

REAL-TIME GUITAR STRING DETECTION FOR MUSIC EDUCATION SOFTWARE

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ABSTRACT

In this paper, we present a novel approach to real-time detection of the string number and fretboard position from polyphonic guitar recordings. Our goal is to assess, if a music student is correctly performing guitar exercises presented via music education software or a remote guitar teacher. We combine a state-of-the-art approach for multi-pitch detection with a subsequent audio feature extraction and classification stage. Performance of the proposed system is evaluated with manually annotated chords recorded using different guitars.

Index Terms—multiple fundamental frequency estimation, string classification, fretboard position, fingering, electric guitar, inharmonicity coefficient, tablature

1. INTRODUCTION

Over the past few years, there have been several new software products that promise to enhance learning a musical instrument by means of assistive software. Acoustic or electric guitars are often the main supported instrument due to their popularity among starters. On the one hand, there are gaming oriented applications such as RockSmith¹, RockProdigy², GuitarBoos³, Songs2See⁴, Jamstar⁵, and BandFuse⁶. They rely on game mechanics inspired by popular music video games such as GuitarHero⁷ or RockBand⁸. That means, the user plays along to a song while playing instructions are presented on screen in sync to music. In contrast to GuitarHero and RockBand, the above mentioned applications allow the user to play real acoustic or electric guitars instead of guitar-shaped plastic controllers. The opposite is done in applications such as FretLight⁹ or GTar¹⁰. Here, the user has to play along to a given song or short exercise on a modified guitar with LEDs lighting up the sequence of strings and frets that are to be played. In the case of FretLight, the playing instructions are usually generated in real-time by a remote guitar teacher. Moreover, there are online services like SoundSlice¹¹ and YouTab¹² that enable users to create and publish so called guitar tabs synced with the corresponding song or video. Guitar tabs are short for tablature notation, which is probably the most popular music notation



Fig. 1. Score and tablature representation of the first bars from Eric Clapton's Layla. The six horizontal lines in the tablature correspond to the six strings with the tuning E2, A2, D3, G3, B3, E4 (from bottom to top). The numbers correspond to the fret numbers on the strings that are to be played.

format among guitarists. The tablature is based on the geometry of fretted string instruments. It specifies the string and fret number for each note and thus resolves the ambiguity between note pitch and fretboard position. The guitarist can immediately see where he has to place his fingers on the strings and frets (so-called fingering). Figure 1 illustrates the correspondence between common music notation and tablature for the guitar. Large amounts of guitar tabs are already available on the internet. However, since most of them are created by amateurs, these tablatures are often incomplete and erroneous. The first application scenario for the method presented here is the semi-automatic extraction of tablatures by means of automatic transcription and string detection from guitar recordings. Secondly, for a remote guitar teacher, it would be helpful to have his playing on a real instrument translated in real-time to corresponding playing instructions for the student. The third application scenario is to assess, if the guitar student is truly following the given playing instructions by means of real-time detection of played notes and strings.

2. GOALS & CHALLENGES

As introduced in Section 1, our goal is to estimate the notes and string number α_i from monophonic and polyphonic (monotimbral) recordings of electric guitars. Based on the note pitch and the string number, we can apply knowledge about the instrument tuning in order to derive the fret number α_f . The first challenge is to get a good real-time estimate of the notes being played. Since we focus on the electric guitar, frequencies between 82.40 Hz and 659.25 Hz need to be investigated as potential f_0 -candidates¹³. The second challenge is the selection of suitable audio features that allow to discriminate between different strings. The automatic classification of the played string poses a challenging task since the physical differences

¹<http://rocksmith.ubi.com/>

²<http://www.rockprodigy.com/>

³<http://ovelin.com/guitarboos/>

⁴<http://www.songs2see.com/>

⁵<http://jamstar.co/>

⁶<http://bandfuse.com/>

⁷<http://ubi.guitarhero.com/>

⁸<http://www.rockband.com/>

⁹<http://www.fretlight.com/>

¹⁰<http://www.incidentgtar.com/>

¹¹<http://www.soundslice.com/>

¹²<http://www.you-tab.com/>

¹³This corresponds to the most common guitar string tuning E2 to E4, and a fret range up to the 12th fret.

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**Alexander Refsum Jensenius, Michael J.
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Springer Handbook of Systematic Musicology Rolf Bader, 2018-03-21 This unique reference book offers a holistic description of the multifaceted field of systematic musicology which is the study of music its production and perception and its cultural historical and philosophical background The seven sections reflect the main topics in this interdisciplinary subject The first two parts discuss musical acoustics and signal processing comprehensively describing the mathematical and physical fundamentals of musical sound generation and propagation The complex interplay of physiology and psychology involved in sound and music perception is covered in the following sections with a particular focus on psychoacoustics and the recently evolved research on embodied music cognition In addition a huge variety of technical applications for professional training music composition and consumer electronics are presented A section on music ethnology completes this comprehensive handbook Music theory and philosophy of music are imbedded throughout Carefully edited and written by internationally respected experts it is an invaluable reference resource for professionals and graduate students alike

Exploring Music Contents Solvi Ystad, Mitsuko Aramaki, Richard Kronland-Martinet, Kristoffer Jensen, 2011-09-15 This book constitutes the thoroughly refereed post proceedings of the 7th International Symposium on Computer Music Modeling and Retrieval CMMR 2010 held in M laga Spain in June 2010 The 22 revised full papers presented were specially reviewed and revised for inclusion in this proceedings volume The book is divided in five main chapters which reflect the present challenges within the field of computer music modeling and retrieval The chapters range from music interaction composition tools and sound source separation to data mining and music libraries One chapter is also dedicated to perceptual and cognitive aspects that are currently subject to increased interest in the MIR community

The Oxford Handbook of Music Performance Gary McPherson, 2022 The two volume Oxford Handbook of Music Performance provides the most comprehensive and authoritative resource for musicians educators and scholars currently available It is aimed primarily for practicing musicians particularly those who are preparing for a professional career as performers and are interested in practical implications of psychological and scientific research for their own music performance development educators with a specific interest or expertise in music psychology who will wish to apply the concepts and techniques surveyed in their own teaching undergraduate and postgraduate students who understand the potential of music psychology for informing music education and researchers in the area of music performance who consider it important for the results of their research to be practically useful for musicians and music educators

Sound, Music, and Motion Mitsuko Aramaki, Olivier Derrien, Richard Kronland-Martinet, Sølvi Ystad, 2014-12-04 This book constitutes the thoroughly refereed post conference proceedings of the 10th International Symposium on Computer Music Modeling and Retrieval CMMR 2013 held in Marseille France in October 2013 The 38 conference papers presented were carefully reviewed and selected from 94 submissions The chapters reflect the interdisciplinary nature of this conference with following topics augmented musical instruments and gesture recognition

music and emotions representation recognition and audience performers studies the art of sonification when auditory cues shape human sensorimotor performance music and sound data mining interactive sound synthesis non stationarity dynamics and mathematical modeling image sound interaction auditory perception and cognitive inspiration and modeling of sound and music computational musicology Music Apps for Musicians and Music Teachers Elizabeth C. Axford, 2015-02-19 In today's digital age learning and creating music has never been so easy and affordable Anyone can enhance their musical knowledge skills and creativity with the multitude of music apps available However sifting through thousands of music apps in the Apple App Store and Google Play can be a daunting task for any musician or music instructor But not anymore Having spent countless hours researching the most interesting useful educational fun and easy to use music apps Elizabeth C Axford in Music Apps for Musicians and Music Teachers surveys the landscape of music related apps for both iOS and Android mobile devices including tablets and smartphones Music Apps for Musicians and Music Teachers lists hundreds of music related apps organized by category including singing musical instruments music theory and composition songwriting improvisation recording evaluating music performances listening to music music history and literature music appreciation and more App developers are listed with each app including links to their websites for updates and support The book sections and chapters align with the newly revised National Standards for Music Education released in 2014 by the National Association for Music Education Suggested activities for educators are provided as well as key terms and a bibliography Music Apps for Musicians and Music Teachers is for anyone interested in music whether hobbyist or professional It enhances the ability to learn on the go by offering musicians music students and music instructors a list of the most useful music apps available Billboard ,2011-04-02 In its 114th year Billboard remains the world's premier weekly music publication and a diverse digital events brand content and data licensing platform Billboard publishes the most trusted charts and offers unrivaled reporting about the latest music video gaming media digital and mobile entertainment issues and trends

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Yamasaki, 2024-12-31 This five volume set LNCS 15520 15524 constitutes the proceedings of the 31st International
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selected papers from the Cross Disciplinary Perspectives on Expressive Performance Workshop held within the framework of
CMMR 2012 **The Instrumentalist** ,1973 **Computergestützte Archivierung von Tonträgern** Rolf

Bader, 2024-10-29 Die Zukunft der Musikarchivierung und der Suchmaschinen liegt im Deep Learning und in Big Data
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