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Digitizing Braille Music: A Case Study

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Abstract

The Music Section at the National Library Service for the Blind and Physically Handicapped at the Library of Congress has been digitizing its tactile braille music collection in order to preserve it, make it electronically available, and to reduce physical space needed for storage. Poor scanning and editing can result in scores that are confusing or even unusable, especially for the blind musicians who rely on our materials. Over the past few years, we have used different scanners and software with varying degrees of accuracy and speed. In this paper, we will explain our digitization process, the types of software and techniques we use, and discuss the challenges we face in capturing and proofreading archival quality e-braille files.

Introduction

The Music Section of the National Library Service for the Blind and Physically Handicapped (NLS) at the Library of Congress has been digitizing and proofreading braille music since 2003. It has become imperative in recent years for us to increase our rate of scanning due to a number of reasons:

- To meet the rapidly increasing demand for digitized braille music through our online digital library, Braille and Audio Reading Download (BARD);
- To drastically reduce physical storage space for braille scores; and
- To preserve fragile and aging scores.

Our braille digitization efforts have been very time consuming and labor-intensive due to the length of time it takes to scan, as well as the attention to detail necessary for proofreading scores. Scanning a page of braille takes between 5-10 seconds using both standard flatbed scanners with optical braille recognition software (OBR) and a specialized braille scanner (DotScan)—the two types of software that we currently use. The created files are either saved as an ASCII text (OBR) or image (DotScan) file, and are then proofread by the braille music specialists and librarians respectively. Even then, however, it is difficult to ensure that these scores are 100% accurate. The proofread scans are then deposited to BARD (Braille and Audio Reading Download), our online content management system that is accessible to registered patrons. Considering the exacting nature of braille music, it is imperative that the librarians who scan and proofread have the best tools to assist them in producing accurate, and therefore usable, scores.

Braille Music Digitization Efforts at NLS

A Brief History of Braille Music

In 1824, Louis Braille invented the braille system of reading using six raised dots arranged in two columns of three dots. Braille, who was a well-respected organist and music teacher, also developed a system to read and write music using six dots organized in a different way than literary braille. Music scores and books containing this braille code have thus been in existence since the mid-nineteenth century. Like in standard literary braille, the dots in braille music are numbered 1 through six from top to bottom.

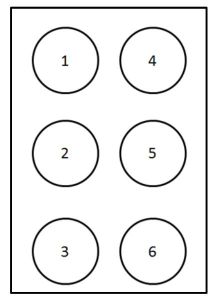

Figure 1. *The six dots of a braille cell*

In music braille code, the top four dots in a cell (dots 1-2-4-5) represent pitch while the bottom two represent the duration of the note, indicating rhythm. Naturally, the two lower dots which can generate only four permutations cannot possibly represent all the different durations of sound contained in music, as there are many more than four note lengths in music. Musicians who use braille music can perceive these differences in rhythm depending on the time signature, and other contextualizing information. Another vital part of the code, especially for piano music and other music that contains multiple parts, are the interval signs. These signs indicate the exact interval between two notes. Along with these two examples, there are many other rules in braille music code that portray how exact one must be in order to create accurate, and therefore reliable, braille scores.

Digitizing the NLS Braille Music Collection

About the Collection

The NLS braille music collection consists of a wide variety of scores acquired through donations and purchases from more than 20 different braille publishing sources in a number of countries. Even though the NLS Music Section was founded only 56 years ago in 1962, many of our scores pre-date that, going all the way back to the turn of the 20th Century. Currently, our print braille music collection takes up approximately 8,700 linear feet of shelving space.

Around three-quarters of our braille music collection consist of inter-point braille: braille embossed on both sides of the paper. Since braille music takes up so much space, embossing the braille cells on both sides of a single sheet can help create a much more compact score. This is good for those looking to save space in their braille music collection, however it creates some more complications when digitizing, as it is difficult for certain software to distinguish between the raised dot and the depression made by the raised dot on the opposite side of the page.

Along with the difficulties presented by inter-point braille, the scores in our collection differ in many regards, including formats, paper size and quality, quality of braille dots, and multiple degrees of wear and tear. These differences have forced us to find creative solutions in order to digitize them, relying heavily on our braille music specialist to fix any inconsistencies and errors in the digitized score.

Only about 0.5% of our collection consists of master copies (braille scores that have never been circulated and have braille embossed on only one side of the paper). These titles scan cleanly due to their crisp and clearly defined dots. The scanned masters usually require very little editing.

The remainder of the collection consists of single-sided braille in a variety of formats, including a large number of thermoform scores, which have proved particularly challenging. Thermoform braille scores are created by melting a special plastic sheet over the master (usually metal) copy with a heating element to capture the raised dots of the original score. The reproduced dots are not as clearly defined as the ones in the original which can result in poor scanning. In addition, the plastic paper used for thermoform scores can become brittle with age and have to be handled with great care. It is also less matte than regular braille paper, and this sometimes causes issues with the scanning software.

Digitization Workflow

We have used many systems and workflows since 2003, and have recently been able to start scanning on a large-scale basis. Although technologies to scan and digitize braille have existed for some time, they are still far from the user-friendly systems that we would like them to be, especially for proofreading. Currently, we do not have the resources to develop software in-house, and we have many more scores than other braille music collections. Therefore, working with a software or software developer that prioritizes accuracy and speed are imperative for our scanning efforts.

The Music Section uses two different braille scanning software programs: OBR (Opitcal Braille Recognition) and DotScan. There are four sighted music librarians who devote about 20% of their working hours scanning and proofreading braille music scores. The librarians are not proficient in braille music code, but they are able to perform proofreading by sight on DotScan by comparing the computer generated grid to the original image.

OBR, however, cannot be proofread without a thorough knowledge of the braille music code since there is no visual aspect to the software other than the ASCII code.

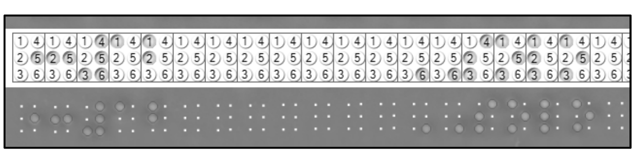

Figure 2. *The software-generated grid compared with the original image*

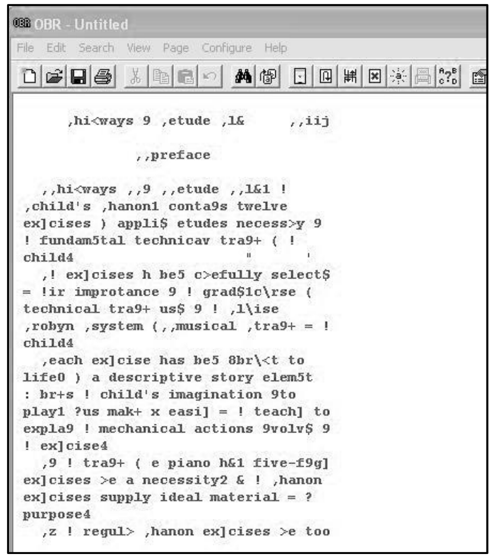

Figure 3. *The ASCII output using OBR*

Since these two systems generate digitized braille requiring different levels of editing, we have divided the labor depending on the need of patrons and of the collection. The first step is mass digitization using the OBR software. Since this software produces a large bottleneck at the proofing level, as our braille specialist must currently inspect each score, we are "proofing on demand" when a patron needs a particular score or when necessitated by collection development.

The DotScan software, though easier to proofread by sighted librarians, is not easy to use with inter-point braille, and its scanning process is longer than that of OBR. Therefore, this software is primarily used for single-sided braille, and specifically when a patron is in a quick need for a digitized score. We are currently scanning all master scores with the DotScan software.

In the near future, we are hoping to outsource most of the proofreading of our OBR scans to certified braille music proofreaders but continue the in-house process using DotScan. We have recently started outsourcing our proofreading, and we are hoping it will rapidly increase our production.

Braille Scanning Software

Optical Braille Recognition (OBR)

We mainly use the OBR to scan inter-point braille music scores on a flatbed scanner. A transparent orange plastic sheet is placed on the scanner glass since the shadows from the dots embossed on the white paper do not provide enough contrast for the scanner to detect them. OBR is suitable for inter-point because it can recognize and group the recto dots (protrusions on the front) and verso dots (protrusions on the back) separately, making it possible for a single scan of one side of the paper to capture both the front and back pages simultaneously. The dots are converted and displayed in American Standard Code for Information Interchange (ASCII) braille on the monitor.

The person scanning examines the ASCII after each scan for rotated images, which are easily detectable because they are right justified. If the ASCII for the manually rotated page still is incorrect, the page is rescanned. Although the OBR manual says large pages are automatically adjusted to fit the scanner, one of the most common problems we experience is missing or mis-scanned top or bottom lines that the scanner failed to capture. The entire line could be missing or one side of the braille cells could be cut off, making it necessary for them to be entered manually. Unless the missing information was something simple such as the page number, it cannot be corrected without knowledge of braille music or the ASCII code. At NLS, this step is usually saved for the braille music specialist who will proofread the text files using a refreshable braille display. We do not use the merge function on OBR because it is time consuming and can have unreliable results.

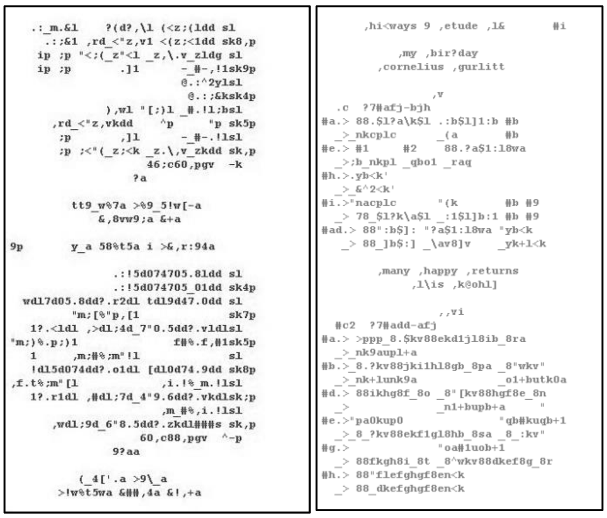

Figure 4. A rotated page on OBR (left) as compared to its corrected version (right)

Another common problem is the missing first columns on the left side of the page. This happens when the new braille line starts too close to the punched binding holes, causing the program to misjudge where the paper edge is. Often, the first columns are the measure numbers, which can easily be filled in using the computer keyboard. Nevertheless, it is time consuming to type in missing measure numbers considering that in some braille music format, the measure numbers appear in every other line. Similarly, we sometimes find lines missing in the middle of the page. This problem seems to be caused by the occasional variation of line lengths in the music. The program will start to read lines of the same length, skipping over any that deviate from the usual length. Our remedy is to block the preceding lines and rescan the page with the previously missing line as the first line. We then cut and paste the newly scanned lines into its proper place in the first scan.

Another frequent problem is the appearance of phantom dots. The scanner picks up noise that is not present or is part of the braille code in the document and converts it into ASCII, resulting in erroneous music notes or symbols. OBR also does not preserve the page separations of the scanned document, so that the pages are saved as one long page.

The saved text file is sent to the braille music specialist who carefully proofs and reformats the scan. As observed, some rudimentary remedies are rendered by the librarians scanning, but there are mistakes that can only be detected by a braille reader who compares the scan dot to dot with the original braille score. The edited version is saved as a braille ready format (brf) file to be uploaded to BARD.

One of the biggest overall issues that we have with OBR is that the company that developed the software does not appear to be in business any longer. If we were able to communicate with the software developers, it is possible that we could work with them to develop fixes for many of the issues that we encounter.

DotScan

The DotScan system consists of software and a large box-shaped scanner. Much like with a regular flatbed scanner, we place the braille music on the glass plate of the scanner and take a picture of the score. Unlike OBR, which is equipped with a variety of advanced image pre-processing abilities, DotScan requires much more manual input. For example, OBR can automatically determine the size of the scanned braille cells and assigning either a large, medium or small size classification for each document. In DotScan, the person scanning has to input the parameter by measuring the distance between the dots of two adjoining cells (inter dots) and within the cell (intra dots), which is an awkward manual process. Nevertheless, this step has to be as accurate as possible because without the precise measurements, the software is unable to establish the gridline of the horizontal and vertical braille cells. The grid groups the dots into braille cells and maps the dots into correct braille ASCII. When the parameter established by measuring the braille dots is inaccurate, the resulting images on the screen are jumbles without cell groupings, making reviewing and editing the scans extremely difficult. This is problematic for many of our older scores since they were created by hand and may not retain spacing consistency throughout the entire work, making the output from DotScan very inaccurate.

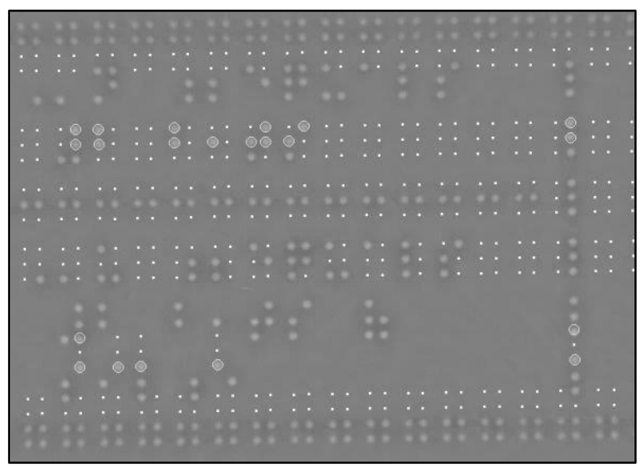

Figure 5. An example of an inaccurate grid placement in DotScan

The next step performed on DotScan is cropping edges. This is another process that is automatically completed on OBR but not on DotScan. Here, a rectangular box is drawn close to the edge of the braille lines using the mouse to crop the edges of the page, which contain no braille information. Cropping reduces the need for storage space and helps pixel computation to be more efficient [8]. Although DotScan is capable of scanning pages at a considerably faster rate than OBR, having to crop each image manually makes the total scanning time about 5-10 seconds, which brings the total rate to one comparable to OBR. Combine that with the fact that OBR scans two pages at the same rate (recto and verso), and the total scanning time for a 100-page braille book increases considerably on DotScan.

When scanning is complete, a sighted music librarian proofreads each line of the scanned music, which can be very time consuming and mentally taxing, due to the need for a continuous detailed review of the output. DotScan displays a single line of braille on the review bar in which the dots of each cell can be added or deleted. The proofreader compares the contents of the review bar against the image of the braille cells appearing just below. Robust dots that are fully captured and recognized by the system will appear in light blue. When the system detects a questionable dot, it will alert the proofreader by encircling the dot in white or dark blue. Heavily used braille with flattened dots, mistaken dots that were pushed back into the paper by the transcriber, unevenly-spaced braille characters, and the dots in the cells that are not aligned properly are all issues that typically fall into this category. An experienced proofreader will develop skills to spot check each line instead of comparing each cell to the image of the page and can locate the white or dark blue circles at a glance.

DotScan is primarily used for one-sided braille because when we scan inter-point braille on DotScan, the depressions on the verso (which are protrusions on the recto) are clearly visible on the scanned image, which is extremely confusing to the sighted proofreader, and also confusing to the DotScan software. Since the proofreading is accomplished by comparing the two images, one on the review bar and the other beneath it, seeing extra dots in different colors significantly slows down the process and reduces the accuracy of the review.

When the software does not correctly extract the braille dots in the document, the reviewer has to manually fill in the dots cell by cell using the computer mouse. There may be a couple cells that require manual entry or there could be multiple lines, page after page, significantly slowing down the review process. For example, a 100-page master copy may be scanned and edited in 4-5 hours. However, a 100-page hand-punched braille music score that has been heavily used can take five times longer to review since the scanned image will be low in quality, requiring hours of manual corrections.

After each page has been scrutinized, we recheck our edits before saving the final copy for formatting. We move to a different editing software to make sure that the books are in the standardized format (40 cells per line and 25 lines per page). This step is important in ensuring that the embosser does not cut off any cells and lines that exceed the standard limit.

Conclusion

Our main goal is to capture an accurate braille-ready file of the braille score, regardless of the quality or format of the original, in a quick and relatively painless manner. This not only requires high-quality scanned images, but also software that can accurately recognize the braille on the page irrespective of the dots' clarity and position, both single-sided and inter-point. Reducing the need to manually type in missing braille dots will certainly increase the speed and accuracy of our digitization process.

Secondly, improved segmentation will result in more accurate grouping of the cells. We would like the proofreading process to be simple and short, which means librarians should not have to regroup dots in every cell in a line caused by a scanning error. We want to avoid having to fix these egregious errors.

Smarter software with more automatic functions will eliminate the need for our staff to manually perform tasks such as adjusting the page on the scanner bed, use the mouse to draw and measure, and the proofreader to reinsert the format present in the braille original. This will help prevent human error and create cleaner, more accurate braille music scores.

Lastly, we would like to have a scanner specifically designed or modified for digitizing braille with a special lighting system and accessories such as special glass or filters that will magnify the contrast between the lights and shadows created by the recto and verso dots so that all the dots in the original documents are captured in the scan.

We would like to encourage more research in braille digitization to improve accuracy such as image pre-processing, dot detection and extraction techniques, especially in the field of braille music

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Author Biography

Donna Koh has been working as a Music Reader Services Librarian at the NLS/BPH, Library of Congress for the past two years. As a lifelong music educator, she is passionate about braille

music literacy and improving access to braille music for students and musicians who are blind and visually impaired. She has written blogs about digitizing braille music and braille music literacy on NLS Music Notes.

Katherine Rodda has worked at the NLS/BPH, Library of Congress for over five years. She holds a MSLIS from Catholic University, a Master of Music Degree from Temple University, and a Bachelor of Music Degree from Gettysburg College. She has worked as both a reference and music librarian, and is excited about the possibilities new technologies bring to the world of braille, especially braille music.