

Application of Music-Encoding Technologies to Guatemalan Choirbooks, Facilitating Preservation and Musicological Studies of the Colonial Repertoire

The goal of this project is to contribute to the preservation and dissemination of the colonial musical heritage of Guatemala by encoding a set of choirbooks into a machine-readable format. The encoding of the repertoire will allow people in Guatemala and abroad to access the music through a web-browser, while keeping the original sources in their homeland. This set of choirbooks (GCA-Gc) are manuscripts written in mensural notation, a music notation style used in Europe throughout the Late Middle Ages and the Renaissance. The GCA-Gc represents the only extant mensural repertoire in the country, and so it is of utmost importance to treasure and preserve them for future access. In this paper, we will explain the different steps that will be taken to contribute to the preservation and accessibility of the Guatemalan Cathedral choirbooks.

The musical heritage from the colonial period of Latin American countries is not well known around the world. Even though colonial music is rooted in the early Western music traditions, little is known about how these traditions and repertoires evolved in the Spanish colonies of the Americas. The lack of high-quality digitization of music documents from these countries and era restricts the access only to the people able to visit the institutions where the original sources are archived. Furthermore, the use of old music notation restricts performance of the music to the knowledgeable experts.

In mensural notation every note symbol has a default durational value, but the length of the note can be modified by the context. Together the context-dependent nature of the notation and the choirbook format of the sources (see Figure 1) hinder the appreciation of the polyphonic texture of the music. It is only until musicians acquainted with the notation sing the various parts together or until an expert transcribes the music into a modern score that these textures can be really

perceived and enjoyed. The layout of the original music deters its study even for experts, because it is hard to visualize the vertical relationships between notes sung simultaneously in two different voices, something that only becomes clear when the music is presented in score format.

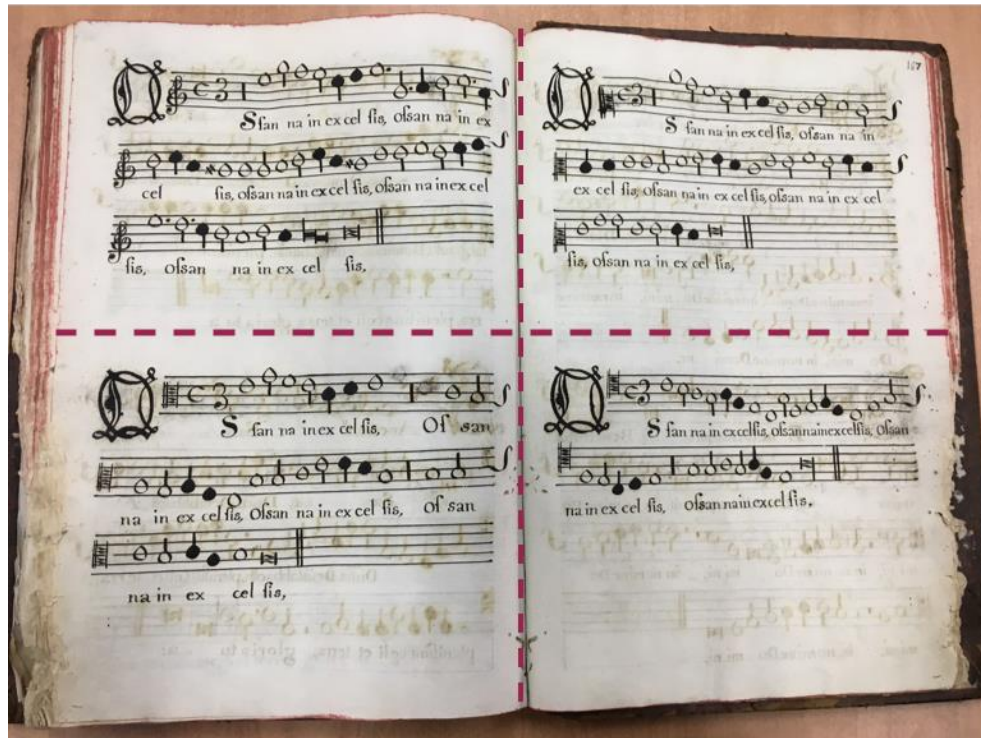


Figure 1: **Choirbook format** used during the Renaissance. The voices are represented in the different quadrants of the book opening.

As a result, the barriers to accessibility in the body of Guatemalan mensural music can be summarized into: (i) the lack of high-quality digital images, (ii) the notation style, and (iii) its layout. We plan to help to unravel these barriers by using three tools: a do-it-yourself (DIY) book scanner, the implementation of a complete workflow for optical music recognition (OMR), and the mensural notation *Scoring-up Tool* (Thomae 2017). While the DIY book scanner will handle the digitization barrier, the *Scoring-up Tool* will handle the context-dependent nature of the notation and the layout barriers. The OMR process will be the link between the two technologies. The process will result in the digitization and encoding of the repertoire as musical scores in MEI (Music Encoding Initiative) format. More details of the relevance of each of these tools follows.

The DIY book scanner. Given their antiquity, the Guatemalan choirbooks cannot be digitized face-down using a common flatbed scanner. On the contrary, they need to be digitized from the top using a book scanner and, ideally, using a v-shaped book cradle to lower the stress on the book spine. Currently, there is no book scanner in Guatemala that has the appropriate dimensions to digitize these books. Since buying a large book scanner is out of our possibilities, we will build the book cradle and will provide specifications for the lighting and camera setup.

The OMR software. Just as Optical Character Recognition (OCR) allows computers to read the characters written in a text document, OMR systems read the music symbols from a music document. OMR software that will be used to read and encode the sources include: a machine learning algorithm for document segmentation (Calvo-Zaragoza et al. 2018) with ground-truth data generated with *Pixel.js* (Saleh et al. 2017), an interactive music symbol classifier based on *Gamera* (Droettboom, MacMillan, and Fujinaga 2003), and a pitch-finding algorithm (Vigliensoni et al. 2011). Alternatively, we can also use a machine learning model developed by Pacha and Calvo-Zaragoza (2018) that detects both music symbols and pitch in one step. This model was trained with Spanish mensural music, which is similar to the notation in the Guatemalan corpus. The resulting data from the document segmentation and pitch finding processes will be encoded in MEI (Roland 2002) according to the MEI Mensural module (Roland, Hankinson, and Pugin 2014). Each piece will be encoded as separate parts—just as it is in the choirbook—by a set of Mensural MEI files, each encoding one voice.

The mensural notation *Scoring-Up Tool* (Thomae 2017). This set of scripts deals with the context-dependent nature of mensural notation. For all the notes in each part, the tool determines whether the surrounding context modifies their default value. If this is the case, the modification is encoded within the <note> element using the @num and @numbase attributes.

Afterwards, the one-part Mensural MEI files are merged into a single Mensural MEI file that encodes the piece as a score.

The resulting Mensural MEI scores from this workflow will enable music experts or enthusiasts: (i) to view the encoded score in mensural or modern values using Verovio, (ii) to listen and appreciate the polyphonic texture of the music, and (iii) to easily visualize the vertical sonorities (i.e., the intervals between the voices), which are useful for counterpoint studies. We hope that the digitization and encoding of the Guatemalan mensural music corpus will contribute to the preservation and dissemination of a historic musical heritage that otherwise may be lost, forgotten, or damaged. The result should facilitate its study by musicologists and appreciation by the general public, especially for repertoires that are virtually unknown in the country and abroad. Furthermore, we expect the outcomes of this project could be used as a model for the digitization of the mensural repertoire of other countries that were once part of the Spanish colonies.

Presentation needs are limited to a VGA or HDMI cable.

Bibliography

- Calvo-Zaragoza, Jorge, Francisco J. Castellanos, Gabriel Vigliensoni, and Ichiro Fujinaga. 2018. “Deep Neural Networks for Document Processing of Music Score Images.” *Applied Sciences* 8 (5): 654–674.
- Droettboom, Michael, Karl MacMillan, and Ichiro Fujinaga. 2003. “The Gamera Framework for Building Custom Recognition Systems.” In *Symposium on Document Image Understanding Technologies*, 275–86.
- Pacha, Alexander, and Jorge Calvo-Zaragoza. 2018. “Optical Music Recognition in Mensural Notation with Region-Based Convolutional Neural Networks.” In *Proceedings of the 19th International Society for Music Information Retrieval Conference, Paris, France*, 23–27.
- Roland, Perry. 2002. “The Music Encoding Initiative (MEI).” In *Proceedings of the First International Conference on Musical Application Using XML*, 55–59.
- Roland, Perry, Andrew Hankinson, and Laurent Pugin. 2014. “Early Music and the Music Encoding Initiative.” *Early Music* 42: 605–11.
- Saleh, Zeyad, Ké Zhang, Jorge Calvo-Zaragoza, Gabriel Vigliensoni, and Ichiro Fujinaga. 2017. “Pixel.js: Web-Based Pixel Classification Correction Platform for Ground Truth Creation.” In *Proceedings of the Twelfth IAPR International Workshop on Graphics Recognition*. Kyoto, Japan: Springer LNCS.
- Thomae, Martha. 2017. “Automatic Scoring up of Mensural Music Using Perfect Mensurations, 1330-1550.” Master’s Thesis, Montreal: McGill University.

Vigliensoni, Gabriel, John Ashley Burgoyne, Andrew Hankinson, and Ichiro Fujinaga. 2011.

“Automatic Pitch Detection in Printed Square Notation.” In *Proceedings of the 12th International Society for Music Information Retrieval Conference (ISMIR)*, 423–28.

Music Manuscripts

GCA-Gc: Guatemala City, Catedral, Archivo Capitular 1–4.