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Synthesizing Image and Text in the Life of the Buddha

Introduction

The challenge of studying visual art, literature, and their institutional contexts in a synthetic fashion is acute throughout the humanities today. The Life of the Buddha (LOTB) project addresses this challenge by providing a digital platform for presenting and analyzing for the first time monumental Tibetan murals depicting the Buddha's life and their related literature within their architectural and historical settings: www.lifeofthebuddha.org. LOTB offers scholarly and learning communities the first tool to research and engage Buddhist images, texts, architecture, and history as an integrated and meaning-rich whole. The project's impact for the humanities and the study of Buddhism is thus twofold: it is the largest study to date on visual and textual Buddha narratives in Tibet, and it is also a new digital tool for synthetic teaching and research of Buddhist images and texts in context.

Such work reflects changing interests and research paradigms in the fields of Buddhist and Tibetan studies. In the past two decades there has been a "cultural turn" in Tibetan literary and historical studies, in which researchers are interested in the ramifications of text beyond the written page, as manifested in visual, material, and performance cultures. Where once scholarship in these areas was siloed into such sub-fields as art history, literary studies, ritual studies, institutional history, and so forth, advances in digital technology have both allowed and encouraged researchers to transcend these boundaries.

LOTB now serves as a major repository for materials pertaining to the Buddha's life as rendered in Tibet. The project's value further lies in its capacity to correlate key components of cultural production in complex ways that has remained a challenge. From the mid-nineteenth through the mid- to late-twentieth centuries, philology and literary scholarship formed the core of "Buddhist studies" as a field of enquiry. Other disciplines such as anthropology or art history treated Buddhist subjects, of course, though often did so in parallel to rather than in conjunction with textual studies. The turn toward visual and material cultures in recent decades has led to a more methodologically plural field of research, in which texts and image are considered equally important and mutually informing sources for understanding Buddhist cultural practices and products. Digital tools allow for increasingly complex forms of analysis across multiple

media simultaneously. They do so by providing means for evaluating text and image side by side in a flexible fashion, and for collecting, structuring, and relating data across large collections of primary sources, regardless of media type. In a digital environment, text and image are drawn together within the same analytical and interpretive space.

LOTB is based on a literary and visual corpus produced at the monastery of Takden Puntsokling (Rtag brtan Phun tshogs gling), seat of the Jonang tradition of Tibetan Buddhism in the Tsang (Gtsang) region of the Tibet Autonomous Region. Created by the monastery's founder Tāranātha (1575–1634), these materials include an extraordinary set of narrative murals depicting the life of Śākyamuni Buddha. The murals date from the first decades of the seventeenth century and are among only a handful of fully preserved narrative paintings in Central Tibet. Practically nothing has been written about the Jonang murals, and no complete visual documentation of them has been undertaken prior to this project.

The LOTB project provides a multimodal framework for reading and analyzing the visual narratives of the Jonang murals in conjunction with their primary literary source, Tāranātha's extensive treatment of the Buddha's life story entitled the *Sun of Faith (Dad pa'i nyin byed)*, and related materials. To do so, we have adapted and extended a suite of tools in the Mirador viewer, a configurable and extensible environment for displaying and annotating images compliant with the International Image Interoperability Framework (IIIF), which has become the international standard for digital image archives.[1]

We chose Mirador over other possible platforms (including WordPress, Story-MapJS, and Media Thread) because of its flexibility and extensibility.[2] The LOTB team valued Mirador for its ability to link texts to specific points and regions in large images (even though other early projects employing Mirador did not exploit this potential), and its flexibility in handling multiple layers of annotations. Media Thread, a platform for collaborative multimedia presentation, annotation, and evaluation developed by Columbia University's Center for New Media Teaching and Learning, was a promising option early on in the project. We worked closely with the Media Thread team to develop an instance for working with LOTB materials. Although it provides a robust and intuitive work environment, it was unable to accommodate our large image files. In the end, Mirador provided three key features in a single product: (1) image delivery and navigation; (2) 2D freeform shapes employed as annotations upon an image; and (3) multiple

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1 For an overview and history of Mirador see Mirador, http://projectmirador.org/. Further details on IIIF technical details and community resources at IIIF, http://iiif.io.

2 See StoryMap, https://storymap.knightlab.com and Mediathread http://mediathread.info.

hierarchical layers of text annotation. At the time of development, we were not able to locate another tool that integrated these features. Finally, Mirador had, and continues to have, an active international community of developers and users who were instrumental to our first technical team's ability to modify the tool's functionality for the project needs.

Background

LOTB is the first full-scale study of the life of the Buddha in a Tibetan setting. Scholarship on Buddhism throughout Asia has analyzed relationships between temple and cave murals, ritual and narrative literature, and the architectural contexts and institutional settings in which they were produced. Ajanta in India, Dunhuang in China, and Borobudur in Indonesia all have been the focus of extensive research.[3] The present case afforded a distinctive opportunity: the combination of a broad Tibetan literary corpus and a parallel set of detailed murals allows us to explore issues such as the planning and design of visual narratives, relationships between written and painted life stories, as well as other social, political, and economic perspectives on art and literature in place.[4]

LOTB brings to light what we have identified as a "Buddha Program" at Tāranātha's monastic seat of Puntsokling: a broad organizational principle consisting of a large body of Tāranātha's writings, including narrative, poetic, ritual, and technical painting literature about the Buddha, and its related religious iconography, statuary, and narrative artwork. The Buddha Program formed a central theme for the monastery, affording it a high degree of institutional prestige in the eyes of his patrons and their potential rivals.

The emphasis on Śākyamuni Buddha at Jonang was the result of competition among major monasteries in Central Tibet, where religious leaders had re-

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3 See, for example, Luis O. Gómez and Hiram W. Woodward, Jr., *Barabudur: History and Significance of a Buddhist Monument* (Berkeley: Univ. of California.Woodward, 1981); Dieter Schlingloff, *Ajantā: Handbuch der Malereien = Handbook of the Paintings* (Wiesbaden: Harrasowitz, 2000); Roderick Whitfield, *Caves of the Thousand Buddhas: Chinese Art from the Silk Route* (New York: George Braziller, 1990); Roderick Whitfield, Susan Whitfield, and Neville Agnew, *Cave Temples of Magao: Art and History on the Silk Road, Conservation and Cultural Heritage* (Los Angeles: Getty Conservation Institute and the J. Getty Museum, 2000).
4 See Andrew Quintman and Kurtis R. Schaeffer, "The Life of the Buddha at Rtag brtan Phun tshogs gling Monastery in Text, Image, and Institution: A Preliminary Overview," *Zangxue xuekan /Journal of Tibetology* 13 (Summer 2016): 31–71; Andrew Quintman, "Putting the Buddha to Work: Śākyamuni in the Service of Monastic Identity," *Journal of the International Association of Buddhist Studies* 40 (2017), 111–156.

course to a number of mythoi around which to construct a symbolically rich institution. The Buddhist bodhisattvas, or celestial beings, such as Avalokiteśvara or Maitreya, were already in use by other leading figures in Central Tibet (Avalokiteśvara by the Dalai Lamas; Maitreya at Tashilhunpo Monastery). The choice of Śākyamuni, the buddha of our age, was an underutilized but undeniably authoritative figure across Tibet. As a guiding mythos, it thus made good strategic sense. On the local level, the life of the Buddha could be employed as a model for emulation in the education of the monastic population of Jonang, with textual resources available for the relatively small group of highly literate monks and visual resources available for the general monastic population and lay visitors. On a regional level, the broad and varied deployment of the figure of Śākyamuni—especially as the institution's principal Buddha icon of miraculous origins—distinguishes the monastery from its neighboring peers even as it suggests comparison with such famous Buddha images as the Jowo Śākyamuni statue in Lhasa.

The literary source for the visual narrative—Tāranātha's composition entitled the *Sun of Faith*, often referred to as the *Hundred Acts of the Buddha (Ston pa Shākya'i dbang po'i mdzad pa brgya pa)*—is one of the most extensive Tibetan treatments of the Buddha's life story. Tāranātha's narrative was innovative; he utilized little-known elements from the early literature of Buddhist monastic law known as the Vinaya, rather than standard and much later Mahāyāna sūtras favored by most other Tibetan writers. Jonang thus serves as a rare, and perhaps unique, example of an extant Buddha life mural in Tibet drawn from Vinaya sources. A related text, Tāranātha's *Painting Manual for the Hundred Acts of the Buddha (Mdzad pa brgya pa'i bris yig)* composed sometime between 1618 and 1620, serves to translate the text into images, presenting a frame-by-frame discussion of the iconography, composition, and symbolism in the Jonang murals. A further work, the *Guide to Jonang Monastery (Dga' ldan phun tshogs gling gyi gnas bshad)* (which is typically included in Tāranātha's collected works, but is likely not authored by him) together with other related texts, maps out a plan of the murals' architectural setting within the monastic complex including the assembly hall and upper gallery, and presents a catalogue of religious objects, statues, and other materials in situ at the time of their construction. Tāranātha's massive autobiography provides additional evidence for the historical, political and economic contexts in which these materials were produced.

Two major mural cycles dedicated to Śākyamuni Buddha are extant at Puntsokling Monastery: (1) the main shrine room and assembly hall, which houses images of the Buddha teaching the texts associated with Jonang's doctrinal traditions, select scenes from the life of Buddha, as well as illustrations of other

narratives. These murals are approximately 10 feet in height and are dominated by 40 iconographically and stylistically distinct representations of the buddha; and (2) the upper gallery, which houses a complete life story of the Buddha. This continuous mural is approximately 5.5 feet in height and runs along all four walls for over 300 linear feet in fifteen discrete panels. (See Figures 1–2)

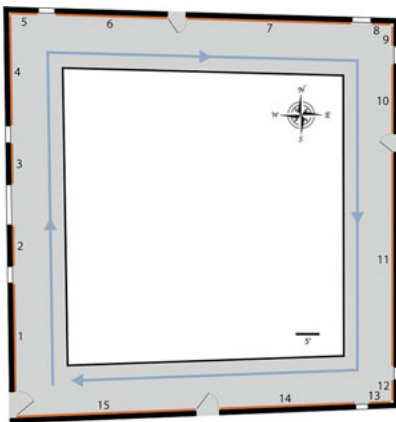**Figure 1:** Location of the Life of the Buddha Murals.

Figure 2: LOTB Mural Panel Locations.

The upper gallery is perhaps the more famous of the two, known by Tibetan authors and scholars of Tibet for its dynamic portrayal of narrative events through the juxtaposition of active human figures, diverse images of landscape and architectural settings, and judicious inscriptions that bind Tāranātha's longer literary renderings to the visual narrative. This gallery visually depicts each of the more than one hundred acts of the Buddha as described in Tāranātha's account. Each vignette, moreover, may consist of anywhere from one to ten individual human or divine figures, so that the mural contains hundreds of human figures in a dizzying array of vibrant poses. (See Figure 3)

Figure 3: Detail from Panel 1, Prince Siddhartha's Archery Contest.

The LOTB Website: Adapting the Mirador Viewer

How did we use and adapt web-based tools to study and present the materials described above? LOTB focuses on the upper gallery murals to document Tibet's most significant literary and visual materials depicting the life of Śākyamuni Buddha (though it could, and we hope will, extend to the lower gallery). At pre-

sent the LOTB website presents all fifteen mural panels in full resolution, with detailed annotations, corresponding to the Buddha's birth, life in the palace, renunciation, enlightenment, and early teaching. This covers approximately 12% of the total visual and literary narrative content, but it forms a cohesive arc of the Buddha's life story, and includes many of the best-known episodes. Our thinking about how a digital framework can help meet our aspirations for synthetically engaging, analyzing, and interpreting visual and literary narratives thus begins with a manageable sample of the total corpus. We worked with Yale University's IT and Software Development staff, in conjunction with student research assistants, over several years (as described below) to produce a basic Drupal website to provide background information about the project and its materials, labor that was supported by our general grant funding. The website also serves as the portal to LOTB digital assets and the major platform at the project's core: the Mirador viewer. While Mirador has been used internationally for a number of archival projects, LOTB has adapted the tool to meet new needs.

The Mirador viewer was initially developed at Stanford University with support from the Andrew W. Mellon Foundation as a "configurable, extensible, and easy-to-integrate image viewer, which enables image annotation and comparison of images."[5] Because it complies with IIIF standards of digital asset creation and management, the viewer is able to draw from digital repositories anywhere in the world. As originally developed, Mirador presents several basic features. It allows for the viewing of an image, or multiple images, selected from a larger gallery. It provides a tool for smoothly zooming and panning across the selected images. It also allows users to create simple shapes for outlining regions of an image and link an associated text annotation. Prior to the LOTB project, Mirador's robust annotation features remained underutilized and we found no evidence that its freeform annotation functionality was used at all. LOTB thus represents the first large scale, public-facing digital project to significantly expand the application of Mirador's annotation features.

Mirador was originally adopted by university libraries and museums as a tool for documenting and showcasing digital surrogates of text manuscripts and artwork. For example, the Wolsey Manuscript Project at Christ Church and Magdalen College deployed Mirador "to enable and encourage academic study and research around the Wolsey Gospel and Epistle Lectionaries."[6] These two lavishly illustrated sixteenth-century manuscripts were originally produced as a set but are currently housed in the collections of separate institutions. Mirador

5 Mirador, http://projectmirador.org.
6 The Wolsey Manuscripts, http://www.wolseymanuscripts.ac.uk/about.

thus allows a user to view the two volumes in conjunction with one another, side by side, as originally conceived centuries ago.

A similar instance of Mirador is found in The Archaeology of Reading project, a collaboration by the libraries of Johns Hopkins University, University College London, and Princeton University, and the Principal Investigators Professors Lisa Jardine and Anthony Grafton.[7] The project aims to create a corpus of "important and representative annotated texts with searchable transcriptions and translations" in order to "compare and fully analyze early modern reading, and place that mass of research material within a broader historical context."[8] In its current state, the Archaeology of Reading project primarily uses Mirador as a platform for viewing digital surrogates of rare book materials. Its directors expect that basic annotations with transcriptions and translations of the primary materials will soon follow.

The SAT Taishōzō image database, led by Mr. Tetsuei Tsuda, chief curator in the National Research Institute for Cultural Properties in Tokyo, uses the Mirador viewer to tag and annotate iconography preserved in the image section of the Taishō Tripitaka, the multivolume Japanese Buddhist canon.[9] This image database, currently the first two of twelve volumes, allows users to click on predefined regions of an image, which results in popup windows containing relevant details, including iconographic identification and descriptions. Users can also perform basic keyword searches from a predefined lexicon of terms.

A more robust application of Mirador's text markup features has been deployed in the Ten Thousand Rooms Project developed at Yale University by Tina Lu and Mick Hunter.[10] The project "allows users to upload images of manuscript, print, inscriptional, and other sources and then organize projects around their transcription, translation, and/or annotation. Both as a workspace for crowdsourcing core textual research and as a publishing venue for scholarly contributions that are less well suited to conventional book formats, the Ten Thousand Rooms Project aims to establish an international online community committed to making the East Asian textual heritage more accessible to a wider audience."[11] Ten Thousand Rooms thus allows users to create and share their own collections of digital texts together with complex layers of associated data. The project required significant modifications to Mirador's user interface

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7 The Archaeology of Reading, https://archaeologyofreading.org.

8 "What is the Archaeology of Reading," The Archaeology of Reading, http://archaeologyofreading.org/what-is-the-archaeology-of-reading/.

9 SAT Taishōzō Image DB, https://dzkimgs.l.u-tokyo.ac.jp/SATi/images.php.

10 "The Ten Thousand Rooms Project," Yale University, https://tenthousandrooms.yale.edu.

11 "The Ten Thousand Rooms Project," Yale University, http://tenthousandrooms.yale.edu.

in order to accommodate multiple annotation streams and facilitate the incorporation of East Asian languages.

Whereas the Ten Thousand Rooms project allows readers to transcribe, edit, translate, and annotate multiple small images in an "annotation window" (in the language of Mirador) arranged side-by-side with an image of a text according to user preference, LOTB required additional functionality that led to three main advancements: (1) the incorporation of large high-resolution images; (2) the creation of freeform annotation outlines on those images; and (3) a structured hierarchy of annotation layers that relate back to the image outlines and a table of contents. A guiding principle in the adaptation of Mirador was to make the technology frameworks as transparent as possible, allowing users to focus on content.

As discussed below in the section on Institutional Opportunities and Challenges, we developed early iterations of the LOTB project in the context of undergraduate classroom teaching with support from Yale's Instructional Technology Group. Together with a small team of technologists and student interns, we prepared basic visual and textual materials, and set up student work sites in WordPress and other digital platforms. Starting in 2015, a two-year collaborative research fellowship from the Robert H. N. Ho Family Foundation, who sponsored the project through the American Council of Learned Societies (ACLS), funded all major aspects of the project, including the development and adaptation of Mirador, digital image processing, database production and management, and website design. Two teams worked side by side, a team of technology experts and a team of research scholars in Tibetan and Buddhist Studies. The technical staff included a project manager; three software developers, one focused on Mirador, one on databases, and one on the Drupal site that serves as the portal to the Mirador program; a classroom technology consultant who helped with early WordPress iterations of the project and digital asset management; an image processing and graphic design specialist; and a user experience specialist. On the content side, a number of research assistants worked on the textual and visual materials: two Ph.Ds in art history and one graduate student worked on visual analysis of the mural; one Ph.D. student worked on Tibetan language transcription and translation; and one Ph.D. student researched the classical Indian literary background of the life of the Buddha narrative.

Unlike other Mirador instances, LOTB uses a small number of large high-resolution image files, each corresponding to one of fifteen mural panels that span approximately 7–30 linear feet (or 40–200 square feet) of painted surface. The two of us digitally photographed the mural panels in their entirety, producing approximately three thousand discrete RAW image files. (See Promey and Floyd's essay in this volume for some further methodological and ethical considerations

about high-resolution site photography carried out in Peru.) We then employed a digital image specialist to stitch the images together and color correct the large files in Photoshop to replicate the mural panels in life-size detail. Significant analytical work was then necessary to identify elements in the mural panels that correspond to chapters in the *Sun of Faith*, as well as smaller narrative units within chapters we designate as "scenes."

A crucial innovation in the LOTB Mirador instance is the ability to create freeform visual markup as a way of demarcating chapters and scenes in the mural panels. Tāranātha divides his literary narrative of the Buddha's life into chapters (numbered 1–125) but not scenes. We therefore defined scenes as discrete instances of action, occurring in a unique time and place and located in a particular chapter of the story. While narrative units in the mural are often suggested by the placement of environmental features such as mountains, trees, and clouds, neither chapters nor scenes are explicitly noted.[12] Identifying and designating chapters and scenes therefore became a key task in our analysis of the murals. In our initial analysis, we used hand-drawn outlines superimposed upon printouts of mural sections to outline the scenes we defined. Mirador was originally built to allow only simple rectangular or circular outlines on an image. To our knowledge, prior to the LOTB project, Mirador did not allow users to define non-rectilineal spaces. Yet this was an indispensable feature for visually mapping out narrative elements that spread across the muralscape in irregular and disconnected ways. LOTB developers thus adapted Mirador to both portray non-rectilinear outlines upon the mural, and to allow content-creating users to draw freeform shapes within Mirador. What was initially a useful heuristic for "reading" the mural, namely drawing outlines around a given portion of a printed image in order to define a scene, is now available as a tool in Mirador. That being said, the drawing tool lacked the sensitivity to draw clean, clear, and elegant lines we required. As a workaround, we collaborated with a graphic design specialist to draw chapter and scene outlines in Adobe Illustrator. The technology team then imported outline coordinates into Mirador as machine-readable data capable of being linked to other annotation layers, such as the literary narrative, painting manual, and inscriptions.

The third innovation of the LOTB Mirador instance is the creation of a structured hierarchy of multiple layers of annotation data. This required an expansion of Mirador's capacity to portray discreet forms of data in a unified way. We began

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12 This is distinct from other examples of Tibetan narrative painting (both murals and portable hanging scrolls) in which discrete vignettes are inscribed with sequential numbers and occasionally descriptive text in order to facilitate reading.

by establishing a spreadsheet using Google Sheets for systematically document-ing data and correspondences between types of data across multiple visual and textual resources including (1) mural panels, chapters, and scenes; (2) Tibetan and English versions of the *Sun of Faith*; (3) Tibetan and English versions of the *Painting Manual*; (4) Tibetan and English versions of the inscriptions; and (5) Buddhist canonical sources for the narratives. Structured correspondences are identified in the spreadsheet across all resources down to the level of senten-ces in the texts and scenes (or parts of scenes) in the murals. The spreadsheet now serves as the source for the content database behind the Mirador viewer. Chapter and scene outlines serve as annotation anchors, to which other annota-tion layers are linked. This allow users to interact with the various kinds of source materials as a seamless and integrated whole. A collapsible Table of Con-tents of chapter titles in English and Tibetan serves as a top-level organizing structure, allowing users to find and read both image and text in an ordered way, much like reading a book.

Reading the Life of the Buddha on LOTB

LOTB users can engage with the life of the Buddha in a variety of ways. First, they can approach the materials in a linear fashion, which emulates the tradi-tional experience of reading the Buddha narrative. A brief walkthrough is the best way to understand how LOTB's Mirador instance works in this approach. Upon entering the Mirador viewer from the LOTB site, a "table of contents" ap-pears screen-left, and the entire panel one mural appears screen-right. Clicking any chapter in the table of contents zooms the mural image to the first scene of the selected chapter, adds a non-rectilineal visual outline in the form of a yellow line around the scene in the center of the screen, and brings up our English translation of Tāranātha's *Sun of Faith*, which appears on screen-right (Figure 4). From there, the user can navigate the story through any of the three windows: table of contents, image window, or text window.

The table of contents is perhaps the easiest tool for navigating the story in a chronological fashion. Selecting a chapter title calls up the text and its associat-ed part of the mural. As the user scrolls through subsequent scenes and chapters in the narrative text, the mural "follows along" as scenes zoom to the center of the image window. Selecting, dragging and scrolling the mural image, or navigat-ing using the movement controls in the lower right of the image window allows one to explore the visual narrative more freely. As a user hovers the cursor over a given section of the mural, an outline appears around the scene, together with a
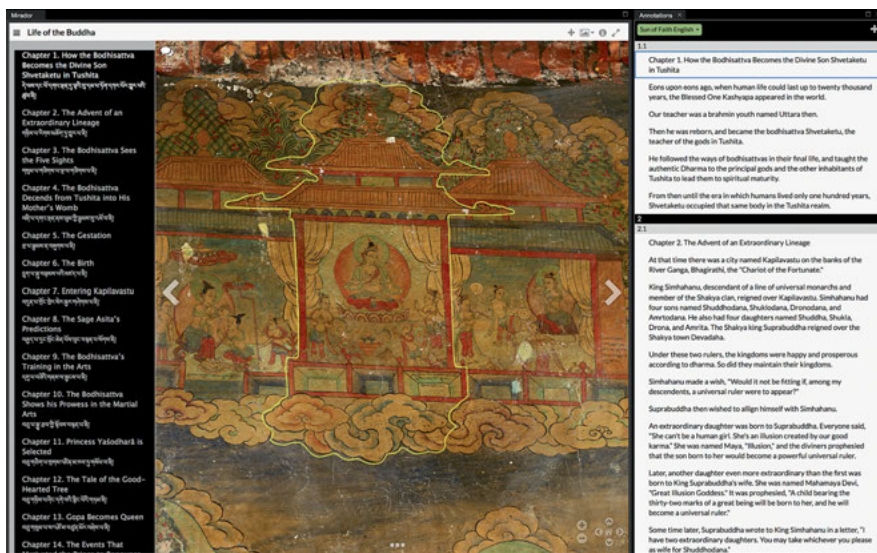
Figure 4: Chapter 1, Scene 1 (ie. 1.1) of the Life of the Buddha.

translucent pop-up box that names the outlined scene by chapter and scene numbers. (Figure 5)

Figure 5: Scene 1 (i.e., 1.1) of the Life of the Buddha, Image and Pop-up Box.

Users who want to read more than the translation of the *Sun of Faith* can click the "plus" (+) button in the upper right-hand corner of the open text window and the Tibetan-language text of the *Sun of Faith* will appear in an adjacent text window. Clicking the "plus" button again opens another text window, this time the English translation of Tārānātha's *Painting Manual*, again outlined

and formatted in such a way that it synchronizes with the already open text windows so that one can read them all together. Clicking "plus" once more brings up the Tibetan text of the *Painting Manual*. (Figure 6) Seven text windows in total are available: *Sun of Faith* in English and Tibetan; *Painting Manual* in English and Tibetan; mural inscriptions in English and Tibetan; and canonical sources of the *Sun of Faith*. (Figure 7) Users may also select a particular text from the dropdown menu at the top of the window.
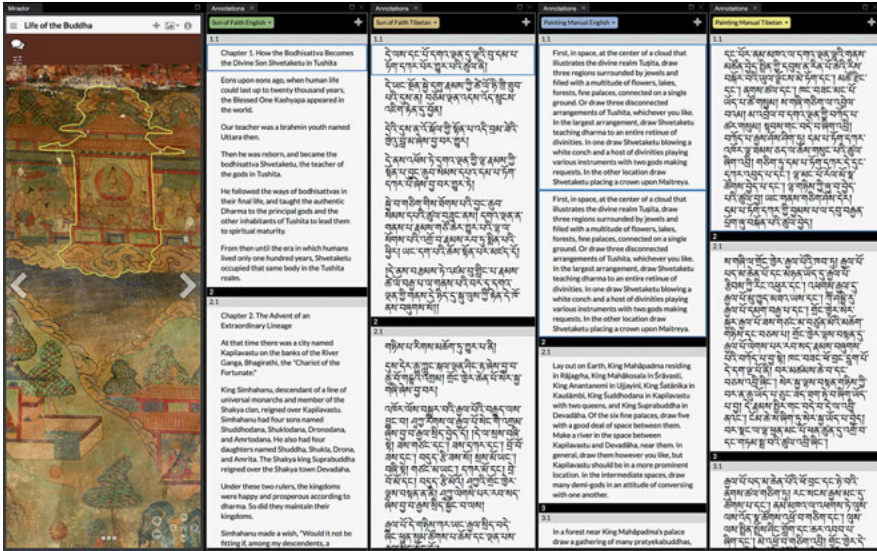

Figure 6: Chapter 1, Scene 1, with the *Sun of Faith* and the *Painting Manual* open in both English and Tibetan.

Mirador allows users to move and resize windows to suit specific needs and preferences, and LOTB takes full advantage of this to enhance user experience of the large mural panels and multiple text types. Users can, for instance, move text windows below the image window to maximize horizontal image space if the visual narrative calls for it (Figure 8).

Users can also prioritize the images over text and thus explore the life of the Buddha in a non-linear way. To do so, the user collapses the Table of Contents and removes the text windows entirely, which makes room for the largest possible view of the mural. The user can then pan and zoom across the visual space and as the cursor moves, it activates chapter and scene outlines and calls up links to the related text passages. (Figure 9).
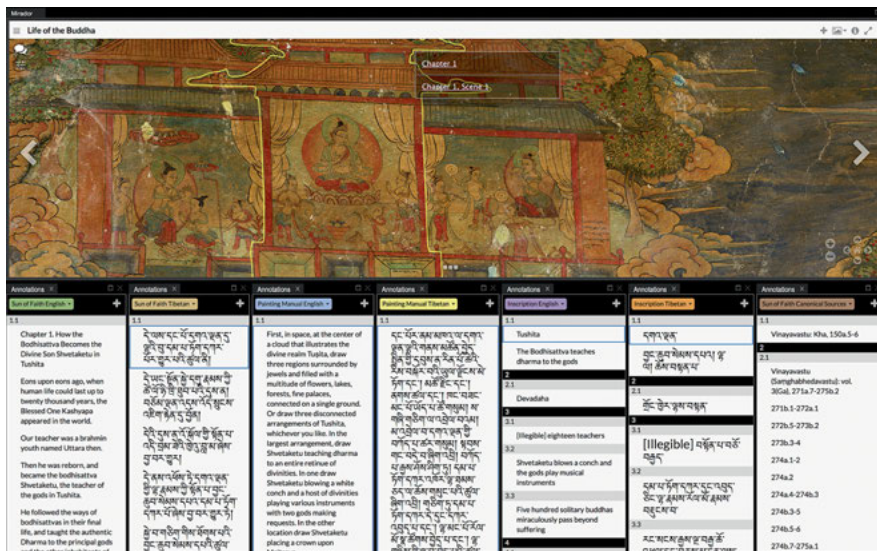
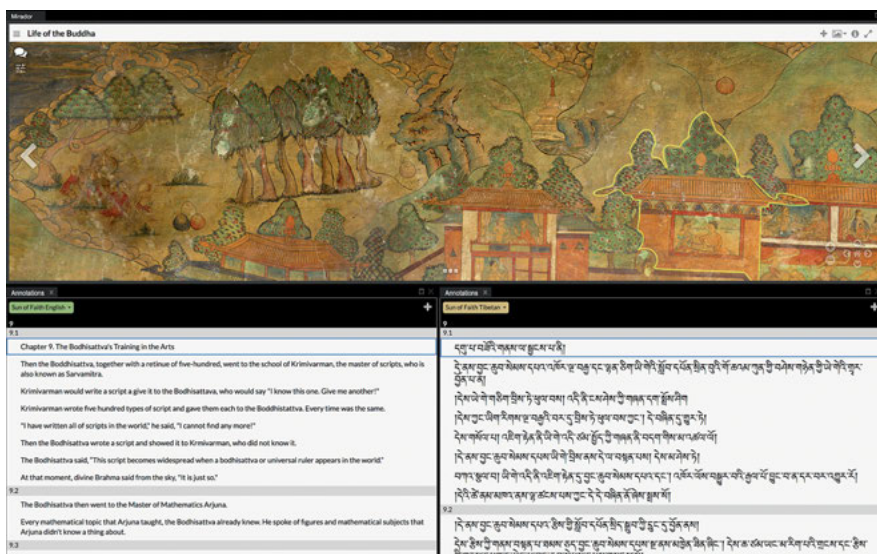**Figure 7:** Chapter 1, Scene 1, with all seven text windows open.

Figure 8: Chapter 9, Scene 1, with image window arranged horizontally above text windows.

Clicking on one of the links (a scene or chapter), recenters the image to that scene and calls up the associated text in an adjacent window.

Figure 9: Chapter 4, Scene 2, with image window maximized within Mirador.

As a final mode of engagement, users may search the entire LOTB corpus of materials for key terms such as proper names, places, and other text strings. From the homepage, the user enters a term into the search box and presses return. This results in a list of all instances in which the term appears, across all texts, together with thumbnail images of the associated mural section. It is then possible to filter the results by text source, panel, chapter, or scene.

Technical Opportunities and Challenges

The challenges we faced in working with a nascent open-source software package may be instructive for those considering similar options in a digital humanities (DH) project. Mirador is, in our estimation, a flexible, extensible application whose potential has yet to be fully tested. The Mirador viewer was designed primarily for images of relatively modest size. Early uses included delivery systems for those images, especially medieval manuscripts in various languages, and associated shallow metadata. Mirador's basic editing capability provided a convenient space in which to make notes, or "annotations," related to features of the manuscript page. For instance, one could easily transcribe the original text, add descriptive notes, or prepare side-by-side editions in the original language and in translation. Projects such as Ten Thousand Rooms make abundant use

of these features by offering the reader a highlighted passage of Chinese text in an image of a manuscript page, and the ability to view electronically readable Chinese text side-by-side with English-language translation, references to commentarial literature, analytical notes, and so forth. In such cases, visual markup of the image is typically limited to rectangular outlines that bound a particular passage. However, we have found Mirador powerful enough to manage larger image files and navigate more complex annotation structures.

The large-scale problem we set before ourselves was to make engaging with the LOTB images and texts as intuitive and natural as reading a book. The book is an obvious metaphor for the technological means to present a narrative in which image and text sit side-by-side on the page. Book readers can move between image and text with the slightest movement of the eye. And depending on the useable area within a given page layout, secondary sources are easy to access. However, presenting large image and text collections using the book as a technological metaphor entails two primary challenges. The first is the challenge of designating precise relationships between a passage of text and a section of image without compromising the reader's engagement of either source on its own. Text superimposed on the image hinders visual appreciation and can make reading difficult. Text set on the margins of the image introduces ambiguity in the text-image relationship. Outlines superimposed on the image impedes the visual impact unless one prints the image twice.

The second challenge is the complete representation of a large and varied body of primary sources. In other words, if you have a large number of images (about 1,500 square feet of primary image assets in the case of LOTB), and many types of textual data to "line up" with them (nine types of text data for the LOTB project, including designations of chapters and scenes), then you will quickly exceed the capacity of all but the most elaborately and expensively produced book. Creating a system for synchronizing the various texts in two languages was further complicated by the differences in their order and organizational structure. The *Painting Manual* proved to be our most challenging source because it sharply diverges from the chapter and scene divisions of the Buddha's life story as presented in the *Sun of Faith*, which served as our benchmark for narrative sequencing.

While the LOTB website began with the book metaphor, we knew we needed to produce a dynamic book, one capable of connecting multiple layers of text with their many associated locations, all within the context of a series of massive images. We began with the basic Mirador viewer framework and gradually added modifications, including a table of contents, drop-down menus for choosing text types, the ability to hover over an image to reveal associated chapters and scenes in both text and image, and so forth. As the LOTB platform grew, we prioritized

the creation of a seamless reading and viewing experience. This necessitated, among other things, changing the text window displays from using spreadsheet-like cells (as they appear in the basic Mirador instance) to a single continuous page of text with designated breaks between chapters and scenes. It also required maintaining visual links between parallel texts, such as the Tibetan and English versions of the *Sun of Faith.*

Developing Mirador with LOTB project goals in mind entailed significant programming effort. Our work was constrained by the state of Mirador's functionality at the time the project launched, and by the limits of our own capacity for software development in terms of financial and technological support. No one was more aware of the challenges these limitations presented than our team of technologists. After a period of preliminary planning and design work, technical development of LOTB progressed in three logical parts.[13]

The first aspect of technical development involved authoring our own application code (Yale-Mirador) for the HTML page that hosts the Mirador instance, which itself is pointed to from a descriptive Drupal website.[14] It included the creation of (1) text windows that can display annotations across different canvases (images), chapters, and scenes, and respond to chapter/scene selection by highlighting the relevant annotation; (2) a layout management system to coordinate the creation, removal, and relocation of image and annotation windows; (3) a tag-based annotation hierarchy system that organizes the annotations into chapters and scenes; and (4) a mechanism to translate annotation IDs contained in a search result into appropriate chapters and scenes and their corresponding locations on the canvas.

The second part entailed the creation of various plugin modules that communicate with Mirador, modify or override some of Mirador's default visual styles and behaviors, and provide additional functionality. These modules include (1) an override of CSS styles to safely embed the Mirador instance within the bigger HTML application, a necessity since Mirador was originally designed to take up the whole browser window space; (2) a side panel that can show the table of contents of the annotations; (3) a custom annotation editor that can attach an annotation layer to the appropriate annotation text; and (4) the ability to programmatically pan and zoom the image on view.

The third part required the rewriting of some elements of the Mirador code itself, creating a Mirador fork ("Mirador-y") that contains minimal modifications

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13 The authors would like to thank Seong-June Kim for his assistance in writing this overview of LOTB's technical development.

14 Details about Yale-Mirador at "yale-web-technologies/yale-mirador," GitHub, https://github.com/yale-web-technologies/yale-mirador.

that could not be taken care of by plugins and overrides in the second part.[15] Modifications of the core Mirador code for LOTB were kept to a minimum in order to avoid creating a "brittle" software package as the program is updated.

Institutional Opportunities and Challenges: From Teaching to Research and Back Again

The process of building LOTB raised a number of practical questions early on. How could we leverage DH research and production for use in the classroom? What aspects of DH-inflected pedagogy could serve to support the core missions of academic research? LOTB served as a test case for the integration of research and teaching, a desirable outcome in theory but difficult to achieve in practice. This required us to navigate the complexities of university IT development and support, which often segregates research and teaching technologies. We found that staff, resources, and funding streams for research and teaching were frequently walled off from one another in a similar way. In-house university grants were typically designated for the support of either pedagogical or research development. Similarly, staff support for classroom and research applications typically came from different units of university IT. On several occasions, LOTB development and implementation was delayed due to reorganization of university IT departments and staffing transfers and turnover.

While we fully intended LOTB to serve as both a teaching and research tool, the project effectively began with the creation of a teaching platform, developed over several years. This decision was largely pragmatic, since modest institutional support and funding was most readily available for the creation of new digital resources to use in the classroom. First, we created a basic database of assets and some shallow metadata. Concurrently we created several presentations of the images and text in WordPress with support by Yale's Instructional Technology Group for use in the classroom. This allowed us to begin image processing, organization, and cataloguing, primarily because these materials were directly relevant to course instruction. Early support for the development of teaching resources also enabled us to create a digital asset management workflow for our image collection, at the time using in the Portfolio DAM system. Such preliminary work allowed us to begin analysing the visual narratives several years before the LOTB Mirador project was launched, even though some of the image process-

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15 See the technical description of Mirador-y at "yale-web-technologies/mirador-y," GitHub, https://github.com/yale-web-technologies/mirador-y.

ing needed to be repeated later on. In order to build up teaching resources for student work, classroom IT groups provided modest funding to hire graduate student research assistants, who in turn helped us undertake preliminary photo processing and stitching, visual analysis, and digital asset organization. The creation of digital resources for teaching also allowed us to test and evaluate a variety of existing digital platforms. With some technical assistance from our universities' classroom IT groups we devised class projects about the Buddha's life story by utilizing products such as WordPress, Zoomify, Google Slides, StoryMap JS, and Media Thread. These student projects in turn helped us test and evaluate these tools for possible use in LOTB, even though we eventually determined no existing "out of the box" platform would serve our needs. LOTB in the classroom thus helped build the foundation upon which the Mirador project would be established.

The scope of LOTB as a research project expanded significantly with the award of a two-year collaborative research fellowship and grant from the the Robert H. N. Ho Family Foundation and administered by the American Council of Learned Societies (ACLS). This additional support allowed the project to begin work in earnest with a team that included computer developers, a digital database manager, front end website and user experience specialists, and a digital image designer, as well as several graduate student research assistants who helped prepare both visual and textual materials and create a more robust Drupal project website. The grant also supported evaluation and testing of the Drupal and Mirador sites by an in-house team of User Interface (UI) and User Experience (UX) specialists.

By the conclusion of its initial two-year development period, we found the LOTB project and the Mirador website was already serving as a platform for successfully integrating teaching and research. The contents of the project, and the publications that have resulted from the related research, have now been successfully incorporated into the classroom, as instructional aids and as resources for individual and collaborative student projects. The Mirador framework has allowed us to make complex materials accessible to an undergraduate audience in a clear and manageable way. Classroom discussions and students' written work have likewise informed and augmented our ongoing research agenda. As the LOTB project moves forward, its additional resources and publications in turn serve to re-seed subsequent student projects. We have found a web-based research environment to be flexible enough to allow, and even to encourage, synergy between research, research reporting, and project-based learning for students at the graduate and undergraduate levels.

LOTB has the capacity to allow users to read the Buddha's life story across different kinds of media. It is also designed to facilitate interpretive analysis

about the relationships between visual and literary expressions of the Buddha's life. (See the essay by Bielo and Vaugn in this volume on the pedagogical value of immersive environments.) It thus allows users to consider the forms and functions of Buddha life narratives by suggesting a series of interrelated questions. How are the murals arranged in the context of their architectural space? Who were the intended audiences for the text and murals, and how might they have been used or interpreted by those audiences? How might we understand the "visual logic" of the murals, or differences between visual and textual logics? Plans are currently in place to expand LOTB's functionality as a platform for collaborative research and learning. This expansion will allow users to upload personalized content (such as reading notes and observations), draw their own visual annotations (say, to highlight and identify all instances of serpent deities in the mural), save these materials, and then share them with a defined group of other users.

Conclusions

Once the primary sources were assembled and integrated within a digital platform for viewing and reading, the central challenge of the LOTB was working at the interstices of computer science and the humanities to co-create a tool that enhanced the engagement with and study of a collection of rich cultural artifacts. As humanists we could imagine many types of tasks we might want a digital platform to perform. At one point, for example, we imagined that it would be productive to mark up every instance of a humanoid figure in the murals and then enter their coordinates and other metadata into a searchable database. This might afford researchers enhanced means to do fine-grained analysis of artistic style and technique, or to theorize how representations of bodily form or movement are related to certain narrative actions across the mural (Is the Buddha sitting during teachings? Is he standing? Walking? Flying? etc.). Yet such tasks were so far from the originally intended usage of our tool in theory, and so time-consuming to carry out in terms of data collection in practice, that they were simply impractical. Throughout the project we, as both humanists and project directors, found ourselves in conversation with the technology team about the gulf between what is imaginable, what is possible, and what is ultimately worth doing given constraints of time, funding, and technology. As one of our technology mentors once said of DH projects, "Almost anything is possible; few things are practical." So the collaborative work of defining and achieving the practical was, and remains, a challenge. And yet in the case of LOTB, the realistic establishment of limits was a profoundly productive exercise,

one that led not only to the creation of the tools that make the life of the Buddha come alive in a new form, but also to their completion.

The LOTB Team 2015–2017

Many people worked on LOTB from 2015–2017. The project would not have happened at all without the generous support of the Robert H. N. Ho Family Foundation who sponsored the project through an ACLS Buddhist Studies collaborative research grant. This enabled us to assemble two teams working side by side: a team of technology experts and a team of research scholars in Tibetan and Buddhist Studies. The technical staff included: Michael Appleby (technology team manager 2015), Oren Kanner (project management 2017–2018), Seong-June Kim (software development), Roy Lechich (software development), Lec Maj (project management, 2016–2017), Pam Patterson (classroom technology, image processing, and database management), Mark Saba (image processing and graphic design), Harry Shyket (software development), and Heather White (user experience design). A number of research assistants worked on the textual and visual materials: Rebecca Bloom (visual analysis), Priyankar Chand (website design), Yong Cho (visual analysis), Rinchen Dorjé (text translation), Christopher Hiebert (canonical text analysis), Peter Jang (website design), Dr. Ariana Maki (mural analysis), and Dr. Sarah Richardson (mural analysis).

Development of the LOTB Mirador instance and associated digital frameworks now continues, with further support from the Robert H. N. Ho Family Foundation, and with the support of the University of Virginia's Institute for Advanced Technologies in the Humanities (IATH), including IATH Director Worthy Martin, Systems Administrator Shayne Brandon, and Scholarly and Technical Communications Officer Sarah Wells.

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