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HUMAN-IST
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On Optical Music Recognition : Using OMR techniques to retrieve and archive musical documents for windband

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1 Introduction

Nowadays, more and more professional and amateur musicians use tablets instead of paper to read partitions and music scores. With this in mind, the archiving of music is more and more numeric and score editors often provide directly pdf files instead of sending a paper version of their music. We currently are in a transition period where there is still paper music that should be dealt with.

As a musician myself and software developer. I created an application to store pdfs of the archives of my windband digitally. The bottleneck, timewise, is often the acquisition of data. To get pdf files, we must scan music scores that are printed on paper and manually select or split the sheets according to the voice or instrument that they are meant for. This application also helps in the distribution of the scores to the musician. All the work that had to be done manually by distributing pieces of paper to the right musician can now be done online and two music band are currently using this software with great returns.

Here is the step where OMR (Optical Music Recognition) can help us. The goal would be to extract the musical information on the sheets and get rid of the pdf format, to store only data. This would allow error correction, easy transposition and lighter storage.

The field of OMR is difficult to access for researchers, especially without musical background, as the notation has its codes and is not very intuitive for non-initiates. "OMR has not defined its goals with sufficient rigor to formulate its motivating applications clearly in terms of inputs and outputs." [2] But there are some "simple" problems that are close to solved. To reduce the field of research, we will focus on a specific category of music sheets, the scores for windband. This will exclude some other music notations, as guitar tab or specific symbols for strings, for example. This will also focus on monophonic music, as sheets for piano are not often found in windband literature[1].

In this project, a case study is performed to find a way to archive musical sheets. Prototypes will be built for wind band sheets, as this is the use case that is the most relevant based on my musical background, and also have quite simple[2] music sheets.

The work will evaluate existing OMR systems and build a metric to evaluate the classifiers. In an archiving use case, we want to achieve maximum accuracy and therefore need to have a good metric to evaluate the tools and push toward maximum confidence in data extraction accuracy.

[1] More and more windband scores have a piano part but is often playable without it. Once the prototype is working for monophonic sheets, piano could be a following step.

[2] Windband sheets are mainly monophonic and depict only one note at a time, in comparison to polyphonic sheets such as piano scores that are often composed of chords.

1.1 Overview

The aim of this project is to find an effective solution for the archiving of music scores, with a particular focus on windband sheets. As more and more musicians are using tablets to read music scores, archiving is becoming increasingly digitized. However, there is still a considerable amount of paper music that needs to be dealt with, which can be time-consuming and labor-intensive. To address this problem, the proposed solution is to use Optical Music Recognition (OMR) to extract musical information from paper scores and store them as digital data.

In this project, we will evaluate existing OMR systems and build a metric to evaluate their classifiers. The goal is to achieve maximum accuracy in data extraction, which is crucial for effective archiving. By evaluating the performance of existing OMR systems and developing a reliable evaluation metric, we aim to improve the accuracy of data extraction, specifically for windband scores.

The project will involve the development of prototypes for windband sheets, which are monophonic and typically depict only one note at a time, making them a good use case for OMR. By focusing on windband scores, we can develop a tool that is optimized for this specific use case, rather than attempting to build a one-size-fits-all solution.

The proposed solution has the potential to streamline the archiving process and make it more efficient, allowing musicians to spend less time on administrative tasks and more time on their music. Ultimately, the success of this project will depend on the accuracy and reliability of the OMR system and the effectiveness of the evaluation metric, which will be the focus of our research.

1.2 Research Questions

1. How do existing OMR systems perform when processing windband scores, and what factors contribute to their accuracy or limitations?
    - This question aims to investigate the current state-of-the-art in OMR systems for windband scores, and assess their performance in terms of accuracy and speed.
    - Factors that may contribute to the accuracy or limitations of OMR systems for windband scores include the quality of the input image, the complexity of the musical notation, the presence of noise or artifacts, and the choice of algorithms and parameters used for detection and recognition.
    - Possible approaches to answering this question include performing a systematic review of existing OMR systems, conducting empirical evaluations using benchmark datasets and metrics, and analyzing the impact of different factors on the accuracy and robustness of the systems.
2. What evaluation metrics are most appropriate for assessing the accuracy of OMR systems in the context of windband scores, and how can these metrics be used to compare different systems ?

- This question focuses on the development and selection of appropriate evaluation metrics for OMR systems that are tailored to the specific characteristics of windband scores.
- The choice of appropriate metrics will depend on the specific goals and requirements of the OMR application, and may involve trade-offs between different types of errors and performance criteria. This include reviewing existing evaluation metrics used in OMR research, comparing results against ground truth, and developing novel metrics that capture the specific aspects of windband scores.

3. How can machine learning techniques be applied to improve the accuracy of OMR systems for windband scores, and what features or preprocessing steps are most effective for this purpose?
    - This question aims to explore the potential of machine learning techniques, such as deep learning and convolutional neural networks, to improve the accuracy and robustness of OMR systems for windband scores.
    - Possible features and preprocessing steps that can be used to improve OMR accuracy include image enhancement, segmentation and grouping of symbols, feature extraction and selection, and integration of contextual and musical knowledge.
    - The choice of appropriate machine learning techniques and feature engineering strategies will depend on the specific characteristics of windband scores, such as the presence of articulation and expression markings and the use of different clefs and transpositions.
    - Possible approaches to answering this question include designing and training machine learning models on annotated windband score datasets, evaluating the performance of different feature extraction and selection techniques, and comparing the results with existing OMR systems.
4. What are the limitations of current OMR systems for windband scores, and how can these be addressed through algorithmic or computational improvements?
    - This research question aims to identify the current limitations of existing OMR systems when it comes to processing windband scores. Some possible limitations could include difficulty recognizing certain musical symbols, inaccuracies in pitch or timing, or the inability to process certain types of notation (such as percussion or extended techniques). By identifying these limitations, the research can help to guide the development of algorithmic or computational improvements that address these issues and improve the accuracy of OMR systems for windband scores.

2 Objectives and overview of the thesis

Based on the research questions outlined in the previous section, the main objective of this thesis is to investigate the potential for OMR systems to accurately extract musical information from windband scores. As noted, this is a challenging task due to the complex nature of music notation and the need for specialized knowledge in both music and computer science. By focusing on windband scores, we can limit the scope of the research and gain a deeper understanding of the specific challenges and limitations of OMR systems in this context.

The specific objectives of this thesis are as follows:

- To evaluate existing OMR systems and determine their performance when processing windband scores. This will involve analyzing a range of OMR tools and assessing their accuracy and limitations for monophonic windband scores.
- To develop and test a set of evaluation metrics that are appropriate for assessing the accuracy of OMR systems in the context of windband scores. This will involve comparing the performance of different OMR tools using a standardized evaluation framework.
- To investigate the potential for machine learning techniques to improve the accuracy of OMR systems for windband scores. This will involve developing and testing machine learning algorithms that are tailored to the specific characteristics of windband notation, and assessing their performance relative to traditional OMR tools.
- To identify the limitations of current OMR systems for windband scores and propose algorithmic or computational improvements that can address these limitations. This will involve analyzing the factors that contribute to errors in OMR systems and proposing strategies for reducing these errors through improved algorithms, better preprocessing steps, or other technical improvements.

By achieving these objectives, this thesis aims to contribute to the development of more accurate and effective OMR systems for windband scores. This has the potential to improve the accessibility of music archives, reduce the time and effort required to store and manage the logistics for sheet distribution.

3 Addressee

The proposed system for OMR improvement in windband scores has a direct application in the field of wind music. Wind music is popular in Switzerland, there are 1972 windband in Switzerland, with a total of 67'000 musicians[1], and 91 societies alone in the canton of Fribourg[3]. By improving the accuracy of OMR systems for windband scores, this research has the potential to directly benefit these musicians and their musical communities. The OMR system could help with the task of digitizing windband scores and make them more accessible and easier to manage.

4 Proceeding and Method

To achieve the objectives defined in the previous section, the proposed methodology consists of the following steps:

1. **Data collection**: We will collect a representative dataset of windband scores in digital format from various sources, including public libraries, music publishers, and online repositories. We will ensure that the dataset covers a wide range of composers, styles, and difficulty levels, while focusing on monophonic scores for wind instruments.
2. **Data preprocessing**: We will preprocess the collected dataset to improve the quality of the input for the OMR system. This will involve several steps, such as cleaning the images, normalizing the orientation and size of the pages, and segmenting the individual parts of the score.
3. **Evaluation metrics**: We will define appropriate evaluation metrics for the accuracy of the OMR system in the context of windband scores. This will involve selecting suitable performance indicators, such as note recognition rate, timing accuracy, and testing the system on a validation set.
4. **Baseline system**: We will implement a baseline OMR system for windband scores, based on existing open-source tools and techniques. This will serve as a reference point for evaluating the performance of the proposed improvements.
5. **Machine learning models**: We will explore different machine learning techniques to improve the accuracy of the OMR system. We will train and test these models on the preprocessed dataset and evaluate their performance against the baseline system.
6. **Prototype development**: We will develop a prototype OMR system for windband scores, incorporating the best techniques and methods identified in the previous steps. The system will be designed to be user-friendly and adaptable to different input formats and music styles.
7. **Testing and validation**: We will test and validate the prototype system on a large dataset of windband scores, including both synthetic and real-world examples.
8. **Analysis and discussion**: We will analyze the results of the testing and validation phase and discuss the strengths, limitations, and implications of the proposed system. We will also discuss potential future research directions and applications for the system.

The methodology described above is iterative and cyclical in nature, meaning that each step will inform and refine the subsequent steps. The final output of the methodology will be a functional prototype OMR system for windband scores, with improved accuracy and efficiency compared to existing systems.

4.1 Activities

1. Collect a representative dataset of windband scores in digital format from various sources.
2. Preprocess the collected dataset to improve the quality of the input for the OMR system.
3. Define appropriate evaluation metrics for the accuracy of the OMR system in the context of windband scores.
4. Implement a baseline OMR system for windband scores, based on existing open-source tools and techniques.
5. Explore different machine learning techniques, such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), and deep belief networks (DBNs), to improve the accuracy of the OMR system.
6. Investigate algorithmic and computational improvements to the OMR system, such as better image processing methods, more efficient data structures, and parallel computing techniques.
7. Develop a prototype OMR system for windband scores, incorporating the best techniques and methods identified in the previous steps.
8. Test and validate the prototype system on a large dataset of windband scores, including both synthetic and real-world examples.
9. Analyze the results of the testing and validation phase and discuss the strengths, limitations, and implications of the proposed system.
10. Discuss potential future research directions and applications for the system.

Please note that these activities are not necessarily sequential, and some activities may be performed simultaneously or iteratively as the project progresses.

4.2 Time Schedule

ToDo:

Phase	Task description	Progress	Plan start	Plan end	Plan days

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6 References

References

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[3] SCMF. Liste des sections - sektionenliste.