The Digital Music Rest e-Service

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Abstract. The digital music rest music-on-demand e-service is presented. Following an e-request from the user for a music score (or part thereof), the digital music rest presents the selected musical manuscript on the user's computer screen. The digital music rest incorporates a variety of viewing options concerning manuscript presentation (such as size and color of the measures, notes and accompanying notation; background color; contrast; page configuration; digital metronome; static/dynamic viewing or scrolling) that allows custom-made screen layout and transition; these can be modified at any time. The initial realization of the digital music rest is put forward as a superior alternative to the traditional music-rest/musical-manuscript arrangement for professional, amateur as well as visually impaired musicians during musical instruction and therapy. Future research aims at developing the digital music rest in order to accommodate for more music scores, users as well as (synchronized) ensembles of digital music rests during performances of orchestras.

1 Introduction

Any musician - be (s)he a music student, an amateur player, a member of an orchestra or a soloist – uses a musical manuscript placed upon a music rest in order to learn and perform a piece of music. At the end of each page of the musical manuscript, the musician uses one hand in order to turn the page and proceed playing. By repetition, the music score is memorized and page turning becomes progressively less imperative, although music-rest/musical-manuscript arrangements are still used during performances: it is important to have a written source to refer to as a prompt or initial stimulus or simply so as to minimize memorization (given that only soloists play by heart during performances).

In this piece of research, the digital music rest (DMR) music-on-demand e-service is put forward as an alternative to the traditional music-rest/musical-manuscript arrangement. Following an e-request from the user for a given music score (or part thereof), the DMR presents the selected musical manuscript on the computer screen of the user. The DMR incorporates a number of viewing options concerning manuscript presentation (such as size and color of the measures, notes and accompanying notation; background color; contrast; page configuration; digital

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metronome; static/dynamic viewing or scrolling etc.) that allow custom-made screen layout and transition. Additionally, the user can modify the viewing options at any time. The DMR e-service allows on-line access to (potentially) any musical manuscript. Moreover, no wear-and-tear of the musical manuscript occurs, while it becomes straightforward and economical for groups of musicians to have access to the same music score at the same time.

No similar e-service for acquiring music scores has been reported to date. The display options of the DMR render it a superior alternative to the professional, amateur as well as visually impaired musician during musical instruction, rehearsal and performance.

This paper is organized as follows: section 2 describes the profile of the potential DMR users, focusing upon the needs of each group (especially of visually impaired musicians); section 3 describes the viewing options afforded by the DMR, while section 4 details the implementation characteristics of the initial DMR realization; section 5 summarizes the advantages of the DMR over the existing music reading options and points towards future extensions; finally, section 6 concludes the paper.

2 Potential DMR Users

The DMR music-on-demand e-service is aimed at amateur and professional musicians (either with normal or corrected-to-normal vision) as well as at visually impaired musicians (persons with vision problems that cannot be completely corrected with an ordinary pair of glasses or contact lenses); the latter may employ music instruction as a means of education, social interaction and the ensuing pleasure.

As far as visually impaired musicians are concerned, the existing options for learning a music score are restricted to either reading the music from Braille [1-4] or using a tape recorder/CD player in order to memorize the music prior to playing it. In Braille, musical information is presented consecutively rather than graphically, whereby appearance is not necessarily related to sound; furthermore, the lack of vertical alignment obscures the relationship between notes in chords, while a single misread dot may render the corresponding measure meaningless. Finally, there is no way of playing with both hands while reading. All of the above, combined with the limited number of Braille music scores available and the variety of formats employed, severely restrict the usefulness of Braille music scores. Unfortunately, it is even harder to accomplish aural memorization of a music score at a level that allows the visually impaired musician to play the score.

In any case, and assuming that learning has somehow been accomplished, large-print music (either printed directly in large format, enlarged while photocopied, or scanned and subsequently enlarged and printed) has been proposed as a memorization aid. While, however, the direct print option is not available for all musical instruments and/or music scores, the other two options are expensive and not easily adaptable to the individual needs of the visually impaired musician: the larger the note size the smaller the amount of music that can be seen at once, and thus the more page turning and head movement become necessary; the latter calls, in turn, for

frequent adjustments of the amount and direction of lighting as well as of the position of the music rest relative to the visually impaired musician.

Recently, a number of software programs providing aid in the musical instruction of visually impaired musicians have been developed:

- Goodfeel by Dancing Dots converts the music files used to produce the music score directly into Braille music notation. The transcription is displayed via pins which are raised/lowered (e.g. ALVA Braille Terminal), accommodating for most Western languages; both the tune and the accompanying notation (e.g. *allegro ma non troppo*) are transcribed.
- Opus Dots Lite by Opus Technologies accomplishes transcription into Braille music notation directly from the scanned musical manuscript.
- SharpEye by Music Reader, Midiscan and Pianoscan by Musitek, Toccata convert the scanned musical manuscript into a MIDI file or some similar format that supports direct transcription into Braille music notation. Furthermore, Magni-Ccata incorporates the option of exposing the melody/musical manuscript correspondence, by highlighting on-screen (and thus assisting the musician to focus upon) the notes currently played.

PortaNum, a software program that acts as a general viewing tool for the visually impaired individual, is also worth mentioning. In PortaNum, a camera connected to a computer takes frames (or a film) of what the individual cannot see. Subsequently, the frames are submitted to user-controlled image processing (zoom-in and navigation within the zoomed window, contrast and brightness adjustment, smoothing, color selection and inversion, edge extraction and enhancement, edge widening etc.) in order to render the desired details visible to the visually impaired individual.

3 DMR Viewing Options

In order to be able to satisfy the requirements and needs of all the potential music-on-demand e-service users and to directly generate a custom-made presentation of the musical manuscript on screen, the DMR offers a number of on-line interactive actions concerning the viewing options of the music score.

The musical manuscript layout and the transition between pages (screens) can be selected as on of the following:

- Static viewing. The user determines the desired number of staffs to fit on the screen as well as the desired number of measures to appear side by side on each staff (single staffs are used for music notation of musical instruments such as the violin, while grand/double staffs are used for musical instruments such as the piano; in the latter case, the grand staff is composed of the upper and lower staff, pertaining to the right and left hand, respectively). Provided that the selected layout is feasible, the first screen is presented to the user with the initial (and appropriately configured) measures of the manuscript; by pressing a certain key (e.g. PgDn/PgUp) the transition to next/previous screens of similarly configured measures is achieved. In order to avoid distortion, the measures are proportionally scaled (by equal amounts along the vertical and horizontal

direction); hence, in order to be feasible, the user's request must result in an easily readable configuration of measures and staffs on the screen. Static viewing is appropriate during musical instruction, as it allows the user custom-made layout of the musical manuscript as well as entire control over the transition to subsequent/previous screens.

- Automatic viewing. Further to the desired number of staffs and measures per staff (as in static viewing), the user determines the tempo with which the music score is to be played. Provided that the requested layout is feasible, the first screen of appropriately configured measures is presented to the user. The digital metronome is activated by pressing a certain key (e.g. Enter), whereby – and depending on the specified tempo - automatic transition to the next screen of similarly configured measures is made as soon as the time required for the on-screen measures to be played has elapsed. Automatic viewing is appropriate during musical rehearsal, as it not only allows custom-made layout of the musical manuscript, but it also provides the use of a metronome as well as automatic advancement to next screens according to the desired tempo, thus allowing the musician free use of his/her hands.
- Scrolling. The user determines the desired size of the measures on screen as well as the tempo with which the music is to be played. The digital metronome is activated by pressing a certain key, whereby consecutive measures of the selected manuscript slide smoothly on the center of the screen, concatenated and with horizontal direction from right to left; the speed of sliding is given by the tempo, as kept by the metronome. Scrolling can significantly aid visually impaired musicians by reducing the amount of head-turning and re-focusing necessary; tempo tuning allows instruction at any level of virtuosity and/or familiarity with the selected music score.

Additional services that enhance the aforementioned viewing options include:

- Selecting the color of the measures, notes and accompanying notation; picking the background color; adjusting the contrast and luminance. These options resemble the image processing capabilities of PortaNum.
- Pausing and resuming, simply by pressing a certain key (e.g. P).
- Adjusting the volume of the metronome.
- Opting for the appearance of a number over each measure. Numbering indicates the count of each measure relative to the first measure of the selected score (or part thereof) and enables the user to directly return/proceed to a given measure.
- Directly moving to a given measure of the score (via its number), to the beginning or end of the score, to the next/previous screen etc.
- Highlighting and/or providing musical accompaniment to the groups of notes currently played; this service is only available for automatic viewing and scrolling since it presupposes the use of the metronome.

The viewing options can be adjusted at any time during DMR operation.

4 DMR Implementation

The initial realization of the DMR is detailed next. The implementation characteristics are focused - on the one hand - upon pre-processing and storing the musical manuscript and – on the other hand – upon ensuring prompt communication with the user and satisfactory music-on-demand e-service.

4.1 Preprocessing and Storage

In order to store a music score, the musical manuscript corresponding to each musical instrument must be isolated. Subsequently, each musical manuscript is scanned and converted into digital form, one page at a time. Digitization is followed by segmentation of the staffs within each page and segmentation of the measures within each staff, keeping together upper and lower staffs in the case of grand staffs. The accompanying notation relating to the clef, time signature and accidentals is retained separately during staff segmentation; the same applies to the notation relating to dynamics. Each measure is stored separately in such a way that the order of measures within the staff as well as the order of staffs in the manuscript are preserved. This format allows custom-made reconstruction of the manuscript by concatenating successive files according to the user's viewing options. Figure 1 illustrates the aforementioned steps; (a) shows the digitized page of a musical manuscript, while (b) presents the result of segmenting the page into grand staffs for the fifth (last) grand staff; (c) demonstrates the result of segmenting the fifth grand staff of the page into measures for the second measure of the grand staff as well as the components that may also be necessary for on-screen viewing. If, due to the user's viewing options, the segmented measure is to appear first on a staff, the accompanying notation must be concatenated to the left of the measure. Furthermore, any dynamics notation must appear above the measure.

Some additional points concerning realistic on-screen presentation are worth mentioning:

- Measure segmentation must be accurately performed so that the bar line appears as a one-pixel-wide vertical line at either end of the measure, with no white space at either end. Double bar lines must be processed differently for the two measures involved: the double bar line must appear with a one-pixel wide vertical line at the left/right end of the following/preceding measure, again with no space at either end of the measure. Dotted bar lines must be ignored during segmentation.
- A certain amount of scaling may be necessary in order to unify the height of measures from different staffs. Scaling can be either proportional or along the vertical dimension only.
- During presentation, the clef, time signature and accidentals corresponding to a staff must appear to the left of the first measure of the staff; the same applies to the notation relating to dynamics, which must be shown on top of the implicated measure(s) (Fig. 1(c)).

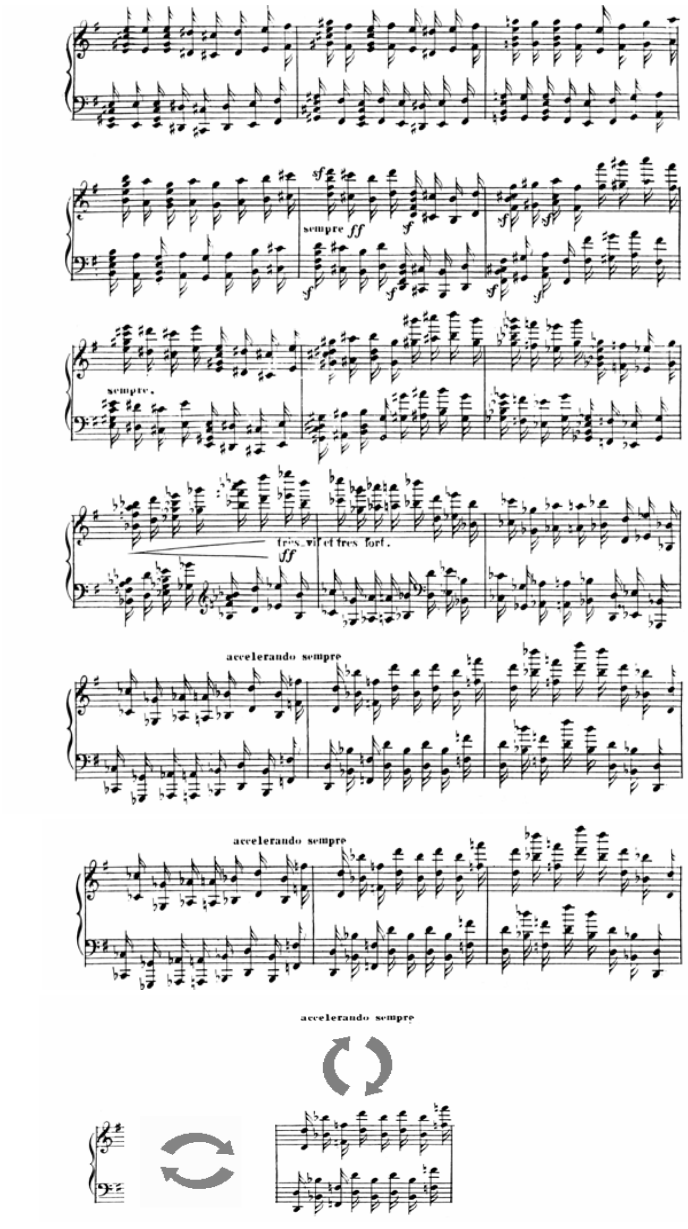

Fig. 1. Preprocessing and storage; digitized page (a), segmentation per grand staff (b); segmentation per measure, segmentation of accompanying notation and dynamics notation, desired reconstruction (c). Excerpt from "Douze Etudes – For Solo Piano", Op. 35, C.V.Alkan

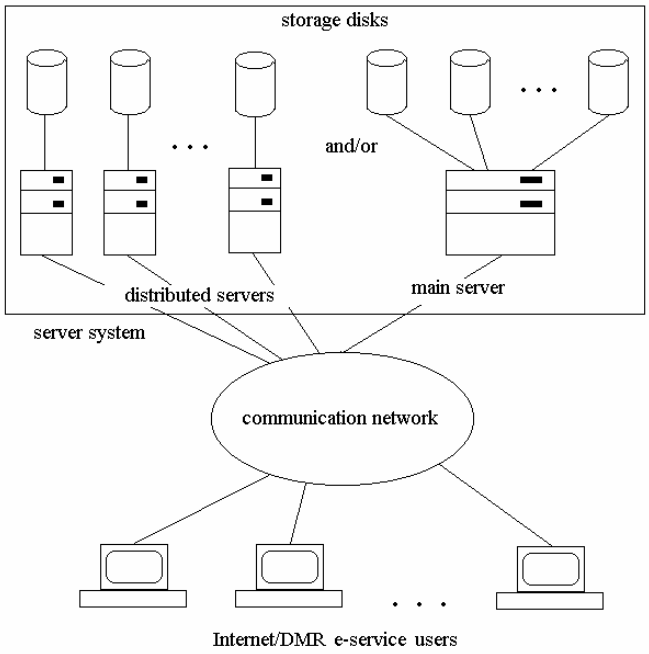

Fig. 2. DMR architecture

4.2 User Interface with the e-Service

Fig. 2 illustrates the implementation characteristics of the DMR music-on-demand e-service; clearly, the architecture is similar to that employed for video-on-demand [5-6] systems. A user (one of the computers at the bottom of Fig. 2) requests a given music score from the communication network (center of Fig. 2)), also specifying the musical instrument as well as the part of the manuscript in which (s)he is interested. The communication network relays the request to the server system (top part of Fig. 2) and the musical manuscript is retrieved from the appropriate server(s). Once configured according to the user's specifications by the server system, the manuscript is delivered – again through the communication network - to the user. The server system can comprise either distributed server configuration (leftmost top part of Fig. 2) or a a main (centralized, single) server (rightmost top part of Fig. 2). For the initial realization of the DMR, a single server makes up the communication network: such a configuration has been found sufficient for the small number of manuscripts and users involved at present.

5 Advantages – Future Directions

The DMR constitutes an economical and efficient means of handling musical manuscripts: a single scan/storage cycle of the music score suffices and there is no need to print, recopy or otherwise handle the music-sheet; additionally there is no wear-and-tear of the music score even after repeated playing.

Furthermore, the DMR facilitates musical practice of all groups of musicians (amateur and professional musicians as well as visually impaired musicians): the musician can directly acquire the desired music score, specify the passage to be viewed, isolate it and have it displayed on screen in a custom-made form; (s)he is allowed extra freedom during practice by not being obliged to use one hand in order to turn pages (screens); the musician can directly employ different configurations at different parts of the manuscript according to his/her current needs. Especially concerning the visually impaired musician, the problem of shadows is totally obliterated since illumination of the screen comes from within, while the requirement of employing a high degree of enlargement is easily accommodated for and can be instantly adjusted.

In terms of realization, and in order to ensure widespread acceptance, the DMR must increase its communication and disk capacity as well as provide low cost and quality of service to a multitude of concurrent users. The use of a distributed server configuration must be adopted, thereby offering:

- superior scalability, i.e. the availability of more music scores, the ability to serve concurrently more users requesting the same or different music scores under a variety of continually changing viewing options,
- robustness, i.e. no disruption in service (either in the speed of service or in the musical manuscripts that are available) when some of the servers fail or are under maintenance,
- access-time minimization, i.e. reduction in network delay and congestion.

Future research shall expand upon the development of accompanying software/hardware similar to the "set-up box" of Internet video-on-demand systems. This will be used not only as a buffer, signal decoder and screen-presentation timer concerning the information relayed from the communication network, but also for setting and adjusting the user's viewing options on his/her computer (rather than on the server system), thus reducing the traffic load imposed on the DMR.

Such a DMR realization will also render possible the synchronized presentation of the various musical manuscripts of a given music score, thereby showing the way to custom-made manuscript presentation during rehearsal and performance of orchestras. Since a full-sized orchestra (a) consists of more than one hundred musicians playing anywhere between eighteen to twenty-five different kinds of instruments, where (b) woodwind, brass, and percussion players play separate parts, whereby they need one music rest each while (c) string musicians sit in pairs and it is the duty of the musician farther from the audience to turn the pages of the shared music rest, the use of an ensemble of DMRs (supplemented with the aforementioned appropriately developed software/hardware) will:

- ease the burden of the musicians assigned with page turning, thus allowing them to have their hands free most (or all) of the time as well as obliterating the risk of incorrectly turning, mixing or dropping the pages,
- eliminate the problem of the wind blowing away or in any way mixing up the pages of the musical manuscripts during open-air concerts,
- give an elegant hi-tech touch to the proscenium of opera houses, concert halls etc.

In order to successfully synchronize the DMR ensemble, and rather than having all DMRs share the same digital metronome, it would be necessary to directly follow the conductor's tempo-setting as well as tempo variations; image processing may prove a viable tool for that.

6 Conclusions

The digital music rest music-on-demand e-service has been put forward as a novel and potentially superior means of reading music scores that can be used by any musician, for any music score and during any kind of musical activity. The digital-music-rest aims at totally replacing the music-rest/musical manuscript combination that constitutes the universal means of reading and playing music.

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