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Enhancing research publications using rich interactive narratives

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Research

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It is desirable in many disciplines to include supplementary information to add value to research publications, particularly in digital form. The concept of interactive publications, in which the reader can browse and navigate through in a nonlinear manner, is one such medium that is explored in this paper. We describe the application of the Rich Interactive Narrative framework to provide such a mechanism in the fields of archaeology and chemistry, to supplement academic journal papers. This system provides both passive (pre-recorded) and active (user-led) interaction modes to navigate through data, including experimental datasets, maps, photos, video and three-dimensional models, and supports event-based audio and text narration. It includes an extensive authoring tool for deployment to the web. We conclude by discussing the future possibilities of such a platform for e-Science and scholarly communication.

1. Introduction

The process of communicating research through publications is well established and lays the foundation for the research community worldwide. A major goal is to enable research to be reproducible, to facilitate advances in the state of the art. This provides challenges as more research becomes digital, and is reliant on different types of data, and processes, that are not easily shareable [1,2]. There is, however, a significant movement to make more research widely available. The scholarly communication process is evolving through initiatives such as open access and research data sharing. The advent of online repositories for specific discipline, and whole institutions, opens up many possibilities for making research assets more easily available. Specifically,

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governments and funding bodies are increasingly moving to ensure that research outputs are made readily available so that other researchers, and the public, are able to benefit more directly from projects ([3]; http://www.rcuk.ac. uk/research/Pages/outputs.aspx).

The extension of academic publications to include supporting data and information is seen as an important step in advancing the scholarly process. In this context, the web provides an ideal mechanism for dissemination to a wide audience, and there is a spectrum of approaches that are currently being explored [4]. Research output repository systems have been developed to enable organizations to publish their outputs online, such as EPrints (http://www.eprints.org/), Fedora (http://www.fedora-commons.org/), Zentity (http://research.microsoft.com/en-us/projects/zentity/) and dSpace (http://www.dspace.org/). These systems are also capable of managing research data assets, such as images, videos and datasets. While this is helping to make research data available, they typically use a document-based approach, resulting in a number of issues that must be addressed:

— *Context*. How is the data related to the research, beyond what is described in the paper?
— *Navigation*. How does the reader navigate disparate, complex, portfolios of data?
— *Visualization*. Is the reader able to investigate the data, including issues of software availability, curation and preservation.

These issues can be problematic when dealing with complex, multi-faceted, research data collections. Often such collections contain disparate data types that require a portfolio of software to process or visualize. It also creates potential problems from a preservation viewpoint, notably around software version compatibility, and availability in the long term.

While much of the focus has been on datasets, increasingly housed in disciplinary or institutional repositories, less attention has been paid to providing ways for readers to interact with the underlying contextual information relating to the data in an intuitive manner. This has been identified as important, as evidenced by the video approach of SciVee [5] and in the humanities [6]. In this paper, we describe how the Rich Interactive Narrative (RIN) framework ([7]; http://www.digitalnarratives.net/), designed for the preservation of cultural heritage by the Microsoft Research India team with the University of Washington, can be applied to produce compelling journeys through research papers using a novel combination of video, audio, data, maps and other information sources.

2. Rich interactive narrative framework

The RIN framework provides an abstracted architecture for data and processes that allows association with artefacts and events. A brief description of the RIN framework is included here (figure 1), with a more complete description in [7]. The data abstraction entities include:

— *Experience streams* to represent dynamic visualizations through data, such as flythroughs of a location;
— *Zones*, around artefacts or locations in the dataset, which can be used to trigger events; and
— *User interface resources*, audio/visual and other UI objects within the narrative.

Process abstractions include:

— *Experience stream providers* (ESP) abstract graphics and audio that can be converted into experience streams as required; and
— *Generalized trajectory* abstracts motion through, and interactivity within, the dataset.

Coordination of the multiple experience streams is handled by the *narrative experience orchestrator* (NEO). The *interactive experience orchestrator* (IEO) handles artefact triggered events. The rendered

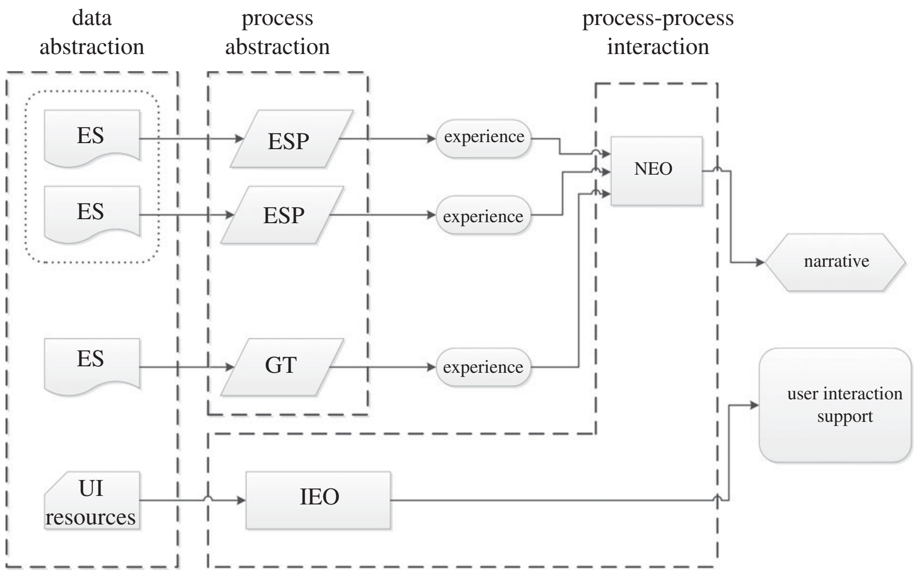

Figure 1. Rich Interactive Narrative framework architecture (from Adabala *et al.* [7]). (Online version in colour.)

output comprises three components:

- *Experience* is the audio-visual output from the ESPs;
- *Narrative* is the final output, comprising multiple ESPs pulled together via the NEO;
- *User interaction support* allows the user to control the experience in a nonlinear way, pausing the narrative at any point and navigating through the experience streams freely.

The RIN framework is extensible, and currently supports a number of technologies for data: mapping, PhotoSynths (http://photosynth.net/), gigapixel imaging [8], DeepZoom (http://www.microsoft.com/silverlight/deep-zoom/), audio, video and text annotations. A typical RIN narrative is shown in figure 2, showing the user interface for interactively exploring; a number of examples are available to experience at http://www.digitalnarratives.net/.

In order to construct a RIN, a self-contained authoring tool has been developed that is similar in look-and-feel to typical video editing software (figure 3). The author simply drag-and-drops content onto the timeline. Using this simple point-and-click interface, it is possible for the user to build up a linear narrative rapidly, once they collected the relevant assets for assembly. The nonlinear exploration mode does not require any additional effort by the author, interactive controls automatically appear when the end-user clicks on the playing RIN. The experience is similar to using basic video editing software included with most computer operating systems, or constructing a computer slide presentation. It allows the user to add local media assets to be used in the RIN, such as pictures and video. It also provides access to online datasets, including PhotoSynths and Bing Maps. Each asset can be customized in an Experience Stream, for example, a map can be navigated through by setting waypoints. The user can set an initial view (position and zoom level), and plot a path for the ES, including zooming and panning, to provide a smooth flythrough of the data. This process is similar for other assets, including photos and PhotoSynths. As an indication of the level of effort required, the examples described in §2 were completed in 2–3 h with no formal software training.

The novel feature of RIN is that it combines a linear narrative mode, similar to a movie, with a fully interactive mode. At any point during playback, the user is able to click, stopping the narrative and providing a fully interactive experience from that point on. In order to resume the

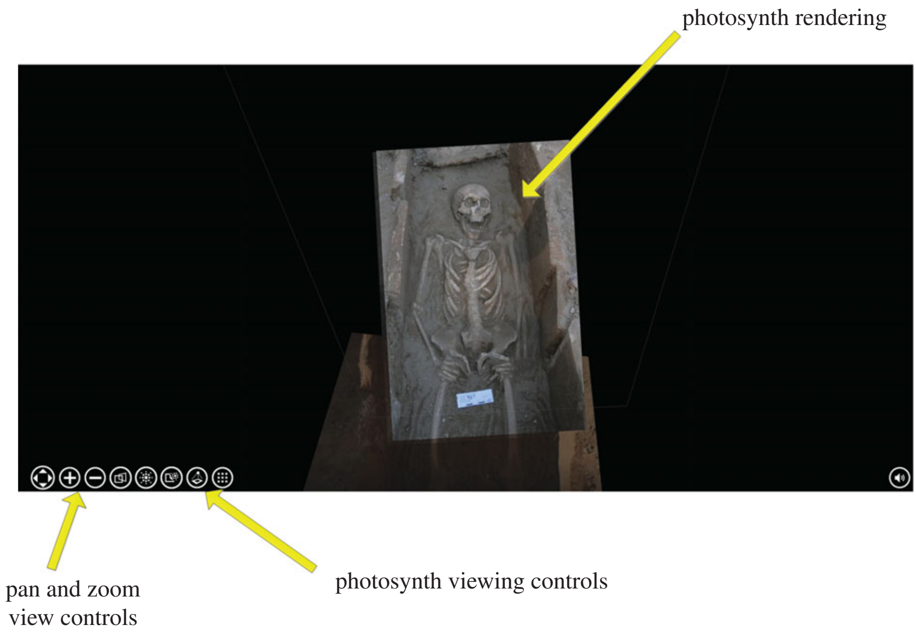

Figure 2. Typical Rich Interactive Narrative playback screen (from Adabala *et al.* [7]). (Online version in colour.)

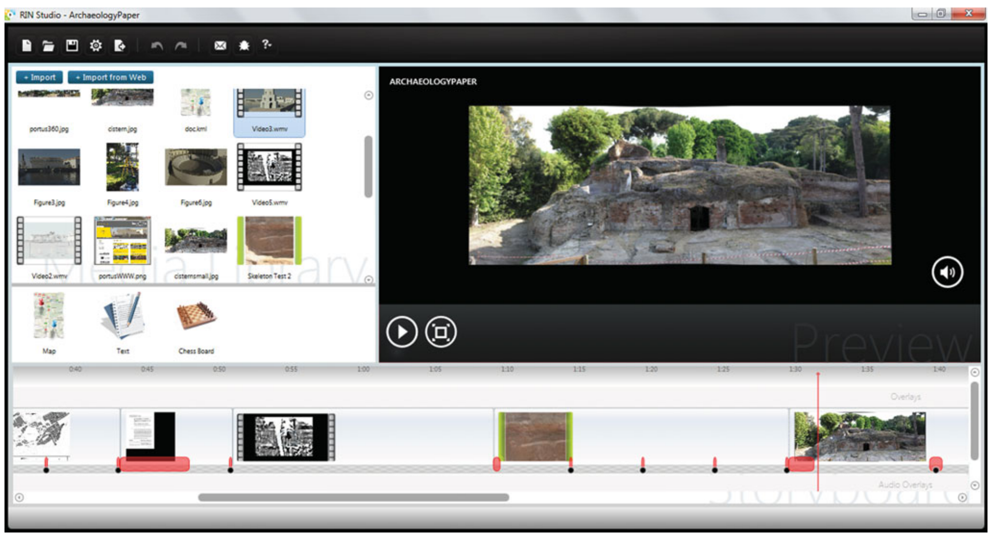

Figure 3. RIN authoring tool. (Online version in colour.)

linear playback, the user clicks on the *play* button and the narrative resumes. This combination of linear and interactive modes means that the author is able to describe their work as a story, while simultaneously enabling full interactivity with the underlying data.

3. Case studies

We demonstrate two case study areas of using RIN to enhance academic journal papers, providing linear narratives, while allowing data exploration using built-in visualization plug-ins. We discuss the application of RIN in the fields of archaeology and chemistry, to demonstrate its utility in disparate disciplines.

(a) Archaeology research paper

Our archaeological case study focuses on the application of RIN to augment a journal article documenting a series of archaeological geophysical investigations undertaken at the site of Portus, the port of imperial Rome [9,10]. For [11], we use RIN to integrate geospatial data in the form of BING satellite imagery, Photosynth, geo-located photography, geophysical survey data (figure 4), computer-generated reconstructions (figure 5), video and DeepZoom, into a coherent narrative supporting and enhancing the paper.

The Portus Project is a multi-disciplinary project funded by the UK Arts and Humanities Research Council focused on the survey, excavation, interpretation and representation of the remains of the Roman port that supplied the city of Rome (http://www.portusproject.org/). In addition to a wide range of conventional archaeological approaches the project has examined the potential for digital methodologies. These include ways of documenting archaeological practice through mobile devices, ways of managing and sharing archaeological data, and the production of graphical simulations as a means to develop interpretations and to disseminate them [11]. The paper around which the RIN was generated explores the potential of integrating a suite of geophysical techniques in the analysis of a central portion of the Roman harbour complex. In the RIN a narration provides an alternative route to navigating the geophysical research, enabling the researcher to interact with high-resolution geophysical data, simulations produced from them and a portion of the site's photographic archive that provides additional information about areas covered by the geophysical survey. The interlinking of journal article, data and explanatory materials provides a significantly more interactive and dynamic view of the data, while also maintaining the option to navigate content in a prescribed, linear fashion.

It is the combination of narration and exploration that offers the greatest benefits in the archaeological publication context, where rich multimedia supporting materials are commonly available but infrequently disseminated along with the scholarly publication. Exemplar projects within archaeology such as Making the LEAP [12] have demonstrated the potential of connecting structured narratives to archives. This is supported by tools such as the L-P Archaeology Archaeological Recording Kit which provides options for connecting archaeological data snippets to more discursive web journals [13]. The RIN provides a complementary approach to these. It can not only link to and embed online content in a similar way, including the ability to query data via PivotViewer (http://www.microsoft.com/silverlight/pivotviewer/), but also can provide an accompanying narrative structure which can be both supporting and orthogonal to the published research article. We envisage our continued development of use of the RIN tool in this context therefore to focus on the development of multiple, interleaved and at times orthogonal narratives reflecting the varying interests of the academic archaeological readership and the varying methods and datasets employed in the creation of archaeological interpretations (figure 6).

(b) Chemistry research thesis

The second case study area demonstrates how research publications in natural sciences can be enhanced using RIN. We use the example of a chemistry doctoral thesis [14] to show how experimental and simulation data can be presented dynamically. This takes advantage of the electronic laboratory notebook framework described by Frey [15], developed to allow researchers to use specialized blog software in order to capture their experimental and research process (http://www.labtrove.org/). These blog posts allow semantic linking, as well as physical linkage to the laboratory environment, for example, through auto-generated barcodes for experimental samples. These blogs typically relate to multi-year projects, while involving multiple posts per

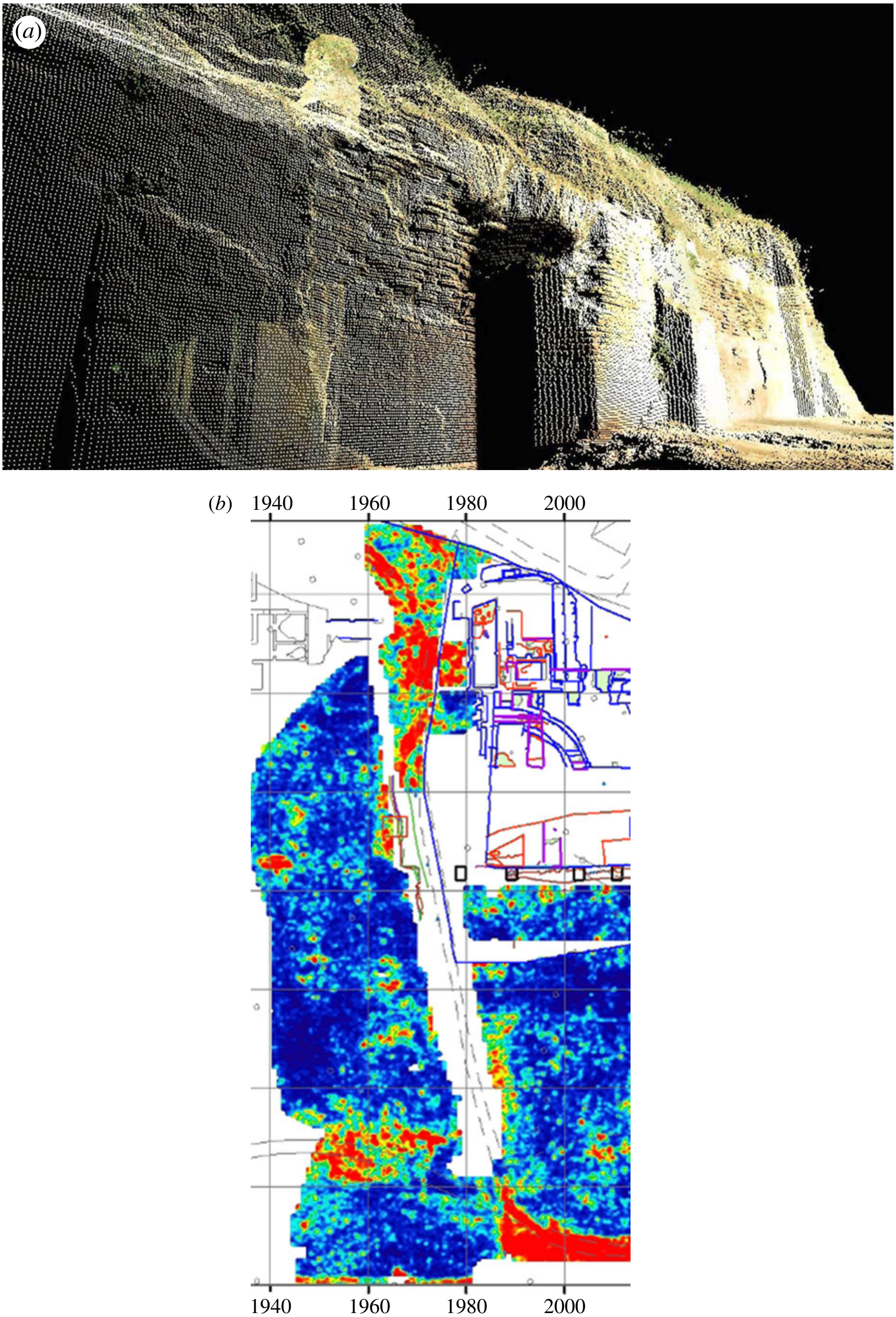

Figure 4. Archaeological survey data from the AHRC Portus Project (*a*) laser point cloud, (*b*) Geophysics survey results. (Online version in colour.)

day, therefore providing a visualization problem across these timescales. DeepZoom technology provides a convenient way of spanning the visualization of these disparate timescales in a smooth, user-friendly way (figure 7).

We illustrate this in the way a few of the pages of how a conventional research thesis (but digital in the sense of having a word processed version) would be transformed using RIN to give a data centric view starting from one of the tables of data but making this the central

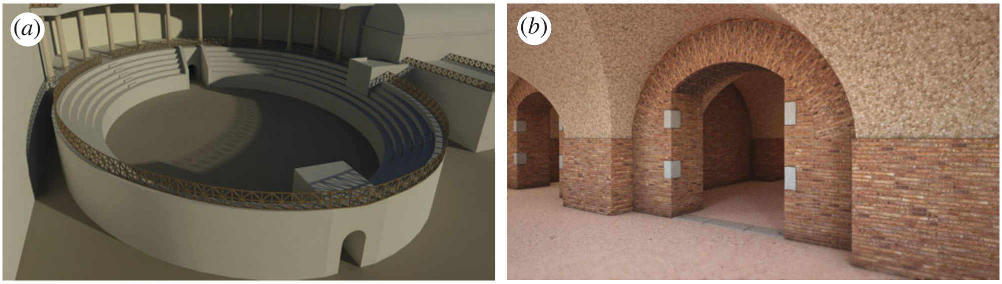

Figure 5. Archaeological computer graphic simulations of Roman buildings produced by the AHRC Portus Project. (Online version in colour.)

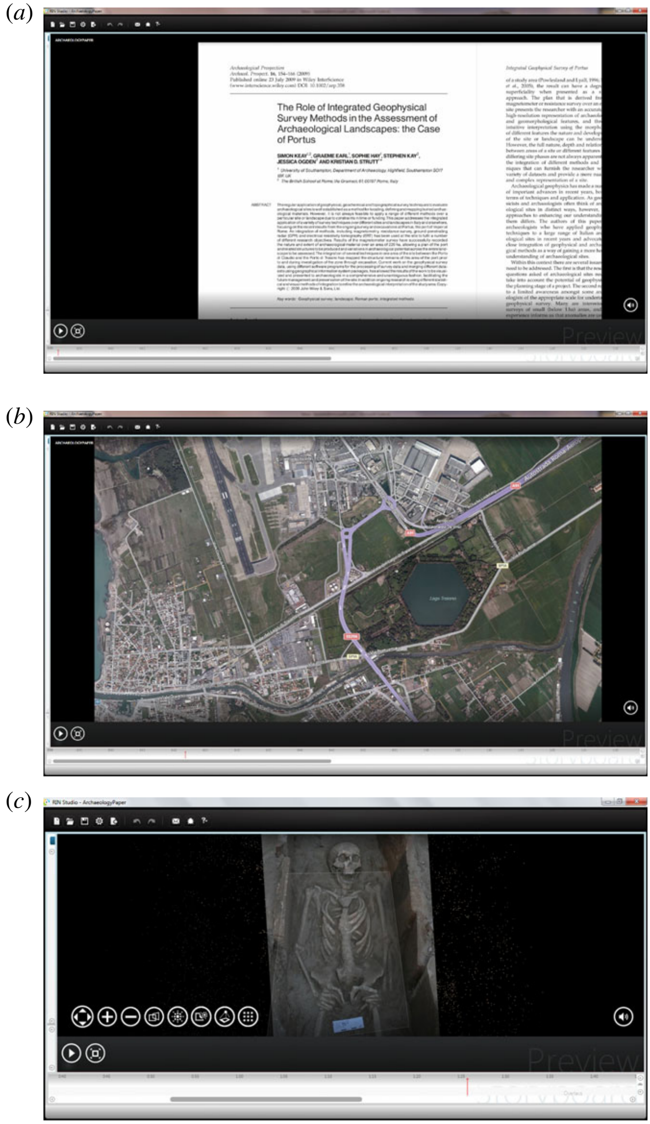

Figure 6. Archaeology paper Rich Interactive Narrative. (*a*) DeepZoom image of research paper, (*b*) Bing maps aerial photography view and (c) PhotoSynth (Gregory Tucker, AHRC Project). (Online version in colour.)

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(*a*)

(*b*)

(*c*)

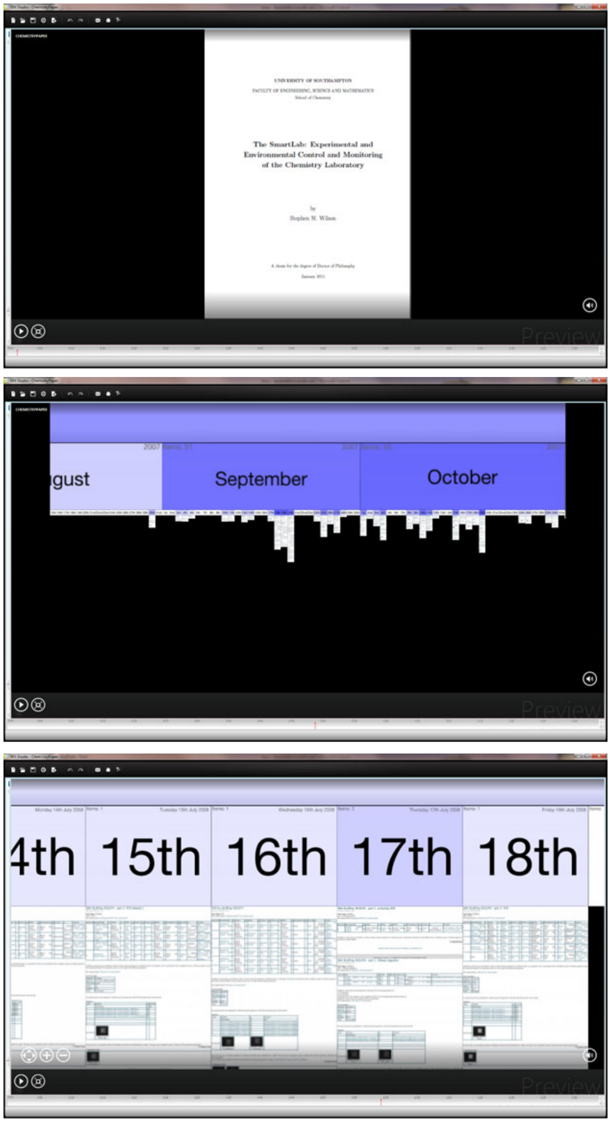

Figure 7. Chemistry thesis Rich Interactive Narrative. (*a*) Research Thesis DeepZoom document, (*b*) Laboratory Blog post timeline, and (*c*) individual blog posts. (Online version in colour.)

way in to access the material, the background, analysis and raw data. The narrative provided by the researcher provides context to the viewer, while the DeepZoom capability makes it possible to bring any specific piece of information to the forefront while maintaining easy access, all by navigating round the page, to all the associated background and resulting information. With the DeepZoom images, we can then navigate over the page to tell a variety of stories about how the data were collected, why they were collected in the way they were (which only becomes clear once some analysis has been completed), and how we have interpreted the experiments.

By providing a linear narrative to guide the viewer through the research, it is possible to provide additional context in an accessible way. The ability to pause, and interact with the data, particularly browsing blog posts and data related to the experiment, provides a powerful additional mechanism for data publication and exploration.

4. Discussion

The enhancement of research publication with data and visualizations may provide significant added value and utility to help with reproducibility and communication of research. The approach described here, using RIN, combines a number of novel features that make it potentially useful for this task. The combination of both linear narration and nonlinear interaction with content provides the user with context from the original researcher, and the ability to explore datasets freely. RINs are hosted online and are therefore accessible from web browsers, without the requirement for local application installation. This circumvents a key problem with data re-use, which is the availability and compatibility of visualization software, both in the short and long term. The open architecture of RIN allows inclusion of additional datatypes to be used, with associated viewer support. The architecture is web-based, so integration and support for web-based tools is a natural fit for the RIN framework. While the current implementation supports a specific set of formats, the open, extensible nature of the framework means that other standard formats could be additionally supported.

An issue with research data management, and particularly the curation process, is incentive for the researcher. RIN provides an immediate feedback to the user—a shareable web experience. This is coupled with an easy-to-use authoring environment, similar to video editing software, and which requires little training. The time taken to put together a RIN is comparable to assembling an electronic presentation.

A side benefit of using RIN for publishing research data is that it is in an accessible format. The original use cases for RIN were for cultural heritage projects, and it is designed to be navigable by a wide audience. This can be advantageous where, for example, public engagement with the research is desirable.

The benefit of using RIN in the physical sciences is that it allows the connection between the data, the analysis, the equipment and the process to be maintained and viewed in an easily navigable manner. This ensures that the reader of a paper is much more aware of the nature of the experiment and the limitations or otherwise of the results obtained; the context neatly surrounds the data. It is a more natural interface, and more flexible than a set of interlinked web pages. The proposed usage here is to support scholarly output, and so algorithmic implementations are not directly supported. As the system is extensible, it would be possible to include executable content to begin to explore how this approach could support algorithmic-based research outputs.

5. Conclusions

The novelty with using RIN to enhance research publications is to present data and supporting information in a contextual manner, using a narrative approach while giving the reader flexibility to seamlessly explore the underlying data and information in a freeform manner. The authoring tool makes it straightforward for the author to compose the narrative, and could therefore make it compelling for them to narrate the paper themselves. This demonstrates an interesting hybrid approach that has many further possibilities for supporting research publications, and also provides a mechanism for making them more accessible to a wider audience.

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