THE SANDCASTLE WORKFLOW

A Malleable System for Visualizing Pre-modern Maps and Views

PI: Edward Triplett
Assistant Professor of the Practice,
Art, Art History and Visual Studies
Duke University

Co-PI: Philip Stern
Associate Professor
History
Duke University

Funded by a Phase II grant from the National Endowment for the Humanities' Office of Digital Humanities (2020-2023)
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Team</td>
<td>2-3</td>
</tr>
<tr>
<td>Project Background</td>
<td>4</td>
</tr>
<tr>
<td>Project Timeline</td>
<td>5</td>
</tr>
<tr>
<td>Audiences</td>
<td>6</td>
</tr>
<tr>
<td>Findings</td>
<td>7-12</td>
</tr>
<tr>
<td>Project workflow diagrams</td>
<td>13-15</td>
</tr>
<tr>
<td>Award products</td>
<td>16-18</td>
</tr>
<tr>
<td>Continuation and impact</td>
<td>19</td>
</tr>
<tr>
<td>Select Bibliography</td>
<td>20-21</td>
</tr>
</tbody>
</table>
# Project Team(s)

| PRINCIPAL INVESTIGATORS | Edward Triplett  
Assistant Professor of the Practice  
Duke University | Philip Stern  
Associate Professor of History  
Duke University |
|-------------------------|--------------------------|
| Graduate Project Managers - Bass Connections Team (2020-2021) | Helen Shears  
(Bass Connections Subteam Project Manager)  
PhD Candidate - History | Rosalind Rothwell  
(Bass Connections Subteam Project Manager)  
PhD Candidate - History |
| | Sam Horewood  
(Data+ Project Manager)  
PhD Candidate - History |
| Consultants and Developers | Ashton Merck - Project Manager  
& Web Developer | Eric Monson - Data Visualization Analyst, Duke University Libraries |
| | Timothy Senior - Lecturer, University of Bristol, UK | Rainer Simon - Web Developer - “Annotorious” |
| Undergraduate Houdini Developers (2023-2024) | Kevin Alvarenga  
Houdini Developer (2023-2024) | Jonah Teklehaimanot  
Houdini Developer (2023-2024) |
| Code+ Undergraduate Development Team (2021) | Renee George  
Code+ team member & lead Houdini developer (2021-2022) | Ali Rothberg  
Code+ Houdini Developer (2021-2022) |
| | Jake Heller  
Code+ Houdini Developer (2021) | Jason Rosenbloum  
Code+ Houdini developer (2021) |
| | Jasmine Clairsaint  
Code+ Houdini developer (2021) | Zane Harrison  
Code+ Houdini developer (2021) |
| Bass Connections Graduate Research Team | Brittany Forniotis  
PhD Candidate - Art History | Sam Schmidt  
PhD Candidate - History |
| | Xinyue Qian  
CMAC MA Student & Houdini Developer (2021-2022) | |
**Project Team(s)**

<table>
<thead>
<tr>
<th>Bass Connections Undergraduate Research Team (2020-2021)</th>
<th>Abbey List</th>
<th>Ali Rothberg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Austin Connors</td>
<td>Caroline Rettig</td>
</tr>
<tr>
<td></td>
<td>David Mellgard Jr.</td>
<td>Emma Rand</td>
</tr>
<tr>
<td></td>
<td>Hannah Thurston</td>
<td>Isa Lu</td>
</tr>
<tr>
<td></td>
<td>Jake Heller</td>
<td>Julia Deitelbaum</td>
</tr>
<tr>
<td></td>
<td>Julia Shenot</td>
<td>Kerry Rork</td>
</tr>
<tr>
<td></td>
<td>Lizzie Bond</td>
<td>Manmit Singh</td>
</tr>
<tr>
<td></td>
<td>Mina Mortchev</td>
<td>Molly Borowiak</td>
</tr>
<tr>
<td></td>
<td>Rebecca Eneyni</td>
<td></td>
</tr>
</tbody>
</table>

A simplified diagram of the Sandcastle Workflow - A Malleable System for Visualizing Pre-modern Maps and Views

Build Houdini Digital Assets (HDAs) capable of creating 3D scenes from three inputs -
1. A folder containing all of the masked features that were traced in Supervisely
2. The original image that was annotated in Supervisely
3. The Json file exported from Supervisely containing Object IDs and metadata about each object's class and tags.

Through the Houdini engine plugin, these HDAs can be opened inside of the Unity game engine, where the rest of the Sandcastle Toolkit will reside. This toolkit will include an interface for navigating and manipulating the 3D mapping environment as a viewer.
Project Background

Spatial humanities projects have long struggled to find a suitable platform for accurately representing pre-modern concepts of space and place. The Sandcastle Workflow: A Malleable System for Visualizing Pre-Modern Maps and Views,—aka, “Sandcastle”—develops a new approach for reading and analyzing historical cartography. Using annotation methods developed for machine learning applications and procedural modeling most typically associated with game design, Sandcastle aims to offer a user-friendly toolkit for rendering historical maps in 3D, rather than 2D, space. Born out of the constant frustration of using tools, like GIS, that compel scholars working in the deep past to struggle against the data demands and output methods of such systems—most notably, the popular technique of warping or “rectifying” historical maps to fit presumably “accurate” modern basemaps—Sandcastle is designed from the ground up to allow scholars and students to take advantage of the experiential, modular, and pliant possibilities of digital visualization to engage the often permeable, overlapping, and non-linear understandings of space reflected especially in pre-Cartesian medieval and early modern maps, views, and plans. Somewhat analogous to the digital turn in text mining, corpus linguistics, and distant reading, this approach investigates what we might achieve by developing strategies for reading visual texts computationally. In short, Sandcastle offers users an opportunity to work with rather than against the affordances of the digital environment so we might visualize, and even experience, the way people in the past understood and accounted for their vision of the world on its own terms.

The research and development for Sandcastle’s core toolkit has been tested using a suite of ongoing exploratory projects, the current state of which can be seen at (https://www.sandcastle3d.org). At its core is the “Book of Fortresses” (https://www.bookoffortresses.org), a digital art history project that spatially reconstructs a rare contemporary account of the castles and fortifications that lined the early sixteenth-century Luso-Spanish borderland. This research has produced new conceptual approaches to the interpretation of medieval and early modern city views, or “chorographies,” as well as insights into how scholars might take advantage of the process of 2D annotation and 3D procedural modeling to produce new research questions. As this project develops, its findings will continue to be disseminated in academic publications, presentations, written and video tutorials, and other public forums (such as the above websites), including documentation of pedagogical approaches to project-based learning in the digital humanities developed through the integration of students into its research team.
# Project Timeline

Major project phases:

<table>
<thead>
<tr>
<th>Date Start</th>
<th>Date End</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019-05-28</td>
<td>2019-06-18</td>
<td>NEH ODH Phase II grant drafting period</td>
</tr>
<tr>
<td>2020-01-10</td>
<td>2021-07-01</td>
<td>Initial 18-month grant period for NEH ODH Phase II grant</td>
</tr>
<tr>
<td>2020-03-16</td>
<td></td>
<td>Duke University switches to remote-only meetings during the Spring 2020 semester</td>
</tr>
<tr>
<td>2020-05-26</td>
<td>2020-07-31</td>
<td>4 undergraduates and 1 graduate student mentor from the Data+ team begin the image taxonomy and annotation process using “Labelbox,” and (later) “Supervise.ly” web applications. 50 views from the Book of Fortresses, and two large chorographies of Lisbon and London are fully annotated. (10 weeks x 40hrs/week) Eric Monson develops python scripts for extracting annotation masks.</td>
</tr>
<tr>
<td>2020-08-17</td>
<td>2020-11-24</td>
<td>First semester of the year-long project focused on the Sandcastle Workflow. 30 students continue the chorography annotation, image database, and annotated bibliography work that began with the Data+ summer program, with help from a “Bass Connections” internal grant.</td>
</tr>
<tr>
<td>2021-01-20</td>
<td>2021-04-23</td>
<td>Second semester of the “Mapping History” Bass Connections-funded course. Students begin developing the Sandcastle toolkit in our procedural modeling software (Houdini), experiment with additional 3D visualizations in GIS, and develop the project website.</td>
</tr>
<tr>
<td>2021-06-01</td>
<td>2022-04-20</td>
<td>Code+ summer program begins. A team of 4 students (including two from the previous Bass Connections project) work with the project PI to develop the bulk of the node-based code for the Sandcastle Toolkit in Houdini. (10 weeks)</td>
</tr>
<tr>
<td>2021-07-01</td>
<td>2022-06-02</td>
<td>First extension period for NEH ODH Phase II grant</td>
</tr>
<tr>
<td>2021-08-16</td>
<td></td>
<td>New Project website <a href="http://www.Sandcastle3D.org">www.Sandcastle3D.org</a> (designed with Webflow) goes live</td>
</tr>
<tr>
<td>2021-08-23</td>
<td>2022-04-20</td>
<td>Development of the Sandcastle toolkit continues in Houdini through the Fall and Spring semesters with the project PI and two undergraduate students from the Code+ program (Renee George and Ali Rothberg) as undergraduate researchers in the Digital Art History and visual Culture research Lab (DAHVC)</td>
</tr>
<tr>
<td>2022-05-24</td>
<td>2022-06-14</td>
<td>PI (Triplett) travels (finally) to Portugal to continue capturing photos of sites drawn in the 1509-1510 “Book of Fortresses.” Four sites were scanned via drone photogrammetry and thirty-one new sites visited and photographed.</td>
</tr>
<tr>
<td>2023-01-18</td>
<td>2023-04-26</td>
<td>PI (Triplett) begins training two new students in Houdini software in preparation for a summer development session in May-June 2023</td>
</tr>
<tr>
<td>2023-05-01</td>
<td>2023-06-30</td>
<td>2 students working 20 hours / week continue Sandcastle Toolkit development, including finishing the procedural generation of hills, walls, rocks and trees.</td>
</tr>
</tbody>
</table>
Audiences

The Sandcastle Workflow was conceived as an alternative to GIS’ layer-based paradigm for the study of historical spatial sources. The original intended audience for the project was historians of cartography, especially those who study varieties of premodern cartography that fail to fit into a gridded cartesian system. As the project developed, we also began to see value for art historians who study landscape painting and all forms of non-mathematical perspective. The premise of the workflow was simple: instead of focusing on a modern-historical comparative method or trying to mine historical sources to reveal places “as they were,” the Sandcastle Workflow would allow the original sources to speak for themselves, regardless of their “logic” according to modern mathematics or basemaps. We called the project the Sandcastle “Workflow” because castle architecture features so prominently in the 1509-1510 “Book of Fortresses” (a source and digital project begun by the PI - [Tripett] in 2018) and because the plan was to combine image annotation software with procedural modeling to develop a more spatially malleable mapping environment. We took the metaphor a step further by imagining the Sandcastle Toolkit (The procedural modeling interface built in Houdini) as a series of templates to help guide researchers who were not familiar with 3D modeling, but wanted to visualize a chorographic view of places like those found in the Book of Fortresses or the Civitates Orbis Terrarum - in ways that retained visual fidelity to the original source. The toolkit thus became like a set of ‘buckets’ and molds to bring into the malleable sandbox. While the research and development of the toolkit has developed a number of stand-alone results that we are proud of, (such as the math that causes objects to scale up proportionally as they move along a vector away from the virtual camera) the project is still a workflow. The first stage is tracing and annotating individual objects in a view, and each stage of the workflow requires the pixel coordinate inputs from the original annotation work.

In retrospect, we should have realized that the annotation stage would take us far longer than expected - especially as historians of cartography and iconography. The images we chose, especially the more complex ones from the Civitates Orbis Terrarum, required us to develop a complex taxonomy of residential, religious, civic, and fortress architecture, as well as flora, fauna, topography, and infrastructure classes and tags. Our hope is to turn this exercise (the creation of a complete visual taxonomy that would suit for a variety of chorographic views) into a publication that helps other scholars break down these images into machine readable data, while also retaining a connection to their position within the whole work. In the short term, the work on image annotation has resulted in a successful partnership between Duke University’s Art, Art History, and Visual Studies department and the University of Exeter’s digital humanities lab. Through a brief workshop focusing on linked open data and image annotation through the Pelagios Network-affiliated application “Recogito” with Rainer Simon, (independent developer) and Leif Isakson (Univ. of Exeter) the rich, but previously unwieldy Sandcastle Annotation data we created was finally published on the web in September, 2023. Rainer Simon’s IIIF (International Image Interoperability Framework) application - called “Annotorious” - has revealed that even chorographic views with thousands of annotated pieces that fill the image from edge to edge can be published on the web. Transforming the data from bitmap (pixel-based) annotation into vectors still creates a few errors, but we consider annotorious’ speed and elegance to be an excellent proof of concept. Examples of our data in this application can be seen here: https://iiif.rainersimon.io/. We are hopeful that this aspect of our work will expand into wider audiences, beyond those specifically interested in 3D visualization.

To this point during the process of research and development, assessment of Sandcastle has been entirely in-house, focused on stress testing and debugging the toolkit at various stages of development. Once ready, which we anticipate will be by the end of calendar year 2023, we will undertake a process of assessment by user trials, sharing with potential partners, and receiving feedback through peer review channels.
Findings

One of the first tasks before the Sandcastle Workflow research team was to develop a primary criterion for defining the scope of work and parameters of investigation. In short, what genres of historical “maps” would best serve as test subjects for Sandcastle? Given a methodology rooted in 3D visualization, we concluded that our initial examinations should center around cartography that included or even better emphasized three-dimensional iconographies and forms of representation; that the core Book of Fortresses project similarly employed such representational strategies only further confirmed this methodological decision. Likewise, our interest in exploring methods for understanding especially non-Cartesian cartographic expression led us to consider primarily focusing on maps and views drawn from a perspective other than a 90-degree, top-down vantage. In short, our main initial area of concentration was to center around a ubiquitous genre of medieval and early modern cartography, often employed for the depiction of urban areas and their environs, and which went by variable names: map, view, panorama, landscape, perspective, bird’s-eye, and others.

It was at this point that we confronted the initial conundrum of this project: what to call this form of cartographic expression? The problem was not simply nomenclatural but seemed to strike to the core of the assumptions, arguments, and ideas that such forms intended and elicited. Our team’s research began to uncover that in many ways no one had really quite grappled with these maps as a genre, despite the fact that they seemed to me one of the more popular modes of mapping in medieval and early modern Europe. Sometimes they were treated as maps and sometimes as art; sometimes they were taken seriously, and sometimes considered as mere ornamentation. What was clear in the end was that there was no out-of-the-box theoretical apparatus for Sandcastle as a mode of history of cartography, and that we would have to develop such an apparatus in conjunction with the technological methods of analysis at the core of the workflow.

From extensive historical and theoretical research, we concluded that this form did indeed constitute a genre of cartography, which we designated as “chorography.” The concept of chorography reached back into the geographical systems of the ancient world, often used, most famously by Ptolemy, to distinguish local or regional description of space (“choros,” place) from those that depicted the world on a much broader scale, which Ptolemy designated as geography (“geo,” or world). Other scholars had distinguished chorography, as a description of place, from chronology, as a description of time. One finding of our research into the term was that there was very little consensus or consistency about both what chorography entailed and what it encompassed as a visual (as opposed to narrative) genre. In an attempt to get a more holistic environment scan of the use of the concept, we built a bibliographical database, along with an archive of full-text scholarship on the subject, and mined those texts for contextual clues as to the methodological and historiographical usage of the term. We also engaged theoretically and pedagogically with the concept. We concluded that while there was some continued value to the distinction between the more local, choros, and more global, geo, the distinction had had the unfortunate effect of isolating the kinds of cartographic expression in which we were interested from the history of geography — effectively writing these kinds of maps out of the history of mapping. Rooted in generations of history of cartography that has troubled the received distinctions between “science” and “art,” our theoretical apparatus employs the concept of “chorography” to mean a genre of map that specifically features a built environment—often but not always a city or town—set within a broader, often rural, landscape. The empirical survey of the maps themselves revealed a nearly ubiquitous tendency for those landscapes to be dominated by some body of water (river, sea, ocean), and to share other common features, such as unrealistic “camera angle” vantages, outsized foregrounded figures (such
Findings

as individuals or viewers), and elements-in-motion (people, ships, and so on) captured in static space. We continue to build on this work, developing our bibliographical database and theoretical interventions, as both a theoretical foundation for the Sandcastle work as well as a finding in itself, which significantly broadens our understanding of what “counts” as a map in the pre-modern world.

With the subject of our study defined, our next step was to research the software solutions we would need to develop the workflow. Before we moved to a fully remote project in March, 2020, our original plan was to use an open standard, IIIF application for the annotation input, like the one developed by Niqui O’Neil at North Carolina State University Library (called “Annonotate.”) We conducted an environmental scan of annotation applications and sought some advice from the Research Computing and Data Visualization Science groups at the Duke Library, but we simply ran into COVID-19 related bandwidth issues while trying to get servers and applications set up - especially since multiple user authentication and version control needed to be solved by May 2020.

In anticipation of the Data+ summer program that would have 3 students, the PI and a graduate project manager annotating images full-time, we researched several image annotation web applications that had to have the following:

- User authentication
- Project management tools to prevent images and parts of images from getting overlapped by team members
- Data management / Controlled vocabulary tools - i.e. the ability to define classes of objects and provide quick pull-downs for answers to questions/tags about each feature
- Annotation precision and speed

Based on our research and meetings with developers, our first instinct was to use vector-based annotation. The vector tool in our first web application (called “Labelbox”) was very quick initially, but unfortunately, after about 100 objects were added to a single image, it began to slow down to the point where it became unusable. This application has been under constant development since, so these issues may have been solved after 2020, but after three weeks, we had to move to a different, very similar web application called “Supervise.ly.” Both of these applications were designed for the emerging (and now maturing) field of machine learning. Accordingly, we were again using a software that was not designed for our purposes – a common theme in the digital humanities and part of our inspiration for developing the Sandcastle Toolkit in the first place. Nonetheless, by using Supervisely’s job management system, and only unlocking specific object classes and images for particular users in each “job,” and by moving to bitmap annotation, (which was able to display many more objects than vector annotation) we found a web application that would serve as the all important origin to the Sandcastle Workflow.

One of our first challenges, having settled on Supervise.ly as our annotation platform, was to translate—one might say “hack”—what was essentially a machine learning web application into something that would suit our purposes for whole image annotation. As we were in a largely remote environment, the team faced a number of logistical obstacles, including memory limitations, lag, failures of saved data, and even concerns as granular as student workers insisting, despite instructions, on continuing to use a trackpad rather than a mouse for input, which did not allow for the precision required. Yet, these challenges turned out to be critically important in honing our ability to articulate procedures around this aspect of the workflow. From this trial and error, we developed a clearer sense of how to overcome the disjunction between a machine learning platform, designed for repeated annotation of particular and definable iconography, and “entire image” annotation, in which the iconography was far more ambiguous and often unique.
Findings

and therefore not repeatable. In short, a platform designed to be trained to recognize a “house” or a “tree” was pushed to its limits when every item in the image had to be annotated and what constituted a discrete “house” or “tree” was itself a matter of interpretation in each instance. Settling on a process for developing typological categorization that would apply across the corpus of maps was itself a critical first step in settling the initial stages for the workflow.

Moreover, the initial process of defining classes and tags within controlled vocabularies that could systematize annotation work across an entire research team was itself a learning experience that led to a number of conceptual and pedagogical insights. In any number of ways, annotating an image text on such a granular and comprehensive level, rather than perhaps more familiar techniques of holistic or interpretive viewing, turned out to be remarkably valuable in itself. In short, such an approach forces a map reader to, quite literally, see differently and thus demand new levels of analysis. The need to create classes, tags, and controlled vocabularies compelled researchers to confront the fact that the kinds of images with which we were dealing often resisted such categorization. What did it mean to have a class of “religious” structures in a world that rarely distinguished between religious and secular life? If we distinguished between “built” and “natural” environments, were we imposing a line where contemporaries would not have placed them?

This was not just a challenge but also an opportunity. We quickly realized the annotation process was a brilliant pedagogical tool for training researchers and teaching students the precise dilemmas which had been the central premise of this project: the ways in which modern tools and assumptions resist the ambiguity and hybridity of early modern epistemologies. At the same time, we also began to see the rhetorical and technical approaches of the chorographers more clearly, realizing, for example, that there were in fact no “houses” per se, but rather stretches of facades drawn as blocks but which gave the illusion or impression of individual dwelling units. Moreover, it occurred to us that, of course, that the translation into a malleable 3D environment would require the ability to see around and behind architectural or natural features that, as 2D images, implied but did not in fact actually depict reverse or side views. We began to understand far more clearly that there were many elements in these images that were designed to imply activity and motion, such as ships or soldiers, only as we struggled with how to capture them as static annotated elements.

In short, far from the kind of distant reading we had initially imagined our process would allow, we learned that granular 2D annotation, as laborious and often tedious as it is, forced a different form of methodical close-reading and close-looking, while the demand to categorize and typologize—and thus the need to force precision on ambiguity—raised questions about just what we were looking at, which might not otherwise have been asked.
Findings

Finally, the 2D annotation process compelled us to confront another productive dilemma about the workflow itself: namely, what point in the process was appropriate for scholarly interpretation and intervention? Should researchers be allowed to make interpretive choices at the stage of 2D annotation, which would be analyzed and engaged as their consequences were revealed in the final 3D models? Or, did we need a more “objective” approach to 2D annotation that would allow for researchers to then undertake their interpretive and analytical interventions by later engaging with the experiential 3D models as more “authentic” or “fidelitous” renderings of the original chorographic image? We knew it could not be both — as then those interpreting the 3D model would simply be reading for the interpretive choices of the 2D annotation rather than the original cartographic and chorographic ones. With respect to the workflow, this was a critical procedural finding that, one might say, was hiding in plain sight and with which we continue to grapple as the project develops.

Early on in the development of our project management documents (a diagram can be seen at the end of this section) we latched on to “translation” as our term to describe the middle parts of the Sandcastle workflow. To move information from two-dimensional annotations of three-dimensionally rendered objects and environments into a ‘true’ three-dimensional sandbox, we had to do a number of translation processes on the data. At the beginning, that meant the annotation data for a fortification wall facade (for instance) needed to include numerical and text data like the number and style of the crenellations on the wall so this data could be procedurally turned into 3D data by the software, rather than by the user. Similarly, one of the principles we set for the development of the workflow was to embed as much semantic data into the annotation so we could cut down on the number of optional “sliders” or inputs that the user would need to add within the 3D system. In the middle of the process, we also literally needed to crosswalk / translate the data between our annotation and modeling software, which functioned as follows:

- Download the Json data from Supervisely containing geometric and semantic data of each annotation
- Run the Json data through a Python Script (written by Eric Monson at the Duke Library) that transforms bitmap strings into vector pixel coordinates, then cut a “mask” for each annotation object and save it to a new file.
- Run an Python import script inside of Houdini
Findings

that turns the combination of Json data, and a folder of masks into a reassembled 2.5D jigsaw puzzle of annotations, within a 3D environment.

Once this critical translation stage was complete, we began designing the toolkit in Houdini so that groups of facade annotations could be replaced by procedural 3D models of houses, walls, church towers, 3D hills, trees etc.

The Sandcastle Toolkit is nearing the last phase of development, but it will remain a proof of concept until we are able to plug in annotation data for chorographic views that are more complex than those found in the Book of Fortresses. Nonetheless, we are very encouraged by the spatial elasticity that Houdini provides, its use of a visual coding interface that can be more approachable for new developers (and humanists), and its deliberate orientation toward “tool building” for 3D artists and game level designers. We also chose Houdini for this project because it allows for a “geometry spreadsheet” view of the data. As simple as this sounds, almost all 3D modeling programs deliberately hide the parameters that can be embedded on the points, edges, and primitives (faces) of the 3D meshes in the software. In essence, we see Houdini as a 3D environment builder for people who have been trained in other software that use data tables as their primary troubleshooting visualization, such as GIS. This opening of the black box of 3D modeling has been a praxis discovery that has helped the PI (Triplett) and a cohort of undergraduate and graduate students (many of whom are not coders) learn a new, complex development software that has rarely been implemented in the digital (spatial) humanities.

The Sandcastle Toolkit is still under development by the PI and two undergraduates majoring in Computer Science (Kevin Alvarenga, [Duke] & Jonah Teklehaiemanot, [NCST]). There are a handful of object classes from the Book of Fortresses that still need to be replaced by 3D models, such as churches, and we are now developing new user interface options for toolkit users that will make objects like crenelated walls easier to “sketch” into place within the Unreal game engine via the Houdini plugin. Along the way, we have also discovered a number of visual and spatial patterns in the Book of Fortresses that have made the effort to translate the drawings into 3D environments worthwhile. For instance, by restricting the placement of buildings to vectors that extend from a virtual camera’s point position...
Findings

through each annotated object’s image-plane position, the toolkit ensures that the 3D scene is driven by the appearance of the original chorography. By also smoothly scaling each object as it moves along that vector, we are able to test hypotheses about hierarchical scale. For example, through the toolkit’s malleable system, we can ask it questions like “If we accept the conceit of the drawing as captured by a camera, and we select a 135 degree horizontal field of view to simulate a human eye, how far back along the camera to image-plane vector does the ‘keep’ (tallest tower) in this view have to be for it to be the correct dimension as measured by the original artist?” Moreover, once this first object is set according to these parameters, we can also ask “Where do all other objects in the scene fit according to overlapping scale?” The answers have varied considerably, from tiny, floating houses next to enormous castles that seem to be the correct scale, to 3D spaces that are so cramped that the artist must have been compressing a panoramic horizontal space into a condensed image to fit the page. The point of each experiment, and the toolkit in general, is not to argue that a virtual camera is any more or less incongruous and ahistorical than a cartesian grid for the study of premodern chorography. Rather, it is to create a malleable environment that does not overtly warp spatial images from the past to suit the present. There are many 3D versions of each pseudo-perspectival drawing in the Book of Fortresses or any other chorographic view that can be built through the Sandcastle toolkit, so the tool is not intended to develop anything like a definitive 3D visualization of any place or image. Instead, the hope for further development is that the toolkit can be fast and responsive enough that users can test multiple hypotheses.
As a workflow and toolkit, most of Sandcastle's findings thus far have been appropriately experimental, conjectural, and process-oriented. Our initial research was filled with false starts and broken pathways, especially with respect to software platforms and data production and cleaning procedures. In this sense, even the aspects we have long ago abandoned or dismissed are, in our minds, part of our findings of how not to structure Sandcastle and how to deal with changes beyond our control—from alterations in software offerings or terms of service to a global pandemic—envisioning those as contributions rather than setbacks to the overall process, for which the project is richer as a result. As an illustration of the complexity of the planning work for the project, especially in its initial phase, see the sub-team project workflow diagrams below:
SANDCASTLE

Process diagrams

*Note: It is *very* likely that additional tutorials will need to be viewed in order to complete Stages 3-6. Some tutorials will be pointed to as being particularly relevant, but you will also need to look for additional ones on your own. If you find a particularly useful one, please add it to Airtable with a description of why it is applicable.

VEX, python and Linear Algebra

Stage 1: Re-watch the intro videos on groups, switch node, and copy to points

Stage 2: Watch all of the "VEX for Algorithmic design" tutorial series

Stage 3: Present how VEX could help us with our challenges:
1. Camera settings and terrain shape
2. Copying HDAs to points based on the "class" attribute

Stage 4: Create a "reflective" scaled environment that is changed by the camera settings

Stage 5: Create a "reflective" scaled environment that is changed by the camera settings

Terrain

Stage 1: Watch and follow three terrain course videos

Stage 2: Skin for Attribute wrangle tutorials that are relevant for terrains and "hill spheres"

Stage 3: Present on how to use VEX point wrangles to automate the position of hills

Stage 4: Place the tops of spheres at the same position as the tops of the 2D hills and create a depth-slider for each hill

Stage 5: HDA: Place the tops of spheres at the same position as the tops of the 2D hills and create a depth-slider for each hill

PDG and HDAs to Unreal Team

Stage 1: (3D Modeling; Stage 3) Watch the HDAs tutorials

Stage 2: Present a sample HDA in Unreal

Stage 3: Watch the PDG tutorials

Stage 4: Present what you learned about how PDG could help the project

Stage 5: Create an HDA that uses PDG to generate models and copy them to points

3D Modeling

Stage 1: Watch and follow one of the 3D modeling courses in SideFX

Stage 2: Present a model of a procedural house

Stage 4: Create an HDA for a procedural house and a procedural wall (wall input = a line which is curved or straight based on the point attributes)

Stage 5: Create an HDA that uses point attributes to set default values of building parts

Texture

Stage 1A: Watch videos on texture creation (COPS in Houdini)

Stage 2: Create tileable textures from patterns found in each of the maps

Stage 3: Scan for texturing & UV Mapping tutorials

Stage 4: For each set of images that share an ID - create a single UVW map

Stage 5: Deliver results to PDG team for large-scale automation

Stage 6:
Share and integrate:
- procedural models,
- PDG networks
- VEX experiments
- terrain network & Texture COPS Network
- into a single Houdini project.

*IF POSSIBLE: Create an HDA and attempt to show off the results using data from one of the maps.

Stage 7:
Deliver requested screenshots and documentation to the visualization team
Award Products

The Sandcastle Workflow project has yielded a wide range of products. The key products we set out to create from the beginning include the Sandcastle Toolkit and the annotation data, but as we have discussed above, we discovered a wide range of unintended research and pedagogical results along the way. In terms of publication, we have attempted to summarize our results in our project website [https://www.sandcastle3d.org/](https://www.sandcastle3d.org/). The site includes screenshots of annotated chorographic views, (of Aden, Boston, Lisbon, London, Marburg, Istanbul, Goa, Ceuta, Turin & Nice) blog posts by instructors and students about each chorographic view, descriptions of the workflow, embeds of our 3D GIS, our Airtable database, and a detailed list of the many members of the project teams. Even the CMS we used to design the website (Webflow) was new to our team, which we think is emblematic of how the Sandcastle Workflow constantly offered opportunities to learn new skills.

Another publication that has already come from the project was written by Brittany Forniottis, (Duke Art History, 2024) a graduate student who worked on the project in 2020-2021. Her book chapter, titled “Maps, Views, and Chorographies: An Examination of the Depiction of Place and the Representation of Architecture in the Civitates Orbis Terrarum” was published in Media Technologies and the Digital Humanities in Medieval and Early Modern Studies, edited by Katharine Scherff and Lane Sobehrad and came out earlier this year. In addition, last year, one of our undergraduate students, Emma Rand turned her research on the chorographies of Lisbon into a graduation with distinction thesis.

Because so much of the data the group produced is embedded in visual annotations, and stored primarily as Json data, it is challenging to describe the scope of this data as a ‘product’ of the project. To provide some context, below is a list of annotations that were developed during the Data+ program—which constituted the most intense period of annotation work.

- **Labelbox**
  - (35 images fully annotated in Labelbox) From the Book of Fortresses
  - 4313 “house parts”
  - 1244 Fortification elements
  - 357 Rocks
  - 356 Religious building parts
  - 224 plants
  - 207 fenced fields
  - 45 flags

- **Supervisely**
  - 19 additional Book of Fortresses images fully annotated
  - 5100 total objects tagged
  - 855 Roofs
  - 39 Flags
  - 103 Rocks
  - 282 Hills
  - 214 trees
  - 118 Christian religious building facades
  - 1796 House facades
  - 325 Fortification wall sections
Award Products

- 216 Fortification tower parts
- 24 Fortification keep facades
- 408 Pieces of text
- Lisbon - Braun and Hogenberg - Civitates Orbis terrarum
  - 800 fortress parts
  - 339 Religious Building parts
  - 529 Residential blocks
  - 292 Roof parts
  - 188 Roads
  - 262 landscape parts
- London -
  - 3566 Objects
  - 1425 Roof parts
  - 201 Religious Building parts
  - 506 House parts
  - 15 animals
  - 185 People
  - 148 Landscape parts

A subset of this data can be explored in a zoomable IIIF viewer at this link, thanks to Rainer Simon’s work to make it follow WC3 standards and his work on Annotorious. The data needs to be cleaned up a little to allow it to throw out minor bitmap errors, and Eric Monson (Duke Library) is currently working on a python script to fix the crosswalking issue, but once this is done, our plan is to embed all of the annotation data in viewers at https://www.sandcastle3d.org/.

In the summer of 2022, the PI also used part of the funds from the NEH ODH Phase II grant to travel to 31 additional sites in Portugal that appear in the Book of Fortresses. Including this set of site visits, the PI has photographed 45 of the 55 castles that were drawn and surveyed by Duarte de Armas in 1509-1510. Triplett also used drone aerial photogrammetry to scan four additional sites from the book, which has made it possible to further develop the 3D GIS portions of the Book of Fortresses project. This data can be seen at the project website https://www.bookoffortresses.org/. The photography work has demonstrated the differences between on-site knowledge of each castle site, and the images drawn in the Book of Fortresses, so this material has slightly different goals from the Sandcastle Toolkit project. Nonetheless, by establishing the need for multiple camera positions, and multiple camera lenses to capture images that resemble the composite drawings in the Book of Fortresses, the PI has made a number of interesting discoveries about this early example of premodern chorography that will be included in a forthcoming monograph. Finally, Triplett is also working on adding annotations to the on-site photography as an additional means of publishing the results of this research on the project website. An example of this work is pictured on the follow page.
Award Products

Photographs of the castle and town of Bragança from the SouthEast (above) and West (Below) paired with a roughly corresponding drawing from the Book of Fortresses.
Continuation and Long-term Impact

Beyond the next steps of continued stress-testing through 2023 mentioned in this white paper, the PI (Triplett) and Co-PI (Stern) expect to distill the findings of this work on the sandcastle website as well as in journal publications, detailing both the theoretical work on the ‘chorographic turn’ as well as the methodological insights from the development of the toolkit. PI (Triplett) is also, as mentioned, planning to publish some of the findings on the Book of Fortresses in a forthcoming monograph. We plan on applying for future grants to support those next stages of development, including broadening our user base and disseminating our continued findings more widely. We also plan to design video tutorials to help users understand how to perform each stage of the annotation, translation and visualization process once the toolkit moves into the beta phase of development. This NEH grant period is over, but the project certainly is not, so our plan is to continue finding ways to perfect the Sandcastle Toolkit and release it publicly, with detailed instructions and demonstrations in the next year. Finally, we have only seen glimpses of our rendered 3D environments within the Unreal Engine - which constitutes the very last stage of the Sandcastle Workflow. We think exploring these scenes through a first person controller view, or through a VR headset will finally bring some of our theories about chorographic image making and immersive scenography to bear in a critical, but malleable sandbox environment.
Select Bibliography


Select Bibliography


