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Automatic Braille Music Score Conversion to Playable Music using Image Processing

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Abstract:

Braille music score is a Braille code that allows music to be notated using Braille cells so that music can be read by visually impaired musicians. It uses the same six-position Braille cell as literary Braille but has entirely separate meaning to each braille symbol or group of symbols and has its own syntax and abbreviations. Thus it makes it difficult for the reader to learn the Braille music. Hence, we propose a system that converts Braille sheet music to playable audio in Musical Instrument Digital Interface (MIDI) format. This involves a series of image processing techniques to enhance the Braille dots and reduce the noise. These are then mapped to a set of musical notes in the form of Octaves which are converted to MIDI format by Optical Music Recognition (OMR). The output can either be sent to music editor software to edit or retrieve music information or can be played in MIDI format depending upon the user's choice. Thus, the proposed system allows visually impaired and vision musician society to easily learn braille music scores.

Keywords— **Braille music, Image processing, MIDI, Optical music recognition**

I. INTRODUCTION

The Braille music system was originally developed by Louis Braille that aids visually impaired musicians to read and write musical scores in Braille notations. It is completely independent and well-developed notation system with its own conventions and syntax. The world's largest collection of braille music is located at the National Library for the Blind, in Stockport, UK. However, many visually impaired musicians require a good deal of music that has never before been transcribed to braille music. It uses the same six-position Braille cell as literary Braille but has entirely separate meaning to each braille symbol or group of symbols and has its own syntax and abbreviations. Thus it makes it difficult for the reader to learn the Braille music. Hence, we propose a system that converts the braille sheet music into playable instrumental music.

The output can either be sent to music editor software to edit or retrieve music information or can braille music for both visually impaired and vision musician society.

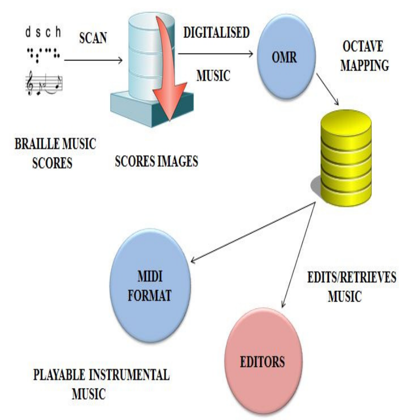

Fig. 1 Architecture Diagram

II. DIGITIZATION OF MUSIC SHEET

The Braille music sheet is given as input to the system as the first step to digitize Braille music sheet using image processing. Braille music sheet can either be captured in a camera using Raspberry pi or scanned using normal flatbed scanner. Optical scanners can also be used, which generally consist of a transport mechanism and a sensing device to converts into gray levels. Digitizing music transposes the piece into a different key, changes parameter such as tempo and instrument voices will also be desirable features in any sort of musical application.

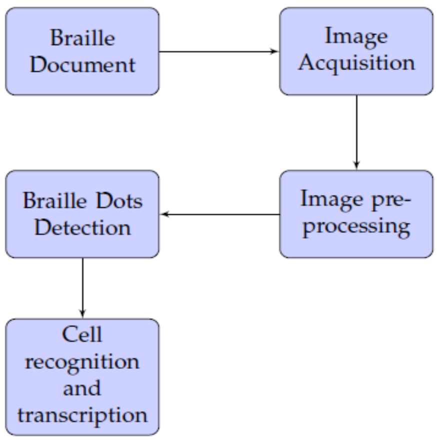

Fig. 2General Processing for Braille Scripts [3]

A. Image pre-processing

The aim of image pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing. It is a series of conversions applied on the captured image. This includes cropping, gray scaling, thresholding, erosion and dilation to find the embossed Braille notes, enhance the braille dots and reduce the noise. The main advantages of using computers for the processing of images are: flexibility, adaptability, data storage and transmission.

1)Gray scaling and thresholding

Grayscale images are distinct from one-bit bi-tonal black-and-white images, which in the context of computer imaging are images with only the two colors, black, and white which is also called bi-level or binary images. Gray scaling is used to convert the original image that still has the RGB color scale into grayscale images. The grayscale intensity will be stored as an integer value of 8-bit which has 256 possible different shades of gray from black to white [13]. Thresholding is the process of converting an image into pure black and white image (binary image).It consists of pixels that are either black or white in color.

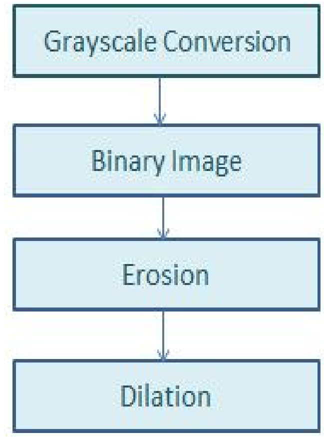

Fig . 3 Image Preprocessing steps [8]

2) Erosion and Dilation

Erosion is used to reduce the noise in the image by a process that minimizes the black area dot and remove noise from the braille image. Dilation enhances the image after noise reduction by a process that enlarges back the black dot on image braille. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. The state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbours in the input image. The rule used to process the pixels defines the operation as dilation or erosion [14]. In dilation, the value of the output pixel is the maximum value of all the pixels in the input pixel's neighbourhood. In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1. In erosion, the value of the output pixel is the minimum value of all the pixels in the input pixel's neighbourhood. In a binary image, if any of the pixels is set to 0, the output pixel is set to 0[14].

B. Braille Dots Recognition and Transcription

Braille dots recognition is based on the relative position of the dots on the sheets.The standard size of the sheets and the dots are taken into consideration and they are recognized by using coordinate system in pixel values.A standard Braille page is 11 inches by 11.5 inches and typically has a maximum of 38 to 40 Braille cells per line and 25 to 28 lines [3]. After the dots recognition in their coordinates, these dots are digitized.

- Each braille cell box has a value 1 or 0.
- For 1, box is filled in black indicating the presence of a dot.
- For 0, the box does not contain the dot and it is empty.

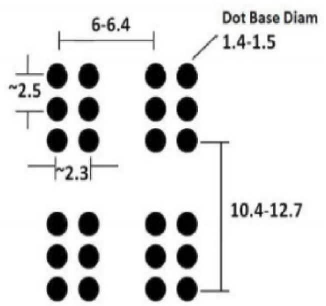

Fig. 4 Representation of Braille cells and their dimension[15]

III. MAPPING MUSIC NOTATIONS TO OCTAVES

Musical notes are in the form of octaves, units of seven notes. An Octave is an interval between one musical pitch and another with half or double its frequency. The most important musical scales are typically written using eight notes, and the interval between the first and last notes is an octave. It is possible to have the same note name but in several different octaves.It serves the purpose of representing the same note as seen in the various octaves in Braille music.

For such notes, it is notated in 6 dot braille script. To differentiate between the music note and normal literary script, a specific kind of prefix is used to differentiate them. It makes it easy for the reader to differentiate the interpretation if the script.

In the transcription process, important details such as clef signs, accidentals (sharp/flat/natural), hand, fingering, octave, music notes, intervals, slur, tie, grouping, triplets are taken into consideration.

These details are directly mapped to create a music string. This music string is used in a particular format such that it can be processed in Java using JFugue v.5.05 external .jar library. This JFugue allows a music string to be played in Java player and convert it MIDI format file as well. A few examples of transcription are as shown.

IV. TRANSCRIPTION OF BRAILLE SCORES TO JFUGUE MUSIC STRING

Every detail in music score is represented by a particular character or group of characters in JFugue music string. The aim of generation of music string through appropriate transcription is the important aspect.

The clef signs – treble and bass are represented as different Voices in JFugue such that they can be played at the same time. Since, it is the music string that is going to generate music, no transcription is required for the hand and the fingering denoted in music sheet.

Example: G clef maybe mapped as voice "V0", F clef as "V1" and so on[9]

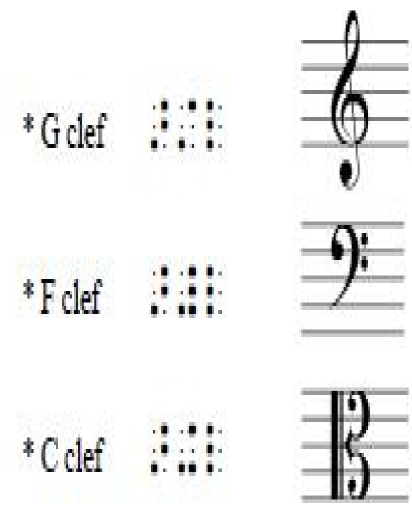

Fig.4 Representation of Clef signs[10]

The music notes C,D,E,F,G,A,B are represented in capital letters,followed by octave (1,2,3,4,5,6,7), followed by the corresponding note length(whole notes –w, half note –h, quarter note–q, eighth – i, 16th note –s, 32nd note – t, 64th note –x, 128th note – o). Hence "C4q" denotes quarter note C in fourth octave[9].

The interval is a way of playing two or more notes at the same time.It is represented by the music note followed by the number of halfs reduced from that music note in Braille transcription. Suppose the music note E of octave 4 and the value followed after it is 2, then it plays, E quarter in octave 4 and C quarter in octave 4 at the same time. This is denoted by "E4q+C4q", where "+" denotes "playing at the same time" in JFugue.

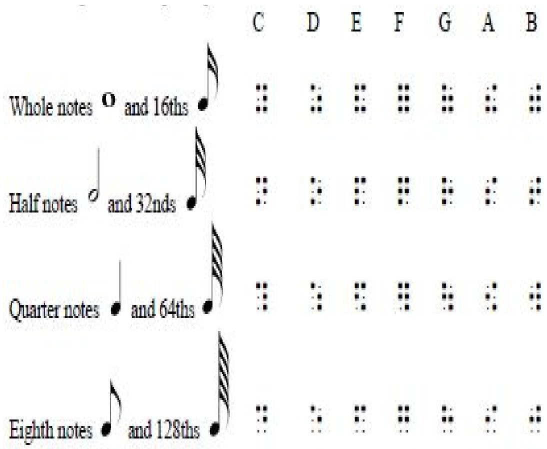

Fig.5 Representation of music notes in Braille[10]

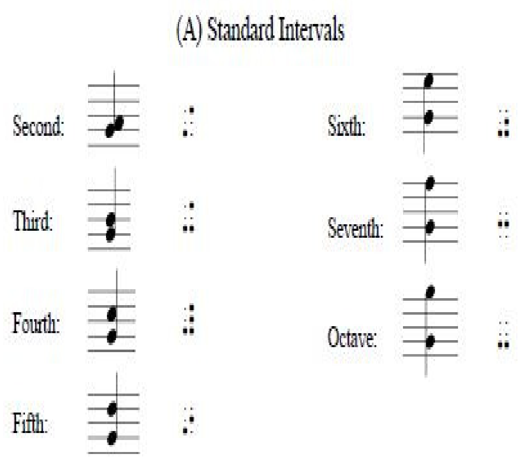

Fig.6 Representation of Intervals[10]

The tie is a way of playing same note continuously without a gap in between. It can be represented in JFugue by simply rewriting the note length of the music note. For example, if the note “D5q” has a tie, then it is represented as “D5qq”. JFugue also allows denoting the music notes in MIDI note value. That is, instead of C4, we can use [48] to represent it

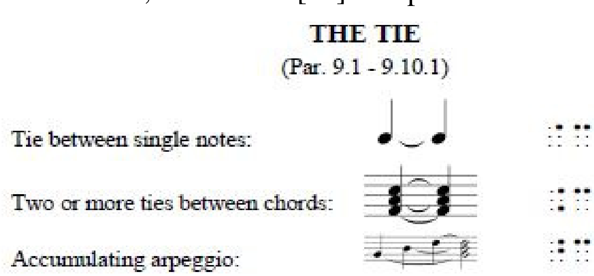

Fig.7 Representation of tie[10]

V. CONVERSION TO MIDI FORMAT

Musical Instrument Digital Interface (MIDI) is a technical standard that describes a protocol, digital interface and connectors and allows a wide variety of electronic musical instruments, computers and other related devices to connect and communicate with one another. JFugue allows a music string that is stored as the type “String” to convert it into a MIDI file. It can be done by using the code:

```
Pattern p1=new Pattern (new String (“C5q E4hh A4s+B4s”));
MidiFileManager.savePatternToMidi
((PatternProducer) p1, new File ("playfile.mid"));
```

	Notes											
Octave Number	C	C#	D	D#	E	F	F#	G	G#	A	A#	B
0	0	1	2	3	4	5	6	7	8	9	10	11
1	12	13	14	15	16	17	18	19	20	21	22	23
2	24	25	26	27	28	29	30	31	32	33	34	35
3	36	37	38	39	40	41	42	43	44	45	46	47
4	48	49	50	51	52	53	54	55	56	57	58	59
5	60	61	62	63	64	65	66	67	68	69	70	71
6	72	73	74	75	76	77	78	79	80	81	82	83
7	84	85	86	87	88	89	90	91	92	93	94	95
8	96	97	98	99	100	101	102	103	104	105	106	107
9	108	109	110	111	112	113	114	115	116	117	118	119
10	120	121	122	123	124	125	126	127				

Fig.8 Numeric note value – MIDI note’s value

VI. EXPERIMENTAL RESULT

The output results of the proposed system can either be sent to music editor software to edit or retrieve music information or can be played in MIDI format depending upon the user’s choice. The input to the system for image acquisition is a Braille sheet music which can be inputted using either a flatbed scanner or can be captured in a camera using Raspberry pi. Gray scaling converts the captured image into grayscale images that do not differentiate how much we emit the different colors, but can differentiate the total amount of emitted light for each pixel; little light gives dark pixels and much light is perceived as bright pixels. Image processing is shown on a sample braille script(Russian Braille)[7].

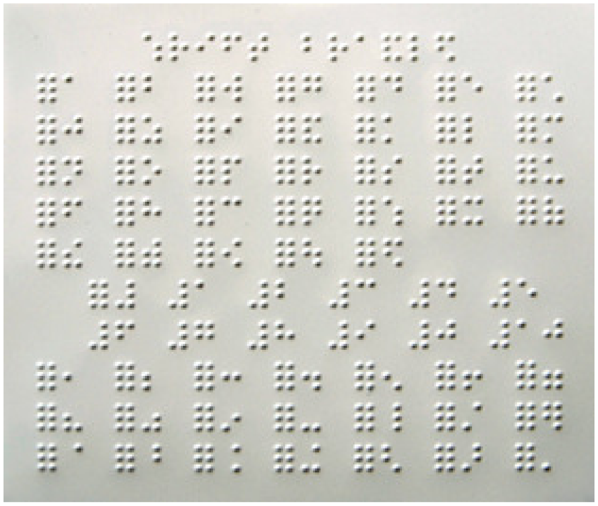

Fig. 9 Sample Braille Script

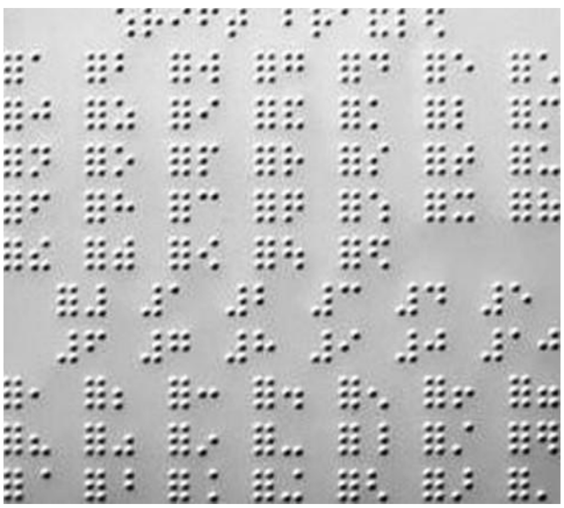

Fig. 10 Grayscaling of Captured Braille script

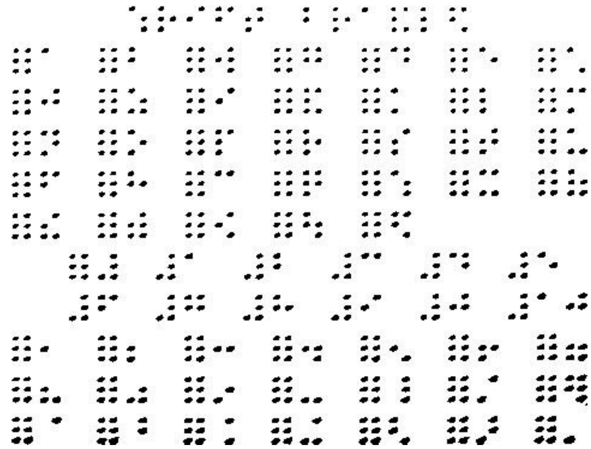

Fig. 11 Thresholding of Braille script

After gray scaling process the image is further processed to reduce maximum amount of noise gained by various image acqusition techniques by the morphological image processing - erosion and dilation.

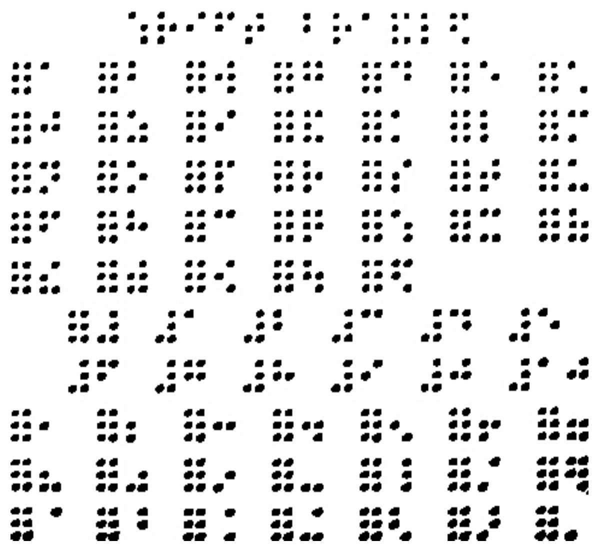

Fig. 12 Erosion and Dilation of Braille script

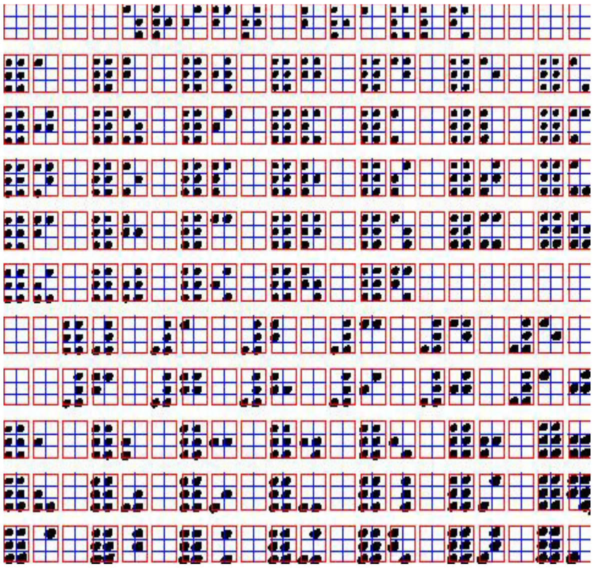

Fig. 13 Braille dots and cell recognition

Braille dots detection,cell recognition and transcription is purely based on the coordinate position of these dots. The relative position of these cells and dots are generally considered in pixels. These dots are later digitized based on the presence or absence of dots in each cell.The digitized image of the Braille sheet music shows the presence of dots with filled cells representing 1 and absence of dots by unfilled cells representing 0 and are mapped to corresponding octaves to play it in MIDI format.

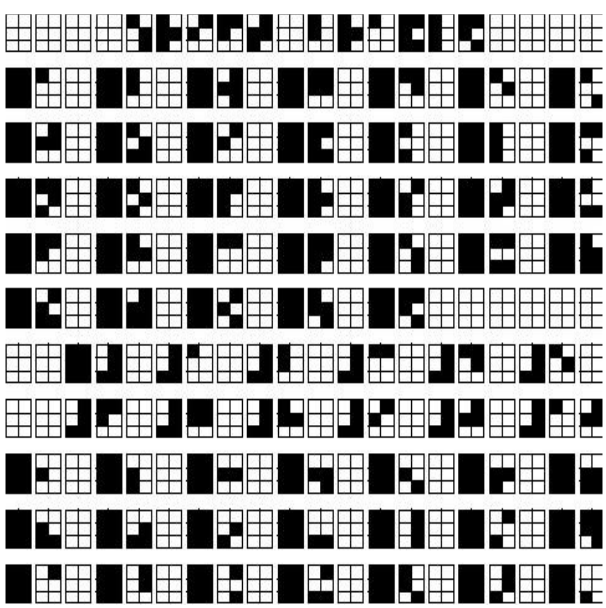

Fig. 14 Digitized Braille script-Detecting presence of dots.

Fig. 15 Player that plays Braille Music score in MIDI format

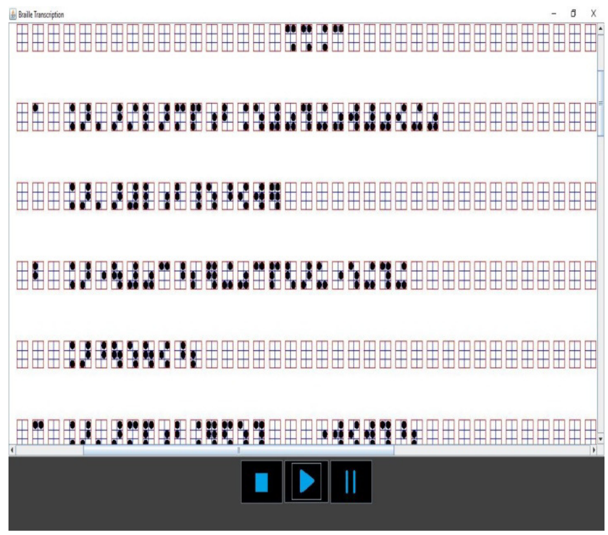

Fig. 16 Final UI representation of the music transcription [11]

VII. CONCLUSION

Automatic Braille music score conversion reduces the complexity of learning Braille music for both visually impaired and vision musician society. Thus the system transcribes various Braille music scores into ordinary music by automatically converting a Braille sheet music into playable instrumental music using image processing technique. The output results of the proposed system can either be sent to music editor software to edit or retrieve music information further or can be played in MIDI format depending upon the user's choice. It also provides better enhancement to the user experience by having compatibility across different operating systems.

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