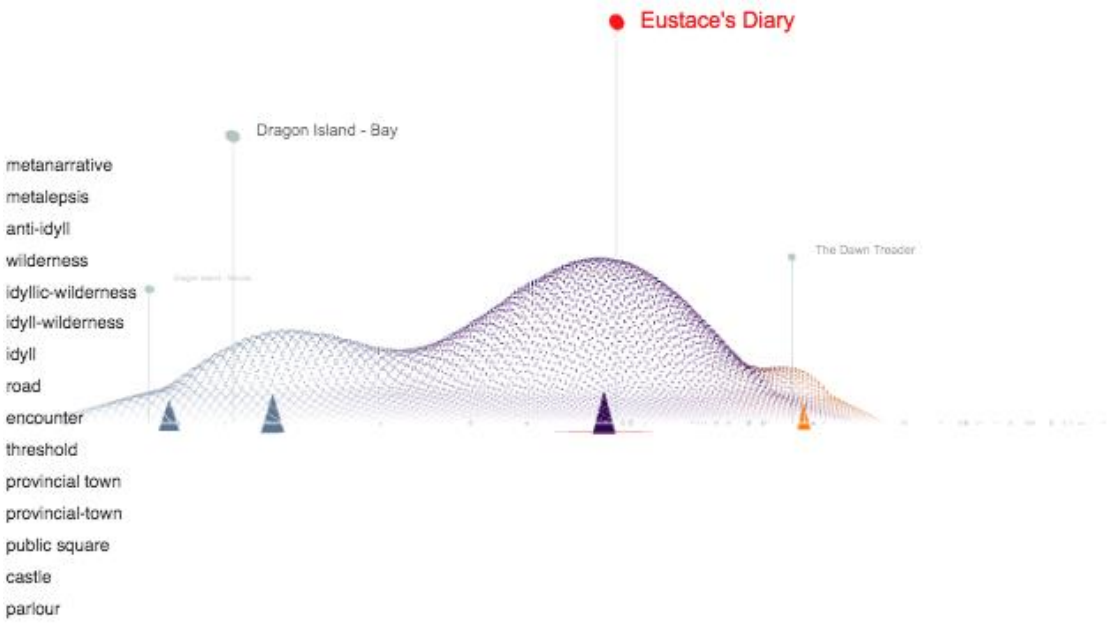

Figure 7. Individual peaks of spaces which are narratively distant from others.

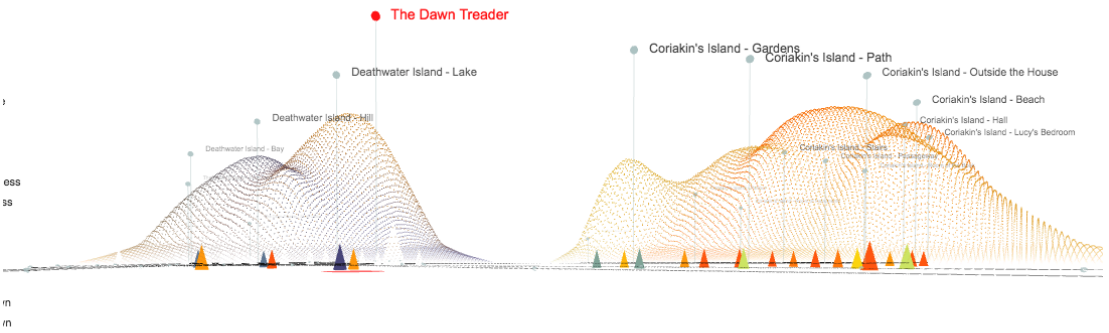

Figure 8. Multiple peaks create mountain 'terrain' of spaces which share time and space.

Generic Difference

The 2d visualisations of *The Magician's Nephew* and *Voyage of the Dawn Treader* discussed above indicated the way in which bridging, mediating or liminal spaces are not incidental to these books, but fundamental to their narrative structures. The 3d visualisations, by re-introducing the temporal dimension, allow us to see that despite this similarity, there are significant differences between the way these mediating spaces function in the two texts.

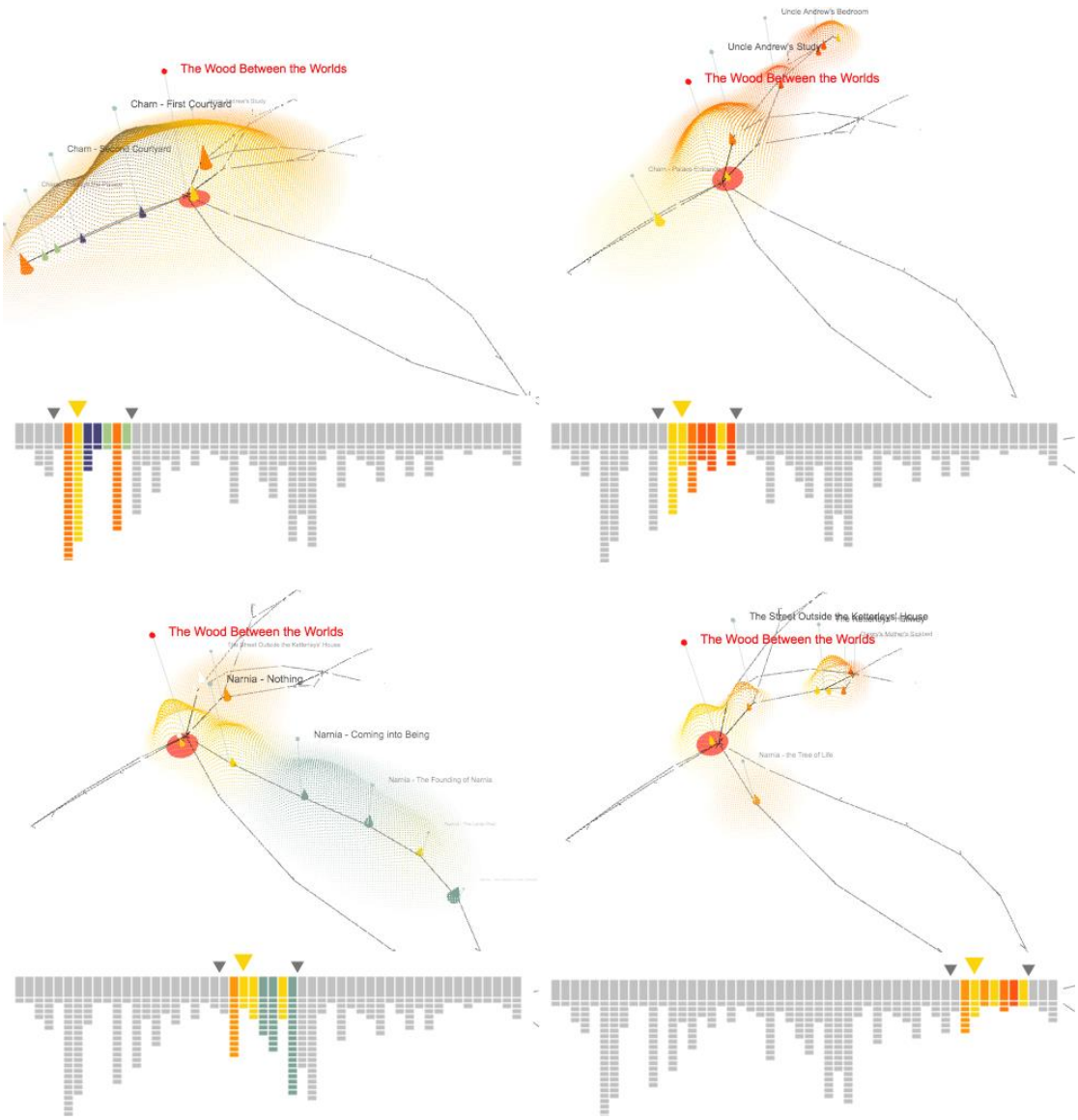

Figure 9. Arrivals and departures from the Wood Between the Worlds.

The most significant mediating spaces (as already discussed) are the Wood Between the Worlds in *The Magician's Nephew* and the ship in *Voyage of the Dawn Treader*. Turning first to the former, if we centre the visualisation and animate the visualisation from the beginning of the text to the end, we see the visualisation return to the Wood Between the Worlds a total of four times (Figure 9). These correspond with the four transitions from one world to another: from our world to Charn and back again, and from our world to Narnia and back. Across the span of the text, the deformable surface which represents the temporal proximity of one topos to another frequently recedes entirely, especially clear in that portion of the text set in Narnia, towards the bottom right of Figure 10. This represents not only the longest span of time in which the protagonists are absent from our world (days, in Narnian time, compared to the hours that they stay on Charn), but also the furthest that they travel from their point of entry to another world. In *Voyage of the Dawn*

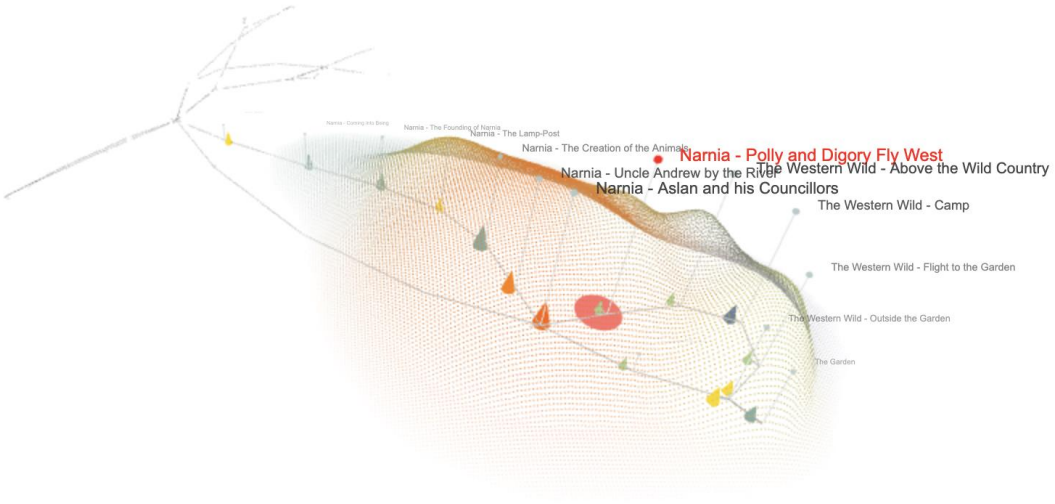

Figure 10. The Narnia portion of The Magician's Nephew.

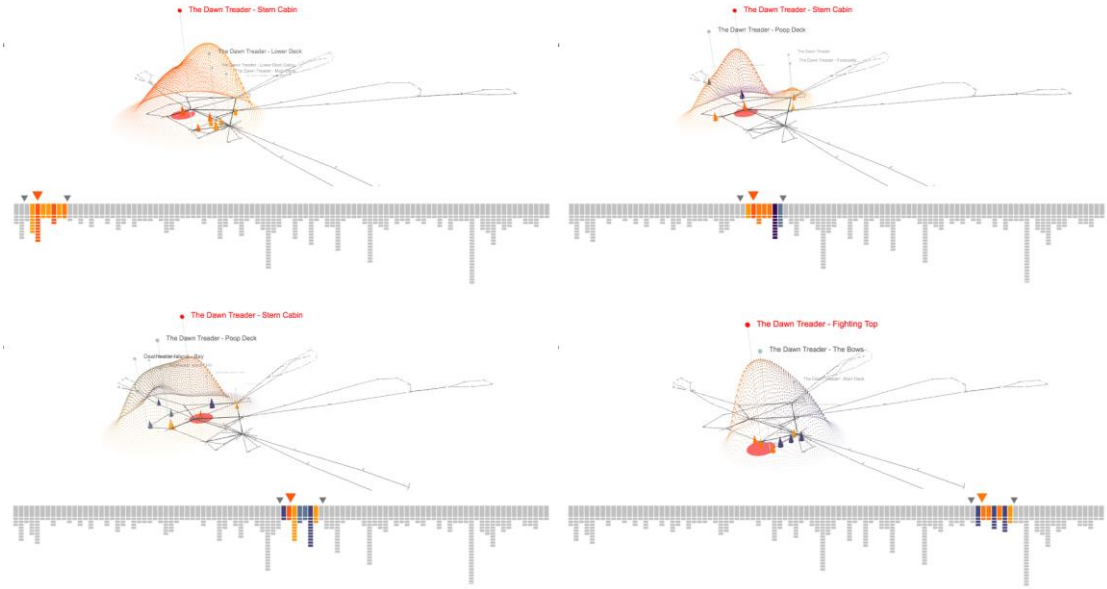

Figure 11. The centrality of the ship in Voyage of the Dawn Treader (the surface rarely recedes).

Treader, conversely, not only does the text return to the spaces of the ship continually (too many times to enumerate here), but the deformable surface rarely subsides entirely from them (Figure 11). We are very rarely far away from the ship, either physically or temporally. Indeed, it is only towards the end of the book, when the children and Reepacheep part from Caspian and his crew for the edge of the world, that the spaces of the ship recede.

We posit that the different rhythm of return and departure from the central mediating space reflects a generic distinction between the texts, and one which is made evident through the visualisations presented here. Turning first to *The Voyage of the Dawn Treader*: whilst as Thomas L. Martin points out, draws on many literary sources (including *The Odyssey*, Milton, Spencer and others) Kris Swank has convincingly argued for the centrality of the *immram* or sea voyage narrative to the plot (Martin 2016: 48; Swank 2019: 75). The *immram* is an Irish form which centres on the moral transformation of the protagonist as he undertakes a journey at sea. The best known of these, *The Voyage of Saint Brendan the Abbott,* is characterised by numerous fabulous and supernatural encounters both on land and at sea, which as John Lawyer points out, find direct analogues in the events of *Voyage of the Dawn Treader* (Lawyer, cited in Swank 2019: 76). The multiple returns to the ship seen in Figure 11, then, show this episodic structure. Multiple loops to and from The Dawn Treader representing the encounters and adventures of the crew over the course of the journey. The moral reformation of Eustace, which features as a major component of the first half of the story, provides another point of coincidence with this older form. (Visualised, we see this moment in Figure 2 with the metadiegetic interlude of Eustace's diaries, in which he reflects on his experience of his journey so far, preceding Dragon Island, on which he learns his lesson and emerges a reformed character).

The spatial structure of *The Voyage of the Dawn Treader*, then, can be shown to be a function of its adoption and adaptation of the *immram* sea voyage pattern. Its complexity, involving many loops and knots, and involving many departures and returns to the ship, is a reflection of the episodic character of this narrative structure. *The Magician's Nephew*, conversely, with four returns to the Wood Between the Worlds, is not episodic. As noted above, it follows a loose three act structure, withthe Wood Between the Worlds serving as a point of narrative articulation in each act.

There is something missing in the account that we present here, however: the problems introduced by the multiple spatio-temporal dimensions of the Narnia series. 'Our World', Narnia, Charn, and the myriad of worlds implied by the many pools in the Wood are, in the cosmology of the series, *linked but separate* universes in which time and space operate under different rules. Time in Narnia flows more slowly than in 'Our World', for example, so the subjective years that the Pevensie children experience as kings and queens of Narnia at the end of *The Lion, the Witch and the Wardrobe* represent hours; moreover, they return as children at the end of the story. These additional dimensions represent a significant challenge for visualising these spatial narrative structures, for we only have three dimensions plus the dimension of time in which to show them. So, whilst *The Magician's Nephew*, when compared with *Voyage of the Dawn Treader*, appears in these visualisations to have the simpler spatial structure, hinging on relatively few visits to the Wood Between the World, a major aspect of its complexity is *omitted* from both visualisations. The relation between 'Our World' and Narnia, in *Voyage of the Dawn Treader*, is comparatively simple: the children enter Narnia at the beginning of the story, undergo their quest, and return at the end. Lewis can therefore quite simply transpose the *immram* to a fantasy geography with little impact on the spatial or narrative structure of the work. *The Magician's Nephew*,

conversely, tells its story across four different continuums, with different moments of its plot, and thus causality, extending across them. As C. N. Manlove has pointed out, whilst *Voyage of the Dawn Treader* was composed in a mere three months, Lewis had significant difficulties in composing *The Magician's Nephew* (Manlove 1988: 71). These difficulties no doubt were in part because of the problem of having to retrospectively explain the events in the books which succeed *The Magician's Nephew* in the chronology of the series. However, we might speculate that devising a narrative structure which could accommodate an adventure with interlinking causes and effects across multiple spatial dimensions – in effect, a chronotope of 'many worlds' – presented a significant challenge in the composition of the book.

Conclusion: The Dimensions of the Text

In the above account we have introduced two modes of visualising the literary text which draw upon a single, graph-based data structure. In so doing, we have demonstrated the affordances that different modes of visualisation offer for the analysis of spatio-narratorial structures of literary texts. However, the purpose of introducing both 2d and 3d visualisations has not been to demonstrate the superiority of one over the other. Instead, what the two visualisation methods reveal are two different views on the same underlying data. In two dimensions, the data are revealed to have a common spatial structure. Adding a third dimension and animation, the spatial (and therefore generic) differences between the two works are shown. The two visualisation methods are complementary, allowing us to highlight different aspects of the works for different purposes.

As alluded to above, there is an aspect of the Narnia books which remains outside of the scope of either of the visualisation methods presented here. The series deals with parallel universes, or multiple dimensions of time and space, between which the characters move. The underlying data model with which the texts have been encoded does not account for this; moreover, it would not be possible to visualise these additional dimensions using the methods explored above. Whilst this has consequences for the visualisation of texts which employ this trope (and there are many, both in children's literature and in science fiction and fantasy), it has implications which extend beyond this specific problem.

The two works discussed, whilst their spatial structures can be shown to be relatively complex, are simple stories told chronologically, and, for the most part, by a single third-person narrator. Literary works are often significantly more complex than this, employing multiple narrators who may or may not be characters in the work, for example, or relating the events of the story in a different order to the one that they must logically have occurred (the *fabula/syuzhet* distinction of Russian formalist criticism). The 3d visualisations presented here have no difficulty in showing the temporal structures of either book analysed, for the order of the telling and the order of the plot (for the most part) coincide. If they did not, however, we would, in effect, have not one, but two, timelines to visualise for each text. Similarly, were there to be multiple narrators in either book, a single topos

might be 'voiced' by one or more of them. Viewed from the perspective of visualisation, these qualities of narrative order and narratorial voice are additional dimensions of the data, over and above those of space and time explored here. The multiple spatio-temporal dimensions of the Narnia books, then, are only a more literal instance of a problem which is common to the visualisation of literary texts more generally. We would suggest that if future research in this area were to address the problem of visualising the multiple worlds of the fantastic, it would therefore be likely to have application beyond the analysis of genre fiction alone.

Notes

[1] In *The Voyage of the Dawn Treader*, where there is also continual change of context (though the Dawn Treader itself is a constant) the journey was much more directional than here [*The Magician's Nephew*]: we knew the voyage was in quest of Aslan's land; but here we do not know for long where anything is leading' (Manlove 1988: 73).
[2] The 3d visualisations are available online at: http://agrichardson.com/chrono.
[3] Though this is possible, and GIS-led and graph-led models are not mutually exclusive: the principles which underlie graph models were developed in the 18th Century by the Swiss mathematician Leonard Euler specifically to solve a geographical problem.
[4] The underlying data model was primarily the work of James Butler, with contributions from the rest of the *Chronotopic Cartographies* research team.
[5] All of the code used on the *Chronotopic Cartographies* project can be found on Github at https://github.com/chronotopic-cartographies. We note here that there is no small degree of subjectivity to the markup process. What the schema facilitates is the generation of a visualisation of a spatial *interpretation* of a text, not an absolute map of its spaces, for none could exist.
[6] An issue in the methodology outlined here is that it is difficult to annotate nested spaces using XML as the document tree rapidly becomes very complex. Were this not the case, it would be possible to present the ship as a single node on the graph.
[7] Lucy is tested during the events on Coriakin's Island, though not to the same extent as Eustace.
[8] To refer to Bakhtin (1981) again, though these are simple texts, the ship is the most explicitly dialogic space in *Voyage of the Dawn Treader*.

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Works Cited

Aigner, W., Miksch, S., Schumann, H. and Tominski, C. (2011) *Visualization of Time-Oriented Data*. Springer London; London.

Bach, B., Dragicevic, P., Archambault, D., Hurter, C. and Carpendale, S. (2014) 'A Review of Temporal Data Visualizations Based on Space-Time Cube Operations.' In *Eurographics Conference on Visualization* (EuroVis 2014), pp. 23-41.

Bakhtin, M. (1981) *The Dialogic Imagination: Four Essays*. University of Texas Press; Austin.

Bostock, M. (2021) 'D3.js - Data-Driven Documents'. [Online] [Accessed 13 July 2021] https://d3js.org/

Bushell, S., Butler, J. O., Hay, D. and Hutcheon, R. (2022a) 'Digital Literary Mapping: I. Visualizing and Reading Graph Topologies as Maps for Literature.' *Cartographica: The International Journal for Geographic Information and Geovisualization*, 57(1), pp. 11-36.

Bushell, S., Butler, J. O., Hay, D. and Hutcheon, R. (2022b) 'Digital Literary Mapping: II. Towards an Integrated Visual–Verbal Method for the Humanities.' *Cartographica: The International Journal for Geographic Information and Geovisualization*, 57(1), pp. 37-64.

Drucker, J. (2013) 'Performative Materiality and Theoretical Approaches to Interface.' *Digital Humanities Quarterly*, 7(1).

Hinrichs, U., Forlini, S. and Moynihan, B. (2019) 'In defense of sandcastles: Research thinking through visualization in digital humanities.' *Digital Scholarship in the Humanities*, 34, pp. 80-99.

Lewis, C.S. (2009) *The Magician's Nephew*. HarperCollins Children's; London.

Lewis, C.S. (2010) *The Voyage of the Dawn Treader*. HarperCollins Children's; London.

Manlove, C.N. (1988) 'The Birth of a Fantastic World: C. S. Lewis's "The Magician's Nephew".' *Journal of the Fantastic in the Arts*, 1(1), pp. 71-84.

Martin, T.L. (2016) 'Seven for Seven: "The Voyage of the" "Dawn Treader" and the Literary Tradition.' *Mythlore*, 34(2), pp. 47-68.

Nöllenburg, M. (2007) 'Geographic Visualization.' Kerren, A., Ebert, A. and Meyer, J. (eds) *Human-Centered Visualization Environments*. Springer Berlin Heidelberg; Berlin, Heidelberg, pp 257-294.

Reuschel, A.-K and Hurni, L. (2011) 'Mapping Literature: Visualisation of Spatial Uncertainty in Fiction.' *The Cartographic Journal*, 48(4), pp. 293-308.

'Processing.org' (2021) [Online] [Accessed 7 March 2021] https://processing.org/

Schöttler, S., Yang, Y., Pfister, H. and Bach, B. (2021) 'Visualizing and Interacting with Geospatial Networks: A Survey and Design Space.' *Computer Graphics Forum*, cgf.14198.

Swank, K. (2019) 'The Child's Voyage and the Immram Tradition in Lewis, Tolkien, and Pullman.' *Mythlore,* 38, pp. 73-96.

Three.js – JavaScript 3D Library (2021) [Online] [Accessed 13 July 2021] https://threejs.org/

Warren, C., Shore D., Otis, J., Weingart, S. and Ladd, J. (2018) 'Six Degrees of Francis Bacon.' [Online] [Accessed 31 July 2021] http://www.sixdegreesoffrancisbacon.com