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An Implementation of the Digital Music Stand for Custom-Made On-Screen Music Manuscript Viewing

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Abstract. An implementation of the digital music stand (DMS) is presented in this invited tutorial. The DMS constitutes an optical music recognition (OMR) system whose principal aim is the custom-made on-screen presentation of music manuscripts (MMs). Aiming at performing the minimum necessary amount of MM processing, the DMS constitutes middle ground between full-processing classical commercial OMR systems/platforms and pure MM presentation systems. The DMS is intended for musicians and choir singers at all levels of music erudition, in both cases including those with visual impairments which cannot be corrected with glasses or contact lenses; music activities ranging from study, rehearsal and performance of individuals as well as of orchestras are accommodated. The DMS implementation stages are detailed, with performance accuracy, which is necessary for correct MM presentation, also being reported.

Keywords: digital music stand, optical music recognition, music manuscript, on-screen presentation, custom-made viewing, minimal processing.

1 Introduction

In the more than 50 years of optical music recognition (OMR) research, a variety of applications have been developed including (a) the preservation of old music manuscripts (MM) editions; (b) their re-editing and translation into a desired font, type of notation (for the same or a different musical instrument) and key; (c) their conversion into WAV format; (d) their classification and compilation into music databases. All of these applications aim at helping music students and researchers, performers and conductors during music study, rehearsal and performance. The enormous volume of research performed (e.g. [1-11], for a review the reader is referred to [12]) has resulted in

- (a) commercially available systems such as MidiScan (<http://www.musitek.com/>); SharpEye and PhotoScore (<http://www.visiv.co.uk/>, <http://www.sibelius.com/products/photoscore/ultimate.html>) and

<http://www.sibelius.com/products/photoscore/lite.html>); forScore (<http://www.forscore.com/>) and platforms, e.g. Gamera (<http://gamera.sourceforge.net/>), used for creating born-digital MMs via the direct input of music symbols by the user

- (b) notation languages for recognising each music symbol of a – usually born-digital - MM and for, subsequently, representing the symbol by the corresponding prototype symbol as well as its relationship to other music symbols of the MM, for instance ABC [9-10]
- (c) pure MM presentation applications for on-screen viewing of MM pages, e.g. forScore (<http://www.forscoreapp.com/>).

The digital music stand (DMS) was introduced in 2008 [13-14] as an OMR system focusing upon the custom-made on-screen and on-line reconfigurable MM presentation. This aim is accomplished via the minimal possible amount of image (MM page) processing, thus rendering the DMS a representative of the middle ground that lies between full-processing classical commercial systems/platforms and pure MM presentation applications. The DMS is intended for musicians at all levels of music erudition as well as at choir singers, in both cases including those with visual impairments which cannot be corrected with glasses or contact lenses; music activities ranging from study, rehearsal and performance of individuals as well as of orchestras are accommodated.

A complete DMS implementation is presented in this invited tutorial, which is organised as follows: Section 2 introduces the main characteristics of the DMS, contrasting them with those of existing OMR implementations; the key stages of the DMS are described in detail in Section 3, with the performance accuracy of each stage also being reported; finally, Section 4 concludes the paper.

2 The Main Characteristics of the DMS – Comparisons with Existing OMR Implementations

Unlike classical OMR implementations ((a)-(b) of Section 1), but like pure MM presentation applications ((c) of Section 1), no prior MM alignment, noise and/or staff line removal, or full music symbol recognition are performed. Instead, only the clefs, global accidentals and time signatures are recognized so as to allow correct on-screen MM viewing, independent of the desired MM on-screen layout and current viewing conditions.

The DMS processes scanned as well as born-digital MMs in the same uniform manner, independent of the image dimensions, format and quality. Thus, MM pages that contain noise (white or coloured) and other imperfections that are due to the state of the original MM and/or the scanning process (e.g. badly aligned, or derived from damaged MMs) are handled exactly as are those derived from crisp, near-perfect born-digital MMs.

Three viewing conditions are available to the user for custom-made on-screen MM presentation:

- Static viewing. The user specifies the desired size of the music notation, whereby the MM is automatically arranged into screens of appropriately-configured

sequences of measures of the MM. The user can navigate to next/previous screens by pressing pre-specified keys; additionally, on-line changes to the music notation size are possible.

- Dynamic viewing. The user specifies the desired size of the music notation as well as the tempo at which the MM is to be played. Further to static viewing, the internal metronome of the DMS causes automatic page turning as soon as the total time required for playing the part of the MM appearing on-screen has elapsed.
- Scrolling, where – as for dynamic viewing - the user specifies the desired size of the music notation and the tempo at which the MM is to be played. In this case, however, the MM is presented in a single-system format, with consecutive measures and systems sliding in a right-to-left direction and at a constant speed that is determined by the tempo. By minimizing head and eye movement, scrolling is a great aid to visually impaired musicians who can keep their fixation point constant on the centre of the screen while viewing the MM.

3 The DMS Key Stages

The correct operation of the DMS is centred upon the maximally accurate detection of the staff lines (stage 1). Next, each MM page is segmented independently into its constituent staves and grand staves (stage 2), as well as into the measures that appear within each of them (stage 3). The key music symbols (clefs, global accidentals and time signatures) of the MM are subsequently isolated and identified (stage 4). Finally, the key music symbols and the remaining parts of the MM are put together in such a manner as to allow custom-made on-screen viewing of the MM that can be altered on-line upon request (stage 5).

The reported results that are shown at the end of each sub-section have been derived from a total of 137 MMs, 115 of which are scanned and the remaining 22 are born-digital.

3.1 Staff Line Detection and (Grand) Stave Segmentation – Stages 1-2

These stages constitute the most crucial stages of the DMS implementation and are, thus, presented together. The following steps are performed:

- An initial estimation of the staff lines as well as of the staff line distance (SLD) is provided by the horizontal projection of the MM page.
- Missing staff lines are filled in for each staff which has less than five detected staff lines; the SLD is used to this end.
- Any extraneous staff lines are deleted from each staff which has more than five detected staff lines; again, the SLD is employed.
- Non-detected staves are identified, based on the free available area as well as on the proportion and spacing of black horizontal line segments appearing within the area.

- The staff line positions are optimised within each identified staff, using the SLD as well as the location of black horizontal line segments of the original image.
- Any staves that were detected during the previous step but do not correspond to real staves (e.g. due to the existence of significantly broken lines, or of unacceptable fluctuations in distance between consecutive staff lines of the same staff) are removed.

Staff line and staff detection accuracy amounts to 95.95% and 90.5% for the scanned MMs and to 97.8% and 100% for the born-digital MMs.

3.2 Measure Segmentation – Stage 3

The measures within each (grand) staff are identified using the vertical projections of windows containing the grand staff and each of the two constituent staves. Measure detection exceeds 94% for both kinds of MMs.

3.3 Key Music Symbol Identification – Stage 4

This stage is vital for the accurate on-screen presentation of the MM in that it makes sure that the current key music symbols (clef, global accidentals and time signature¹) pertaining to the viewed part of the MM are presented to the user, thus allowing him/her correctly study and/or play the MM.

A database of each key music symbols has been compiled from the available MMs. Between eight and 13 exemplars from each key music symbol have been employed to this end, each exemplar covering different sizes and fonts. Once a MM is input in the DMS, windows (of size equalling each exemplar) of the measures that were isolated in the previous stage are exhaustively matched against each exemplar and the match locations as well as the identity of the matched exemplar are retained.

Clef, global accidental and time signature identification accuracy reaches 99.8%, 92.3% and 100%, respectively, for both kinds of MMs.

3.4 MM Presentation – Stage 5

The sequence of measures of the MM is presented on-screen according to the user requirements concerning notation size, tempo and viewing condition. The key music symbols are positioned at the left end of each staff, with their identity changing whenever there is a change of clef, global accidental and/or time signature in the original MM.

¹ The key music symbols affect the way the MM is played in terms of tonality as well as tempo.

4 DMS Evaluation

The DMS is centred upon the maximally accurate detection of the staff lines (stage 1). Subsequently, each MM page is independently segmented into its constituent staves and grand staves (stage 2) as well as into the measures that appear within each (grand) staff (stage 3). Next, the key music symbols (clefs, global accidentals and time signatures) of the MM are isolated and identified (stage 4), thus allowing the concatenation of the appropriate key music symbols and the remaining parts of the MM in such a manner as to allow custom-made on-screen viewing of the MM (stage 5). A number of demonstrations of the constituent stages as well as of the operation of the DMS will be presented at the Eight AIAI Conference.

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