The Dream and the Cross: bringing 3D content in a digital edition

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***Abstract*—The Dream of the Rood is one of the earliest Christian poems in the corpus of Old English literature, and an example of the genre of dream poetry. While its complete text can be found in the 10th Century "Vercelli Book", the poem is considerably older, and its oldest occurrence is carved (in runes) on the 7-8th Century Ruthwell Stone Cross. In this paper, we present the prototype of a web-based digital edition of the Dream of the Rood, as it appears on the Ruthwell Cross. The multimedia framework presents the highly detailed 3D model acquired with 3D Scanning technology, together with the transcription and translation of the runes that can be found on its surface. The textual and spatial information are linked through a system of bi-directional links called spots, that give the possibility to the user to have a free navigation over the multimedia content, keeping the 3D and textual data synchronized. The proposed work provides discussion and solution on two main issues related to digital editions: the integration of three dimensional content in the context of the presentation on the web platform of heterogeneous multimedia data, and the creation of an XML encoding that could account for the necessities of 3D data disposition, but keeping the encoding rules in the context of the standards of the community.**

I. Introduction

The Dream of the Rood, dating back to the first half of the 8th Century in its earliest version, is one of the first Christian poems in the corpus of Old English literature and one of the main examples of the genre of dream poetry in English. Due to its artistic qualities and overall relevance for Anglo-Saxon studies it is considered one of the most important achievements of Old English poetry; it is also one of the very few texts in this tradition that has been preserved in more than one witness. The complete poem can be found in the late 10th Century Vercelli Book manuscript (*Codex Vercellensis CXVII*, Archivio Biblioteca Capitolare di Vercelli), but a fragment was carved in runes on the 8th Century *Ruthwell Stone Cross*. Finally, a small excerpt can be found also on the *Brussels Cross*, an Anglo-Saxon cross-reliquary of the early 11th century.

The purpose of the Visionary Cross project (http://www.visionarycross.org/) is to create a digital edition of a group of important objects related to *The Dream of the Rood* and to the Cult of the Cross in general. The goal is to create a multimedia presentation putting together not only the critical edition of the poem, linked to the digitized images of the Vercelli Book, but also the three-dimensional data related to the Crosses. The strong link between the poem and the objects, also from a spatial point of view, should be preserved to fully describe the messages and interaction between visual and poetic art.

In this paper, we present the design and implementation of a web-based integrated digital edition, focused at presenting *The Dream of the Rood* and its close relationship with the Ruthwell Cross. The multimedia presentation system employs a highly detailed 3D model acquired with active 3D scanning technology, together with the transcription and translation of the runes that can be found on its surface, and a detailed description of the carving of the cross. The textual and spatial information are linked through a system of bi-directional links called *spots*, which allow the users to freely navigate the data, supporting a *synchronized* browsing and analysis of the 3D model, the textual data and the digital editions of the poem. The proposed work provides discussion and solution on two main issues related to digital editions and multimedia presentation:

- The integration, on the web platform, of three dimensional content in the context of the presentation of heterogeneous multimedia data. In this case, using WebGL and a system of XML configuration files, we took advantage of a framework that is able to easily encode and visualize interlinked modules covering different types of data (i.e. text, 3D models, editions). The framework proved to be easy to handle and flexible enough to be adapted to different types of media and to cope with the specific characteristics of this object.
- The creation of an XML encoding that should support innovative functionalities for data organization and presentation; at the same time, it should adopt encoding rules compatible with the standards of the academic CH community. This should ensure interoperability and easiness of use also for the experts in the humanistic field. The encoding of the runic text presented in this work is fully interoperable with both the web-based visualization system and the tools commonly used in the digital philology.

II. Related Work

In this Section, we propose a short overview of the issues and solutions related to the main subjects of interest which were mentioned above. Hence, the first part will be devoted to the problem of 3D content visualization on the web and integration with textual data, while the second one will propose a short overview on the issue related to encoding and digital editions of ancient books.

A. Three-dimensional content on the Web, and its integration with text

Text, images and videos have been ingredients of a web page right from its birth. Three-dimensional content have been included only in a much later stage, with the advent of graphic accelerated hardware. Hence, the visualization of 3D models in Web pages was devoted to embedded software components, such as Java applets or ActiveX controls [1]. There was no standardization, so that a number of proprietary plug-ins, which needed local installation, were created.

Virtual Reality Modeling Language (VRML) [2] in 1995 and X3D [3] in 2007 aimed at finding a standardization. But the 3D scene visualization was still delegated to external software components.

The introduction of the WebGL standard [4], promoted by the Khronos Group [5] in 2009, was a fundamental change. The WebGL API is a one-to-one mapping of the OpenGL|ES 2.0 specifications [6] in JavaScript. This brings Web browsers to be able to *natively* access the graphics hardware without needing additional plug-ins or extensions. A number of higher-level libraries have been developed to help non-expert users using WebGL. They range from scene-graph-based interfaces, like Scene.js [7] and GLGE [8], to more programmer-friendly paradigms, like SpiderGL [9] and WebGLU [10]. A declarative approach is implemented in X3DOM [11], whose use is simpler for people experts in web development, due to the similarity of the core principles.

More in general, the presentation of complex datasets comprising images, videos and other media have been studied since a long time [12]. The lack of standards delayed a rich use of 3D content, but its integration with textual information have been thoroughly studied in all its aspects, including not only navigation, but also the disposition and readability of the text [13], [14], and the usability of interaction paradigms [15], [16].

All the above works proposed the disposition of the text in a spatial fashion, immersing the text tokens it in the 3D environment. This approach did not handle a data structure where different types of media could be interconnected in a multi-directional fashion, as theorized by Halasz and Schwartz [17].

More recently, other approaches combined 3D models and textual information in an integrated fashion. The first one [18] presented a system to link textual information and 3D models, where the right point of view for the 3D model and the exact portion of the text are visualized automatically. This was implemented as a stand-alone application. Another recent work [19] explored the possibility of the integration of text and 3D models on the web, by proposing two visualization modes: one is a typical hypertext, while the other one creates a virtual 3D environment, where text is attached to 3D hotspots.

B. Text encoding and digital editions

In recent years, a good number of digital editions of ancient and modern texts have been published, and more are under work. The first examples of such editions date to the second half of the 90s of the last Century, and while most of them were based on simple HTML and/or Flash (e.g. see the MS Junius 11 by Bernard J. Muir http://www.evellum.com/index.php?option=com_virtuemart&Itemid=190), with a few exceptions already choosing XML for text encoding (see the Electronic Beowulf by Kevin S. Kiernan [20] http://ebeowulf.uky.edu/). They all shared the CD-ROM as a distribution medium. More recently, while retaining a considerable diversity (alternative approaches include such WYSIWYG tools as the Classical Text Editor by Stefan Hagel http://cte.oeaw.ac.at/, or using LaTeX macros for typesetting, possibly in a customized form as in the Mauro-TeX project [21] http://www.maurolico.unipi.it/mtex/mtexen.htm), many digital editions have settled on two standards: the World Wide Web for publication and dissemination, and the Text Encoding Initiative XML schemas and related Guidelines [22] for encoding of the edition text.

The TEI XML schemas are modular in nature, allowing for a great flexibility, so that for the purpose of creating a digital edition it is possible to only pick and choose the modules needed for the task: besides the essential TEI modules (*core*, *tei*, *header* and *textstructure*) most users only need to add the *msdescription* (Manuscript Description), *transcr* (Transcription of Primary Sources) and *textcrit* (Critical Apparatus) modules; if the edited text(s) include special or otherwise non-standard characters it is also possible to include the *gaiji* (Non-standard Characters and Glyphs) module, as well as *analysis* (Simple analytic mechanisms) if a linguistic, syntactical or other form of analysis is to be performed on the texts. A simple web interface (http://www.tei-c.org/Roma/) allows to create a new schema or modify an existing one, it is also possible not only to select only the XML elements really necessary for the text markup, but also to modify their characteristics and even create new elements and attributes.

Adding the *transcr* module makes available for use the elements (<facsimile>, <surface>, <zone>) and attributes (@facs) necessary to create digital facsimiles: this is particularly useful in the case of diplomatic or semi-diplomatic editions, where it is possible to have the manuscript images and the corresponding edition text facing each other, with a synchronized text-image linking down to the level of a single word or character, if so preferred. The TEI XML markup makes it possible to have different edition levels within the same XML file, which means that it is not necessary to have separate versions of the edition texts, for instance, for diplomatic and interpretative levels: it is very easy to extract these ”views” of the edition from the XML document by means of XSLT style sheets. As it is often the case with complex XML markup, the editor may have to face one of the most grievous limitations of the XML language, that of conflicting hierarchies: fortunately there are several possible workarounds, and the TEI Guidelines suggest many useful solutions.

Thanks to their power, flexibility, comprehensiveness and excellent documentation, available in both on-line and off-line forms, the TEI schemas have been chosen by a large number of projects aiming at creating digital editions, encompassing texts of all historical periods and a variety of philological methods [23], [24], [25].

The very flexibility and modularity of these XML schemas make it possible not only to customize them for one’s own purposes, but also to expand them according to the most recent philological theories, possibly experimenting with a non-standard extension which, after a period of testing and examination, is accepted within the existing collection of TEI modules. This is the case of the genetic criticism module (http://www.tei-c.org/SIG/Manuscripts/genetic.html) which has been accepted for inclusion and is now undergoing a testing period.

III. Preparing the digital edition

The Ruthwell Cross is an extremely interesting object of art and its relation with *The Dream of the Cross* goes beyond the presence of the carvings. There's a strong relation between the poem and the Cross considering at least three presentation levels:

- A *global* level, due to the shape of the object (the cross, intended as a monumental religious artifact).
- A *panel* level, where the single scenes depicted on the Cross are linked to the carvings.
- And finally a *rune* level, where the lines of the poem are linked to the object not only at a meaning level, but also due to their spatial disposition on the stone.

For this reason, the digital edition needed not only to be able to visualize the poem verses, but also to handle the other levels of presentation. Moreover, both the digital edition framework and the runes encoding needed to be structured in the most flexible end extendible fashion, so that they could be applied on other objects which share similar features.

Defining the target audience is an essential step in the design and development of a presentation system. In our case, we wanted to build a presentation system oriented towards didactic purposes. The aim was to compile a sort of "interactive textbook", to be used by teachers and scholars when presenting this artifact. For this reason, we had from the start the idea of presenting each level of exploration (the cross, the panels, the runes) in an independent way, but following a common presentation paradigm, to make the experience seamless. The web platform was chosen because of the wider and easier access, and to provide a uniform view over the data from different platforms.

In the next Sections, we will present the proposed integrated framework and the XML encoding.

A. Visualizing the high-resolution 3D model

The first step in this project was to display the high resolution 3D model, result of the 3D scanning campaign, in the webpage. Displaying high resolution models on the browser is not just a matter of optimizing the rendering speed, but involves also considering the loading time and network traffic caused by the transfer of a considerable amount of data. While WebGL gives direct access to the videocard resources, how data is transferred and managed is totally in the hand of the programmer. Loading a high-res model as a whole through the web, does require transferring a single chunk of data in the order of the tens of megabyte; this is unpractical.

Fortunately, multiresolution techniques may help both rendering and data transfer phases. Multiresolution schemes generally split the geometry in smaller chunks and for each chunk have multiple levels of details. Transmission is on demand, requiring only the essential parts of the objects to be loaded and rendered. While this principle is key to be able to render very large models at an interactive framerate, it is also helpful considering the network data transfer, since the data transferred will be divided in smaller chunks, and only transferred when needed. The advantages of using this kind of methods is the fast startup time and the reduced network load. The model is immediately available, even if at a very low resolution, for the user to browse, and it is constantly improving its appearance, as new data arrives. On the other hand, since refinement is driven by view-dependent criteria (observer position and distance from the 3D model sections), only the needed data are transferred.

We implemented one of such multiresolution scheme on top of the SpiderGL library [9], obtaining optimal performances. An extremely important aspect of using SpiderGL/WebGL is that the 3D visualization does not require additional plugins; this solution works on most browsers (currently it does not work on Internet Explorer, but it has been recently announced that WebGL will be supported soon also on this browser). The entire visualization system is based on HTML5, JavaScript and XML.

The Ruthwell Cross model currently used in the system (see Figure 3) is composed of 15 million triangles, with the color reconstructed by integrating digital photographs and mapping this info using a vertex encoding. Some tests are ongoing to exactly evaluate the network load, and to define optimal parameters for tuning the data exchange. While theoretically possible, we discarded the idea to use online the master full-res model (150 million triangles), because most data would be wasted, given the resolution of the visualization webpage and the level of zoom normally used in 3D navigation and rendering.

B. An integrated framework to visualize 3D and text on the Web

While the goal of the first version of the visualization scheme was simply to provide remote visualization for 3D and textual content, the proposed framework was designed with a larger scope, to be simple but extensible to other types of data (like images, video...).
Hence, the presentation system was organized in a modular and interconnected manner, where all the elements of the system could be easily reconfigured, arranged and assembled in a visualization page.

The basic idea is to let the user explore different datasets (in this case the 3D model, the descriptive text and the digital editions) independently, but also jump from one dataset to another exploiting some predefined connection points. Most multi-media presentation systems simply feature a *main* media dataset, to which other information is just "glued on". Conversely, we wanted to present to the user the different media on a true peer level. The scheme of the system is shown in Figure 1. A set of Viewer Modules is able to handle different types of data: in the current edition, only the 3D model and a structured textual information are taken into account (but we are planning to add at least a 2D images module in our future work). Each viewer component is able to display its dataset, leaving to the

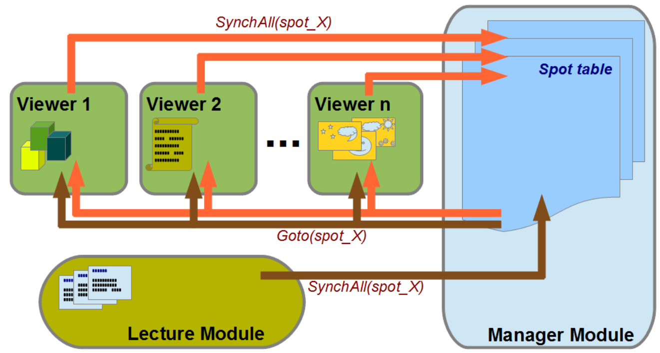

Fig. 1. A scheme of the presentation system: the Manager module communicates with Viewer modules using a synchronization signal. The Manager receives the message and broadcasts a command to focus on the given spot. The Lecture module is able to use the same signals to provide a path through pre-defined spots

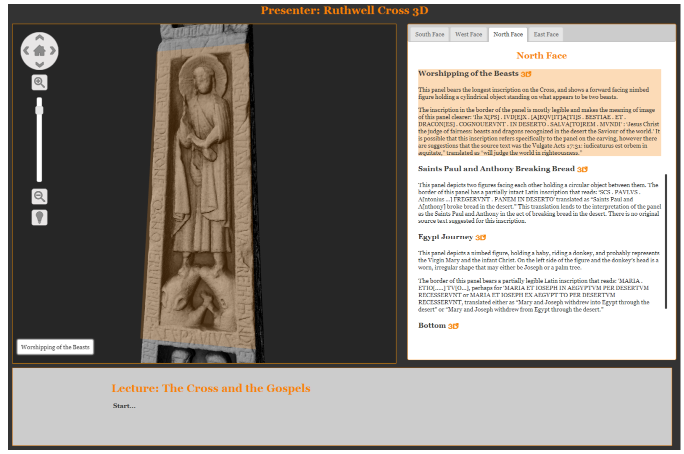

Fig. 2. A snapshot of the presentation framework, where a panel on the Cross is linked to a portion of text describing it.

user the possibility of a totally free exploration. When the user, while browsing a dataset, encounters one of the predefined points of interest, it may select it, forcing all viewers to synchronize, focusing their visualization on that specific point. The viewer modules communicate with the Manager module through a synchronization signal, which refers to a specific *Spot* entity. The Spot is a semantic element which defines a location in a dataset which is contained in the Manager module. Each spot connects different positions in each dataset presented by the viewer modules, associating for example a viewpoint for the 3D entity, and a portion of text for the textual module.
The Spots can also be used also by the Lecture module, which is able to provide a predefined thematic exploration path through them to suggest relations between spots.

All the mentioned modules are configured using an XML structure; this total separation between the presentation code and the data makes the system extremely flexible and reusable. XML was chosen due to both its flexibility and the fact that non-computer science people involved in the project (mainly Cultural Heritage operators) were more familiar with this kind of encoding, and already had all the proper tools to edit this data format (editors, viewers, exporters from their databases). The XML files are parsed using JavaScript, which gives also the possibility to easily handle the messaging procedure. The independence of the viewers and the simple message mechanism enable to introduce new types of data, by simply introducing a new viewer. For a more detailed description of the XML structure, and of the multiresolution structure that enables to handle extremely detailed 3D models, please refer to [26].

The subdivision of the cross in panels fits perfectly this paradigm, and it was simple to configure the system to present the cross at *panel* level: Figure 2 shows a snapshot of the system presenting one of the panels of the Cross, together with the corresponding textual description. On the left side, the 3D viewer lets the user to browse the 3D model by using a cylindrical trackball (especially suited for the specific geometry of the cross). Moving the mouse over the surface, the user may see the active areas as overlayed transparent polygons; once selected, the 3D viewer zooms in to better frame the selected area and the structured text viewer change the current tab and scrolls the text to present the appropriate descriptive text to the user. On the other side of the page, the structured text viewer presents the descriptive text of the panels, divided in tabs (one for each side). The user may navigate the tabs (when a tab is selected, the cross rotates accordingly), browse the text and, by selecting the different links, force the 3D viewer to move the point of view to frame the appropriate panel.

Given our system's architecture, it is simple to consider the editions as a new type of media: following this scheme, we will then add a new viewer, to display the editions, and establish connections between the elements of the edition and the 3D model. The definition of the XML encoding at the *runic text* level proved to be more complex, due to the more fragmented nature of the content, and to the need to comply as much as possible to the standards of the encoding of text in Digital Editions. The next Section will describe the choices of implementation, and the first results in showing the verses of *The Dream of the Rood*.

C. XML encoding of the text using TEI standard and XLST

Using our presentation system, presented in the previous section, it would have been easy to just take the structured text viewer and, with minimal changes, change it to display a digital edition of the text. However, this would have made both the encoding and the visualization completely unusable outside this specific system. Our aim, on the other hand, was to have this part of the presentation system completely interoperable with the tools and workflow of the rest of the project. For this reason the first issue taken into account was the encoding.

Encoding a text in XML, easy as it may seem, is not a straightforward task. In order to obtain an encoding which is both meaningful, complete, but also reusable and comprehensible for an external partner, it is necessary to follow existing standards and conventions. We used the guidelines [22] defined by the TEI (Text Encoding Initiative consortium), obtaining an encoding which is fully interoperable with the other digital tools used in the project. To this purpose, in addition to the basic set of modules provided by TEI, we

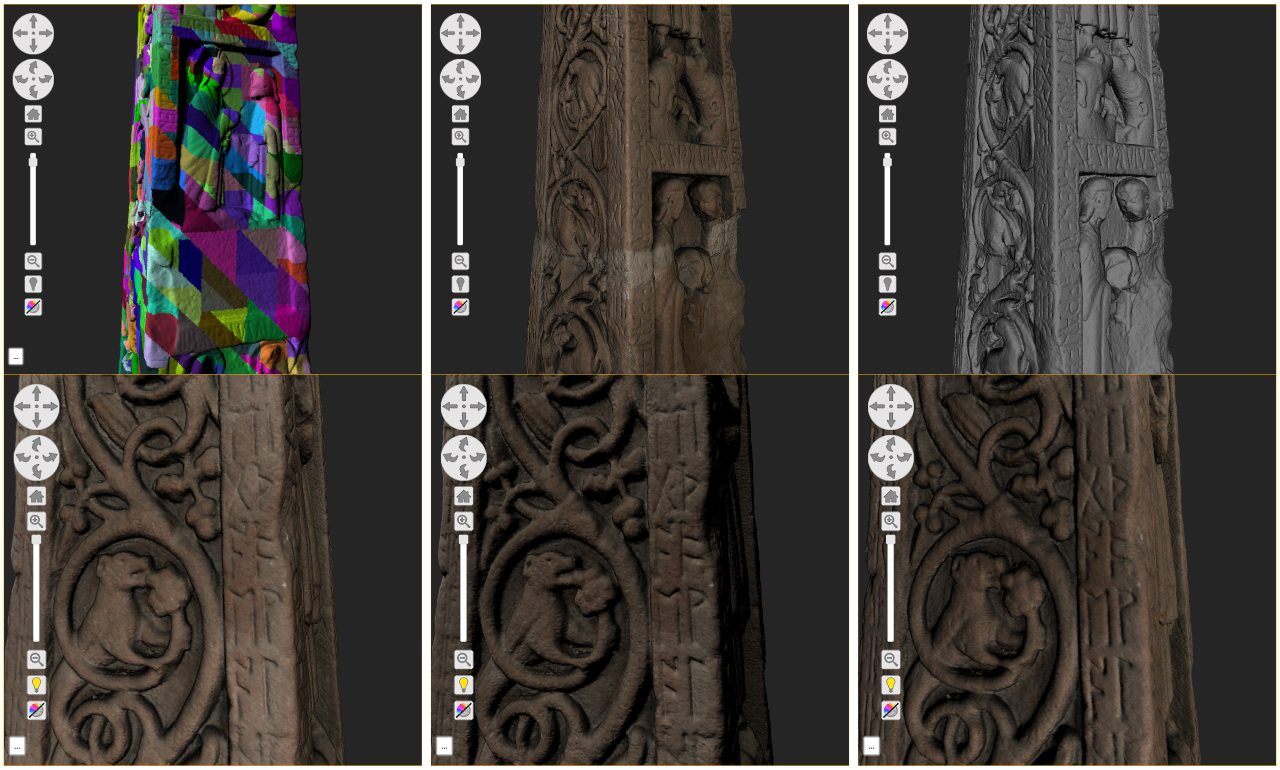

Fig. 3. Screenshots of the rendering of the high-resolution 3D model of the cross. Top left: the patches of the multiresolution rendering engine. Top middle: the geometry with mapped photographic color. Top right: the geometry in a simple lambertian shading. Bottom row: changing the light direction, to simulate raking light, helps the readability of the carvings.

selected those modules which coped with the peculiarities of the poem: *transcr*, used to represent primary sources, like manuscripts; *gaiji*, used to encode non-standard characters, like runes; *linking*, used to aggregate and add structure to the entities.

Then, to transform the XML into HTML, instead of using homebrew JavaScript code, we used XSL Transformations, another widely used standard in the field of digital philology and digital editions. XSLT (eXtensible Stylesheet Language Transformation), a standard upheld by W3C, is a declarative language used to transform an XML document in another type of document. It is interesting that the XSL document which defines the transformation is itself an XML document, where a series of substitution/recursive/branching templates are encoded. A processor, which may be integrated into a web browser or as a stand-alone tool, reads the XSL templates, and applies them to the XML document to be transformed. Note that the XSL Transformation was used not only in the online system, but also in the other activities of the project.

An important point for the integration of this new media element in the system, is to preserve its dynamic nature. This can be achieved, since XSL Transformation may be invoked dynamically, making it possible to follow the same strategy used for the structured text viewer: loading the XML when the page is about to be displayed, transforming the XML into HTML (this time, by using XSL) and injecting the HTML into the appropriate empty element in the page.

1) Encoding the Facsimile*:* Especially when dealing with an ancient text, there is not a unique way to transcribe and format it, because text is a living entity, and has changed during time. It has appeared in different shapes and variants, depending on the time period of its publication, the media it has been recorded upon, and the amount of editorial intervention. For this reason, when presenting one of these ancient texts, it is often necessary to provide different versions or, more precisely, editions of the text.

In our project, we wanted to display three different editions of *The Dream of the Rood* poem, starting from the one closest to the shape and characteristics of the carving on the cross (the *Facsimile* edition); moving to a more structured representation (the *Diplomatic* one), which is a compromise between the format on the cross and a book-like formatting of the poem; and finally reaching the one representing as faithfully as possible the original version, as it has been reconstructed by the integration and comparison of different sources (the *Critical* edition).

Our work started from the encoding and visualization of the *Facsimile* edition. This choice was made because the *Facsimile* edition offered three unique challenges:

- This edition should preserve the runic characters; this had to be considered in the XML encoding, in the parsing, and in the rendering of the web page.
- The *Facsimile* has to mimic as closely as possible the actual spatial arrangement of the runes on the cross (an inverted U), which is more complex to manage with respect to a formatting more akin to poetry (which is easier to encode and display).

- This edition is the closest to the 3D shape of the cross; thus, this made it the ideal candidate to experiment with the concept of 3D-connected digital edition.

The encoding copes with the mentioned peculiarities by using XML tags and properties (see Figure 4). The inverted U arrangement was achieved by dividing the runes among three containers (upper horizontal line, plus two vertical arrangement of lines). The runes were managed using a sort of "dictionary": the actual characters were encoded as *gliph* elements, each one with a unique ID (to be able to individually address each rune) and a type, which specifies the kind of rune. In the dictionary, for each kind of rune, the unicode character used to display it, and its transcription in modern English were stored. Finally, the different indexable entities (runes, words, lines) were each grouped using basic XML tags, or more complex elements such as <join>.

Defining the XSL Transformation used to transcode the described XML was not easy, for the very same points of interest mentioned earlier (the use of runes, and their spatial arrangement). Each container was transformed in a div, shaped and formatted using CSS. The runes, to be transformed, required a level of indirection (from the text to the dictionary). Thanks to the double encoding, it was possible to print them using both the appropriate runic symbol and its transcription in modern English, obtaining a side-by-side visualization of the *Facsimile*. Besides the required formatting, it was also necessary to add the HTML elements which are used by the system to manage spots (selection and viewer focusing); this was done quite easily.

As a minor issue, all existing browsers do support XSLT 1.0 but not the newer 2.0 version. While it is possible to do the transcoding in both formats, XSLT 2.0 is more stable and it is easier to use in order to manage the more complex XML structures used in our encoding (the same transformation, in XSLT 1.0, would require tricks and a substantial use of recursion). This resulted in having to provide two different versions of the transformation, a more elegant and optimized XSLT 2.0 version to be used in the offline tools, and an XSLT 1.0 version to be used in the web-based presentation system.

2) Multiple levels of linking: In the first example of the system (see Section III-B), we connected the 3D dataset and the textual dataset by using, as connecting spots, the panels on the cross surface. This choice was made because this data granularity was easy to understand but, at the same time, complete enough to properly describe the object.

However, when working with the editions, we soon realized how the definition of the level of linking in the dataset was an issue. The *Facsimile* edition is in runic, should we allow to link each single rune? each word? each line (as it appear on the cross)? We had to face two problems: A) the granularity of the linkage is much smaller, B) there may be more than one level of linking for each edition. While the point A) only required more spots to be created, the point B) needed some additional work to make possible to change the level of linking on the fly, according to the choice of the user.

In the case of the *Facsimile* edition, we opted to maintain the linking at two different levels:

Fig. 5. The *Facsimile* edition with spot linking at word and line level. Top, linking at word level. Bottom: linking at line level.

- **Word**: each word of the poem is a synch spot; see Figure 5, top.
- **Line**: each line of the carving is a synch spot; see Figure 5, bottom.

These two levels were also chosen because one was much closer to the physical shape of the carving, while the other was closer to the semantic structure of the poem. The user may change the level of linking at any time (using a button), depending on his interest. While giving the XML encoding, a linking at the level of each single rune is entirely possible (each rune has a unique ID), it seemed uninteresting to reach this level of granularity.

3) Other Editions: As discussed, we started from the *Facsimile* edition, because of its availability and its peculiarities (the runic alphabet, the shape, and its close relationship with the 3D shape). The work on the other editions, the Diplomatic and Critical ones, is still ongoing, as the project is still working on completing them. Thanks to the work done in the *Facsimile*, in terms of XML encoding and XSL Transformation, the addition of these two new editions to the system will be easier. The kind of formatting required, closer to the one used in poetry, is easy to obtain in HTML, and the displaying of properties of the characters (missing, damaged, supplied) is also feasible. It is clear that also in the other two editions there will be multiple levels of linking.

```xml
29    <charDecl>
30       <char xml:id="feoh">
31          <charName>RUNIC LETTER FEHU FEOH FE F</charName>
32          <mapping type="transliterated">f</mapping>
33          <mapping type="runic">&#5792;</mapping>
34       </char>
35       <char xml:id="ur">
36          <charName>RUNIC LETTER URUZ UR U</charName>
37          <mapping type="transliterated">u</mapping>
38          <mapping type="runic">&#5794;</mapping>
39       </char>
40       <char xml:id="thurs">
41          <charName>RUNIC LETTER THURISAZ THURS THORN</charName>
42          <mapping type="transliterated">&#254;</mapping>
43          <mapping type="runic">&#5798;</mapping>
44       </char>
[.....]
212         <ab type="strip_left" xml:id="RC_ES_ab2">
213            <lb n="1"/><w xml:id="RC_W_016"><g xml:id="RC_G_069" ref="#ac"/><g xml:id="RC_G_070" ref="#haegl"/>
214            <lb n="2"/><g xml:id="RC_G_071" ref="#os"/><g xml:id="RC_G_072" ref="#feoh"/></w>
215            <lb n="3"/><w xml:id="RC_W_017"><g xml:id="RC_G_073" ref="#is"/><g xml:id="RC_G_074" ref="#cen"/></w>
216            <w xml:id="RC_W_018"><g xml:id="RC_G_075" ref="#rad"/><lb n="4"/><g xml:id="RC_G_076" ref="#is"/>
217            <g xml:id="RC_G_077" ref="#is"/><g xml:id="RC_G_078" ref="#cen"/><g xml:id="RC_G_079" ref="#nyd"/>
218            <lb n="5"/><g xml:id="RC_G_080" ref="#aesc"/></w>
[.....]
340         <join xml:id="RC_L_039" target="#RC_G_101 #RC_G_102 #RC_G_103"/>
341         <join xml:id="RC_L_040" target="#RC_G_104 #RC_G_105 #RC_G_106 #RC_G_107"/>
342         <join xml:id="RC_L_041" target="#RC_G_108 #RC_G_109 #RC_G_110 #RC_G_111"/>
```

Fig. 4. Snippets of the XML encoding for the facsimile edition. In the first chunk (lines 29-44), it is visible the character "dictionary", where each rune type is mapped to its modern transcription and Unicode char code. In the second chunk (lines 212-218), it is displayed a part of the encoding of one of the vertical strips of runes; all the elements, runes and words, have their own unique ID in order to be individually addressable (e.g. RC_G_71 is the $71st$ rune, RC_W_018 is the $18th$ word). The third chunk (lines 340-342) shows how some different grouping of runes; in this case, the lines of the carving, have been expressed as <join> (again, each one individually indexable).

IV. Results: an Integrated Edition of the Dream of the Cross

The prototype of the integrated edition is built entirely using the described presentation system. As said, the idea was to provide a tool for didactic purposes, to be used as an active textbook. In this sense, we wanted to mimic the way books divide different levels of information in different chapters. The three different level of significance of the cross (the cross, the panels and the poem) are then arranged in three different "chapters", each one implemented as a single webpage built using our presentation tool. When moving from one page to another, the user moves through the level of presentation:

- **The Cross**: in this page, the cross is presented as a whole, using only the 3D viewer. The Lecture component is used to provide a guided walk-through of the cross, presenting the signs left on on the cross by its difficult history.
- **The Panels**: as described in Section III-B, by using the 3D viewer and the Structured Text viewer, this page presents the different panels and their depicted stories (see Figure 6, top). The Lecture component provides thematic walk-troughs (stories from the gospels, mythological figures).
- **The Poem**: in this page, the poem is the main focus. The 3D viewer is sided by the Edition viewer, where the different edition are presented (see Figure 6, bottom).

For review purposes, a video showing the navigation features and the interactions can be downloaded from the following link: http://www.youtube.com/watch?v=Wov-2ik4ibY

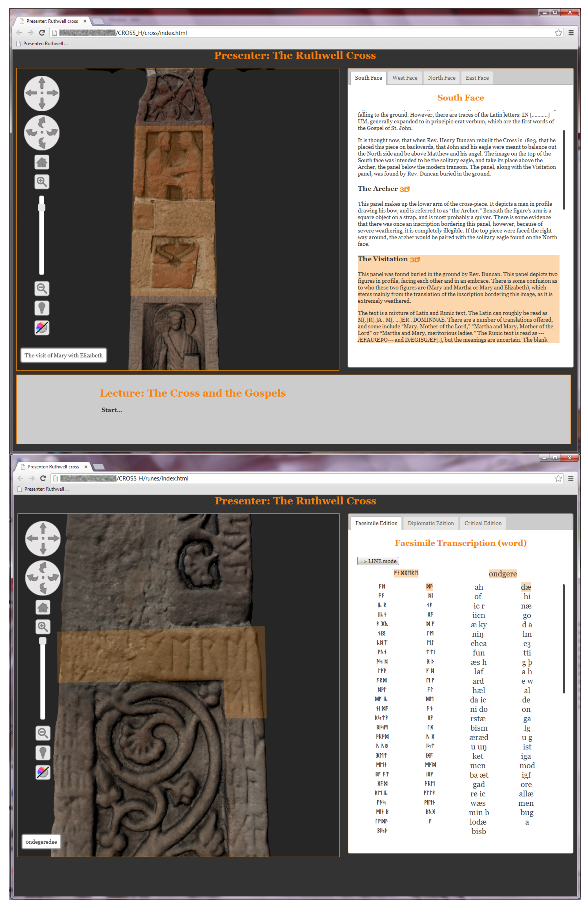

Fig. 6. Screenshots from the Integrated Digital Edition: on top, the cross explored at the level of the carved panels; on bottom, the digital editions of the poem, connected with the geometry.

V. Conclusion

In this paper we presented the first prototype of an Integrated Digital Edition, aimed at the exploration of the *The*

Dream of the Rood poem and the Ruthwell Cross, showing their deep interconnection.

In order to be able to represent the different level of relation (global, panels, runes) between the two elements, we created an integrated framework to visualize 3D and textual content. The entire system is based on HTML5, JavaScript and XML, works on most modern browsers, and does not require additional components or plugin to work. Moreover, the configuration of the webpage is obtained using a set of XML file, which are easy to modify also for non-expert users. The system proved to be easy to use and flexible enough to encode the different levels of presentation we needed. An extremely important point is that the tool is extensible and configurable; thanks to the modular structure and the complete separation between visualization code and data, it is easy to add new types of media, and to reconfigure it to display a different set of artifacts and media.

Additional effort was put in the encoding of the editions of the poem verses that were carved on the Cross. The XML encoding was implemented following the standards defined by the TEI initiative. Hence, it is fully interoperable with both the web-based visualization system and the tools commonly used in the field of digital philology. Moreover, different levels of linking for the runes (lines or words) were implemented to enrich the modalities of navigation.

Regarding the future work, the goal is to encode all the necessary editions of the poem (i.e. Diplomatic and Critic). Other possible extensions of the current system include new mechanism to create content, and the possibility to visualize and integrate other types of media, like images and videos.

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