Preservation of Gagaku in the Digital Age

Structuring Traditional Notation for Computational Analysis and Data Integration

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Outline

1. Background and Motivation
2. Introduction to Gagaku
3. Gagaku Notation & Method for Digitizing
4. Preliminary Data Analysis
5. Future Prospects & Conclusion

Background and Motivation

Background: Why is Digitalization Necessary?

- Digital imaging of scores has progressed.
- However, image alone cannot be machine-processed.

Structured data is essential for computational analysis and to analyze a volume of data beyond human capacity.

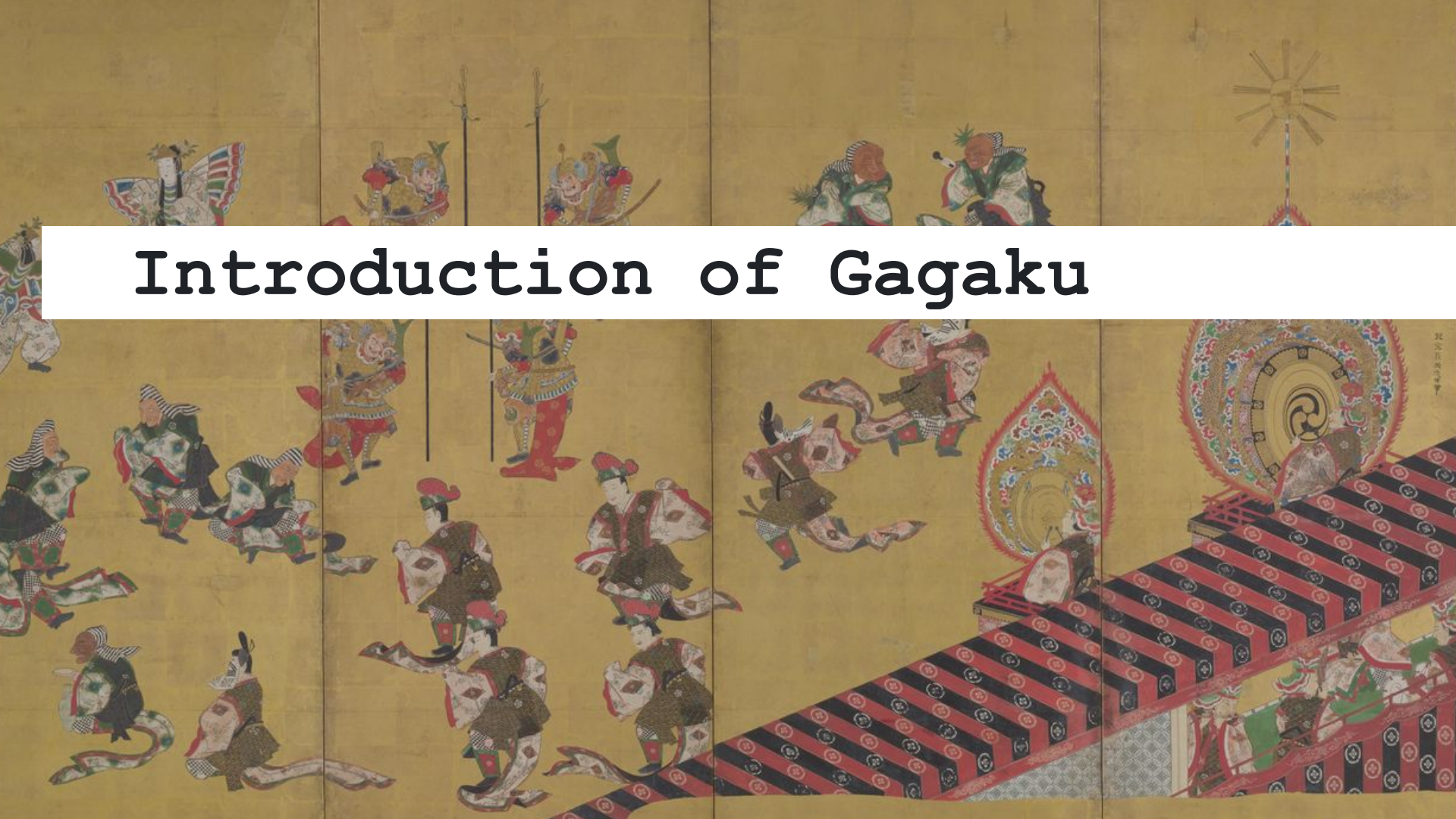
Research Objectives

1. To establish a methodology for digitizing Gagaku scores as structured data.

2. To attempt statistical analysis based on the digital scores.
    - Focus on the usage trends of characters used in the scores.

3. To build a hub connecting multiple Gagaku-related materials: connecting multimedia materials such as other scores, videos, and audio, centered around one score.

Introduction of Gagaku



What is Gagaku?

Ancient Japanese Traditional Music originating over 1000 years ago.

Performed at imperial ceremonies, religious events, and as a hobby of the nobility.

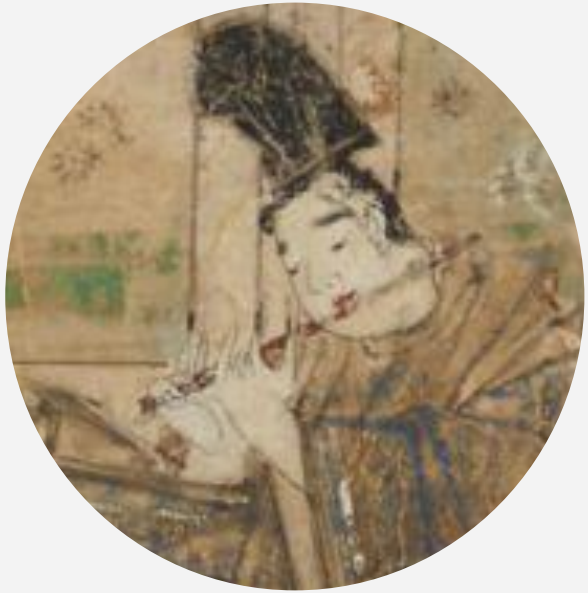
Detached Segment of Illustrated Scroll of Love Affair of Courtier and Girl at Sumiyoshi (Kamakura period, 13th century), Tokyo National Museum
《住吉物語絵巻断簡》（鎌倉時代，13世紀）東京国立博物館

Instruments in Gagaku

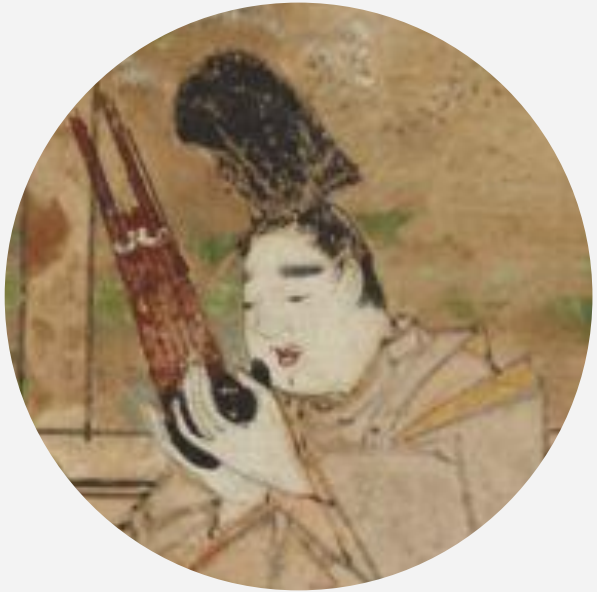
Instruments in Gagaku

Instruments:the Winds

Hichiriki
[篳篥]

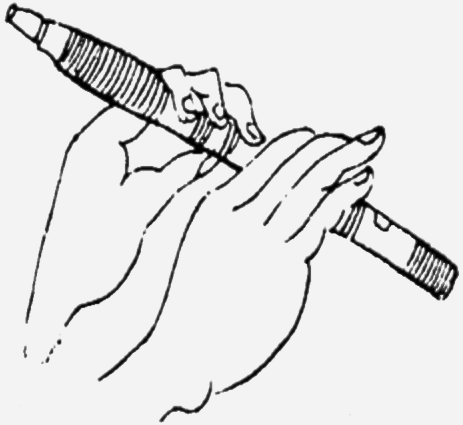


Ryuteki
[龍笛]

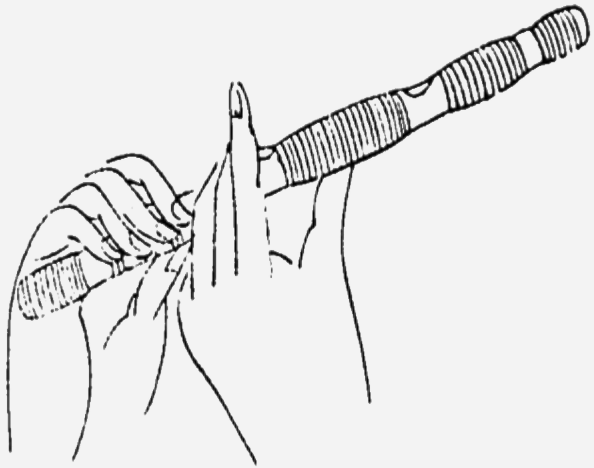


Sho
[笙]

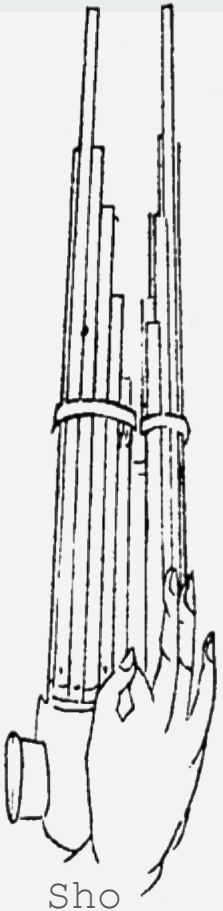
Instruments:the Winds



Hichiriki
[篳篥]



Ryuteki
[龍笛]



Sho
[笙]

Instruments:the Strings

Biwa[琵琶]

Gakuso[楽箏]

Instruments:the Strings

Biwa[琵琶]

Gakuso[楽箏]

Instruments:the Drums

Shoko
[鉦鼓]

Kakko
[鞨鼓]

Taiko
[太鼓]

Instruments:the Drums

Shoko
[鉦鼓]

Kakko
[鞨鼓]

Taiko
[太鼓]

Types of Performance

- Instrumental ensemble
- Music with dances
- Songs

Types of Performance:Instrumental Ensemble

Types of Performance:Instrumental Ensemble

《舞楽楽器之図》(江戸時代, 1815), 狩野伊川院？, 振鉾, 東京国立博物館研究情報アーカイブズ , 一部加工, https://webarchives.tnm.jp

Types of Performance:Dances

春日権現験記絵（模本）巻第二 本文8-9 冷泉為恭他 (模) 東京国立博物館所蔵
https://webarchives.tnm.jp/imgsearch/show/E0049746

Types of Performance:Dances

舞楽図 左, 高島千春, 北爪有郷 筆, 芸艸堂, 国立国会図書館デジタルコレクション, 一部加工, https://dl.ndl.go.jp/pid/1885985/1/1

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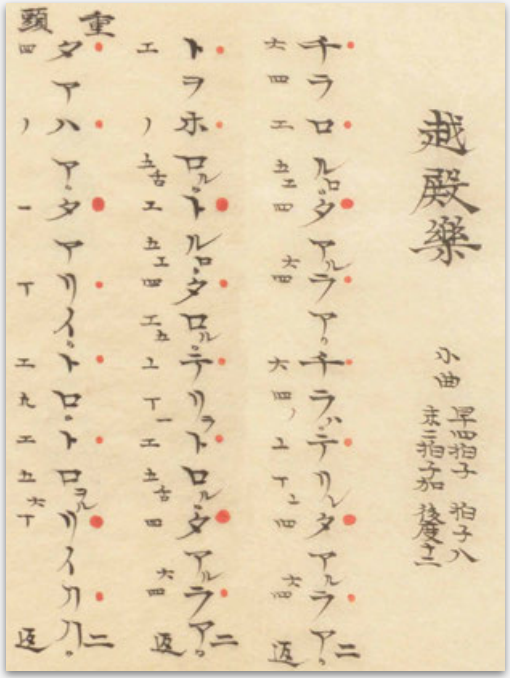
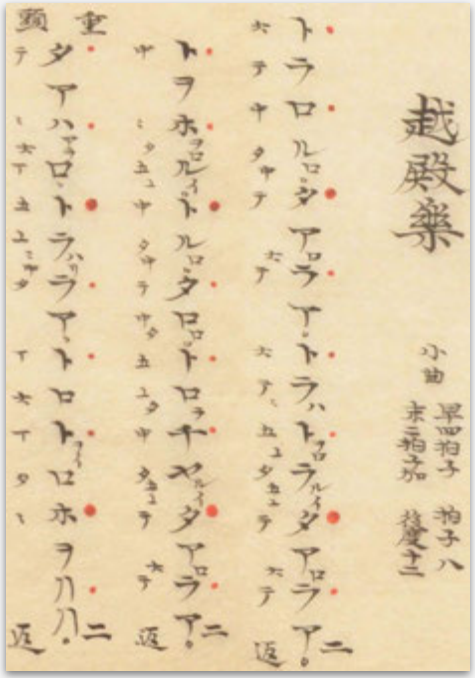
舞楽楽器之図 , 狩野伊川院？, 部分9, 東京国立博物館研究情報アーカイブズ ，一部加工 , https://webarchives.tnm.jp

Gagaku Notaion

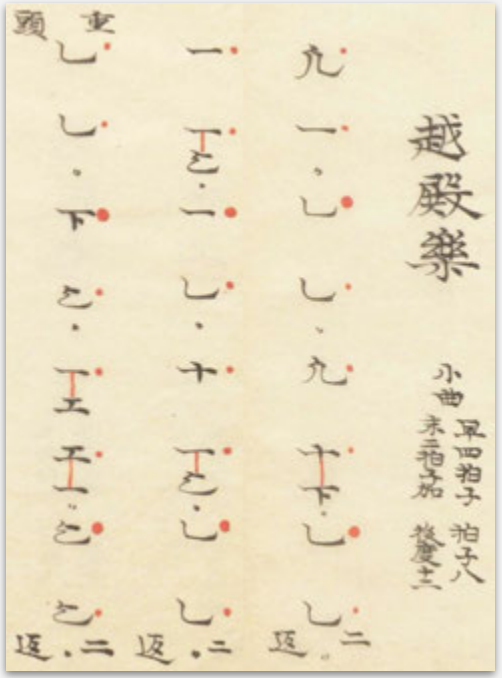
Gagaku Score:the Winds



Hichiriki
[篳篥]



Ryuteki
[龍笛]

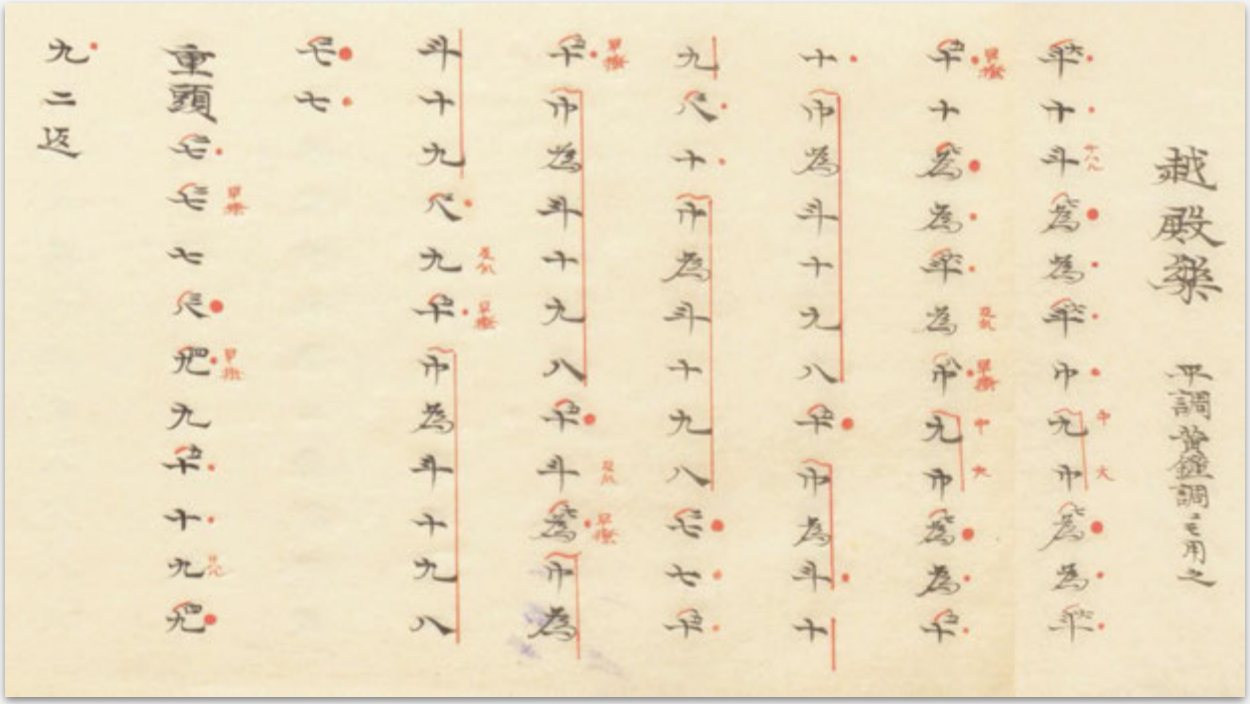


Sho
[笙]

Gagaku Score:the Strings

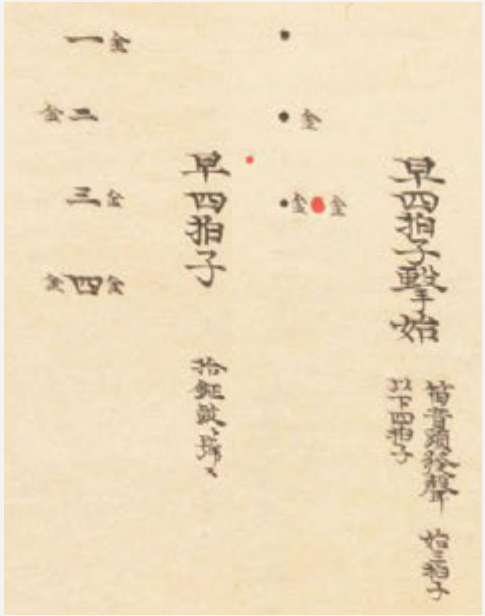
Biwa
[琵琶]

Gagaku Score:the Strings

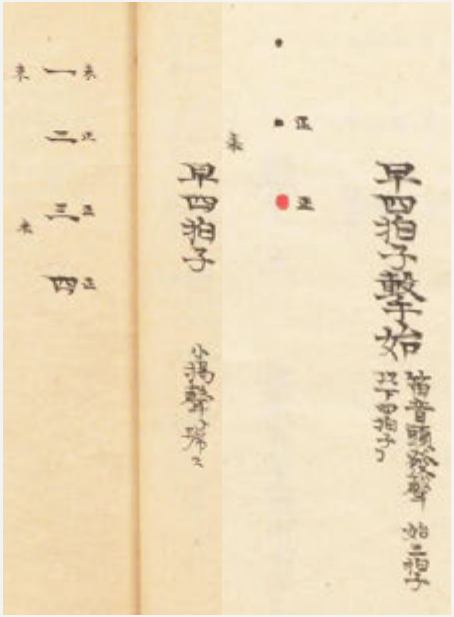


Gakuso
[楽箏]

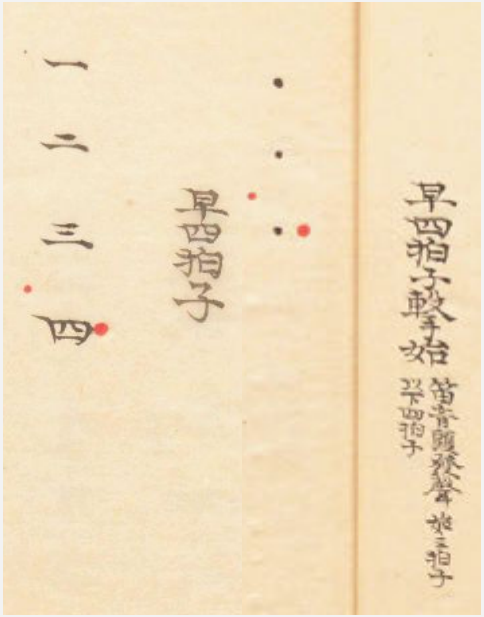
Gagaku Score:the Drums



Shoko
[鉦鼓]

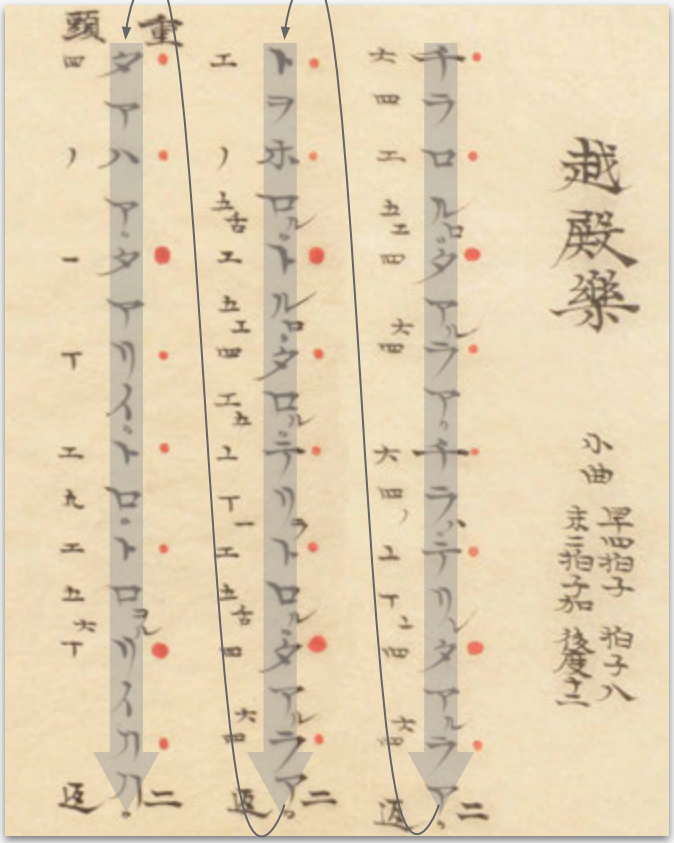


Kakko
[鞨鼓]

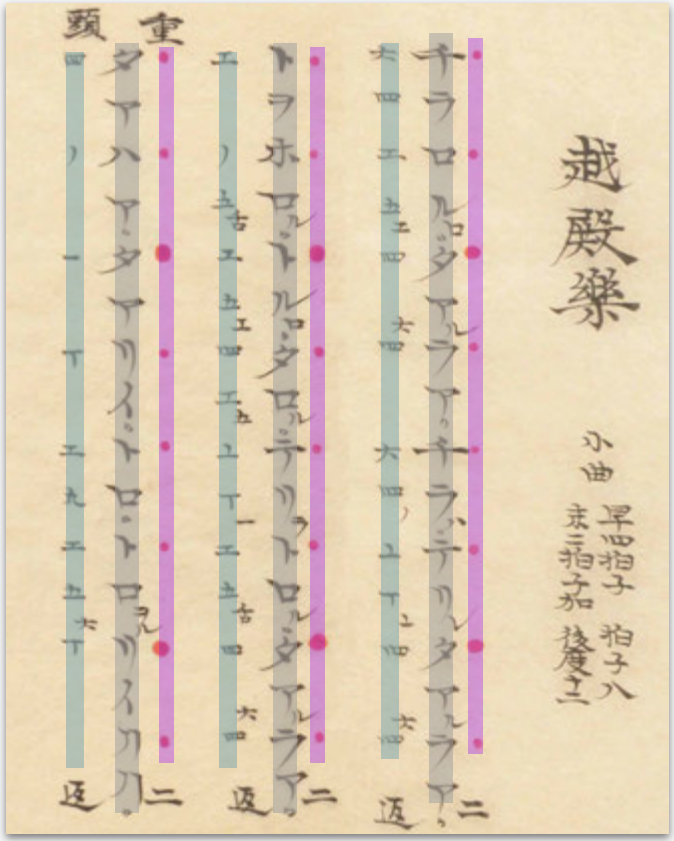


Taiko
[太鼓]

Gagaku Score:Example of Hichiriki



Gagaku Score:Components



Three main components

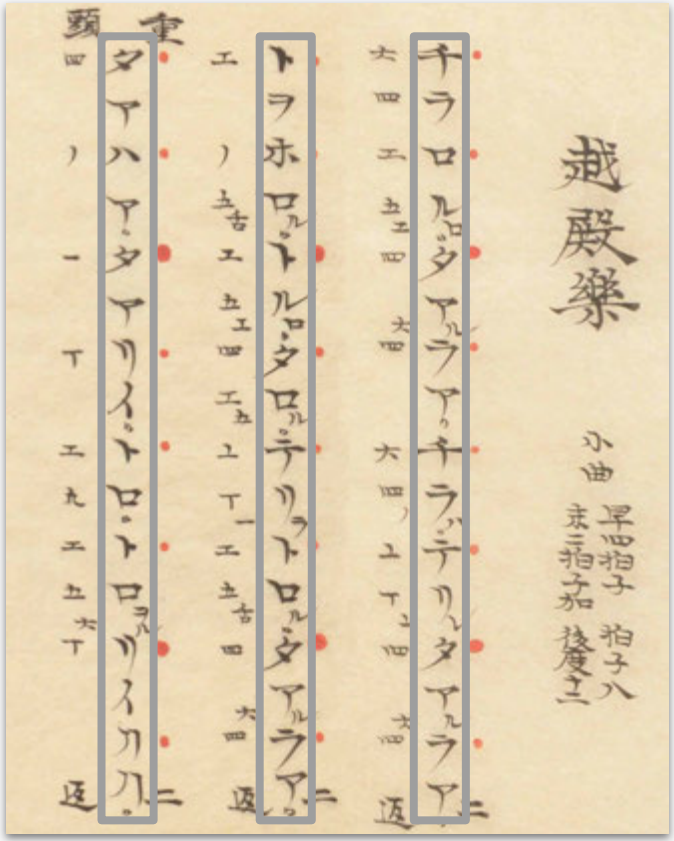
- Fuji（譜字）
- Shōga（唱歌）
- Hyōshi（拍子）

Gagaku Score:Components

Fuji [譜字]

Kana and Kanji corresponding to the fingering of each instrument

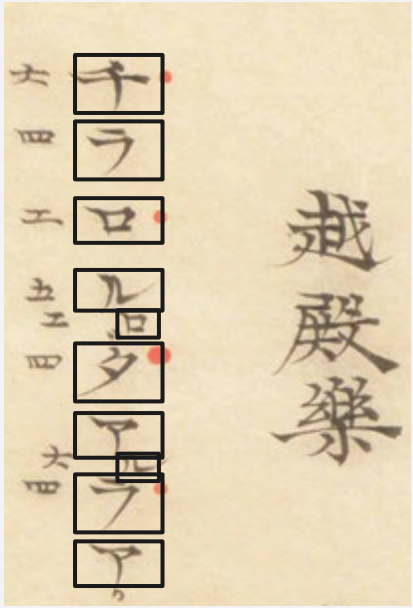
Gagaku Score:Components



Shōga [唱歌]

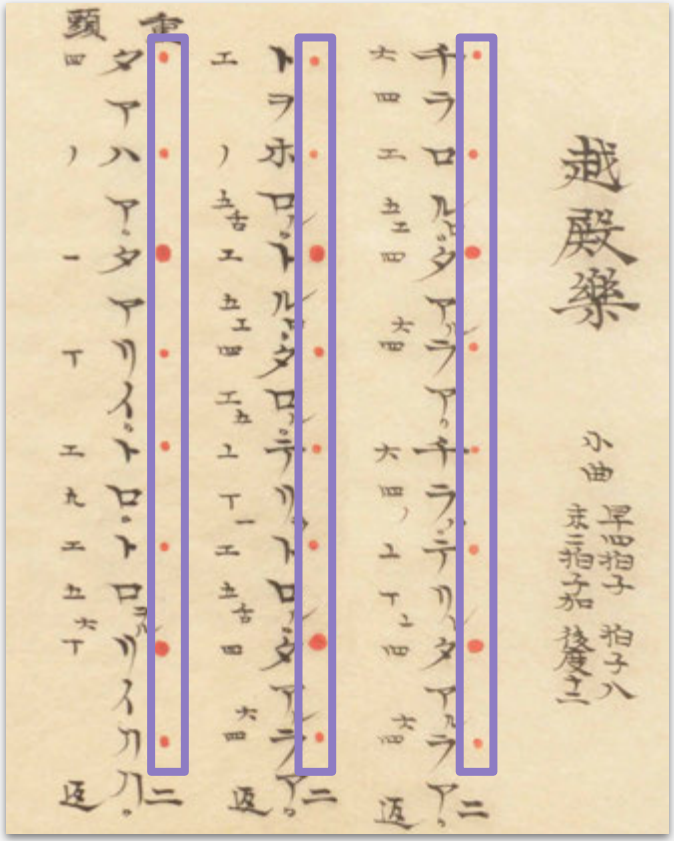
- For memorizing melodies.
- Japanese traditional music's unique way of passing on music.

Example of Shōga



東京藝術大学小泉文夫記念資料室 日本 篳篥の唱歌（雅楽）『平調越殿楽』https://www.youtube.com/watch?v=A70lzl2igds&t=27s

Gagaku Score:Components



Hyōshi [拍子]

- Indicate first beat
- Equivalent to measure
- A big drum is struck at the large dot.

Challenges of Gagaku Scores

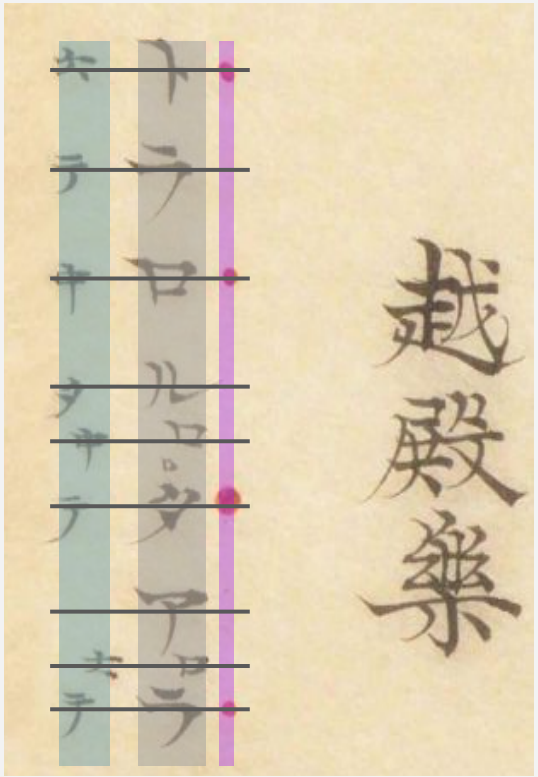
- Unique notation system:
  - Vertical writing, expression using kana and kanji.
  - Different notation systems used for each instrument.
- Only expresses a portion of the information necessary for performance.
- The influence of scores on the transmission of music is very limited.

Encoding with XML

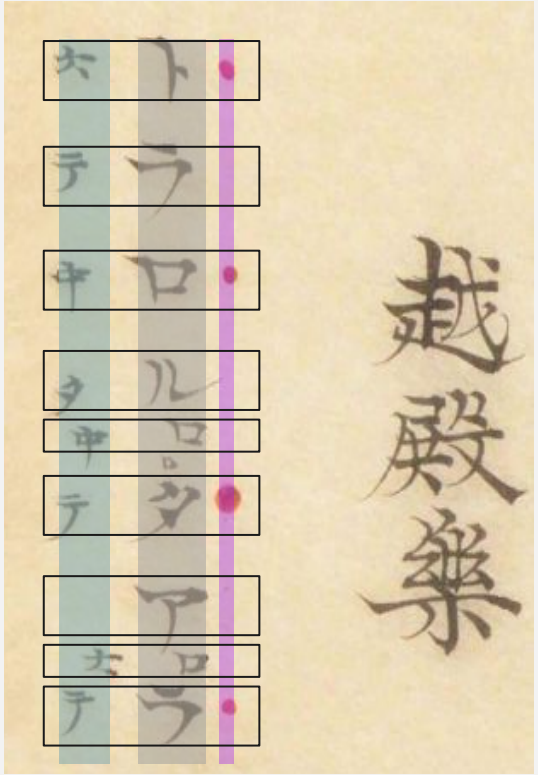
XML-Based Data Structuring

- Inspiration: MusicXML, MEI for Western notation.
- Challenge: Existing schemas insufficient for Gagaku.
  - Crucial to preserve original notation (characters, not Western symbols).
- Solution: Designed a new schema for Gagaku scores.
  - Aligned fuji, shōga and hyōshi are put together in <cell>.
- Interoperability: Adapted MEI's <meiHead> for metadata.
  - Aims for future linkage with other music data.

Special Element for Encoding: <cell>

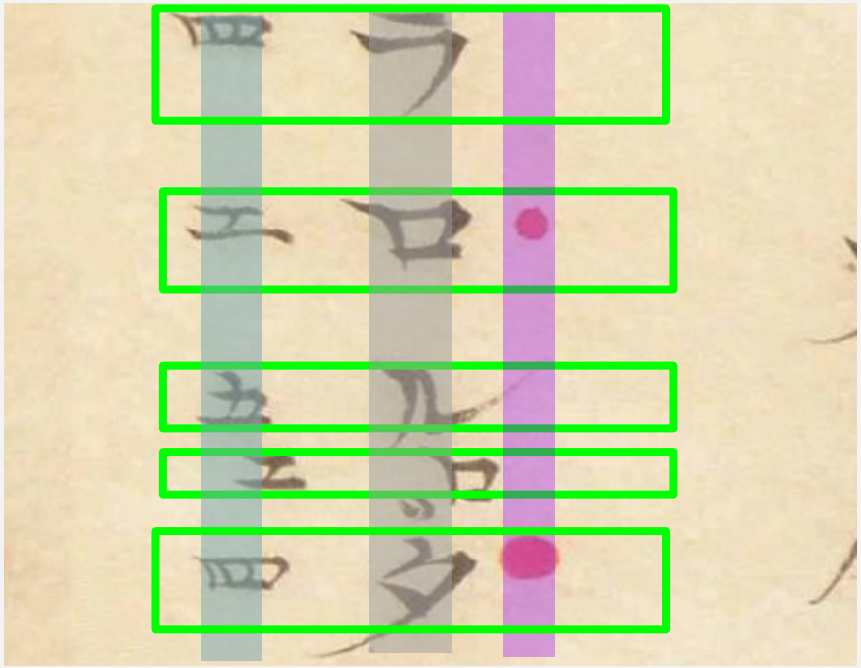


Special Element for Encoding: <cell>



Basic Structure

```
music/
└── page/
    └── line/
        ├── cell/
        │   ├── fuji
        │   ├── shoga
        │   └── hyoshi
        └── cell/
            ├── fuji
            ├── shoga
            └── hyoshi
```

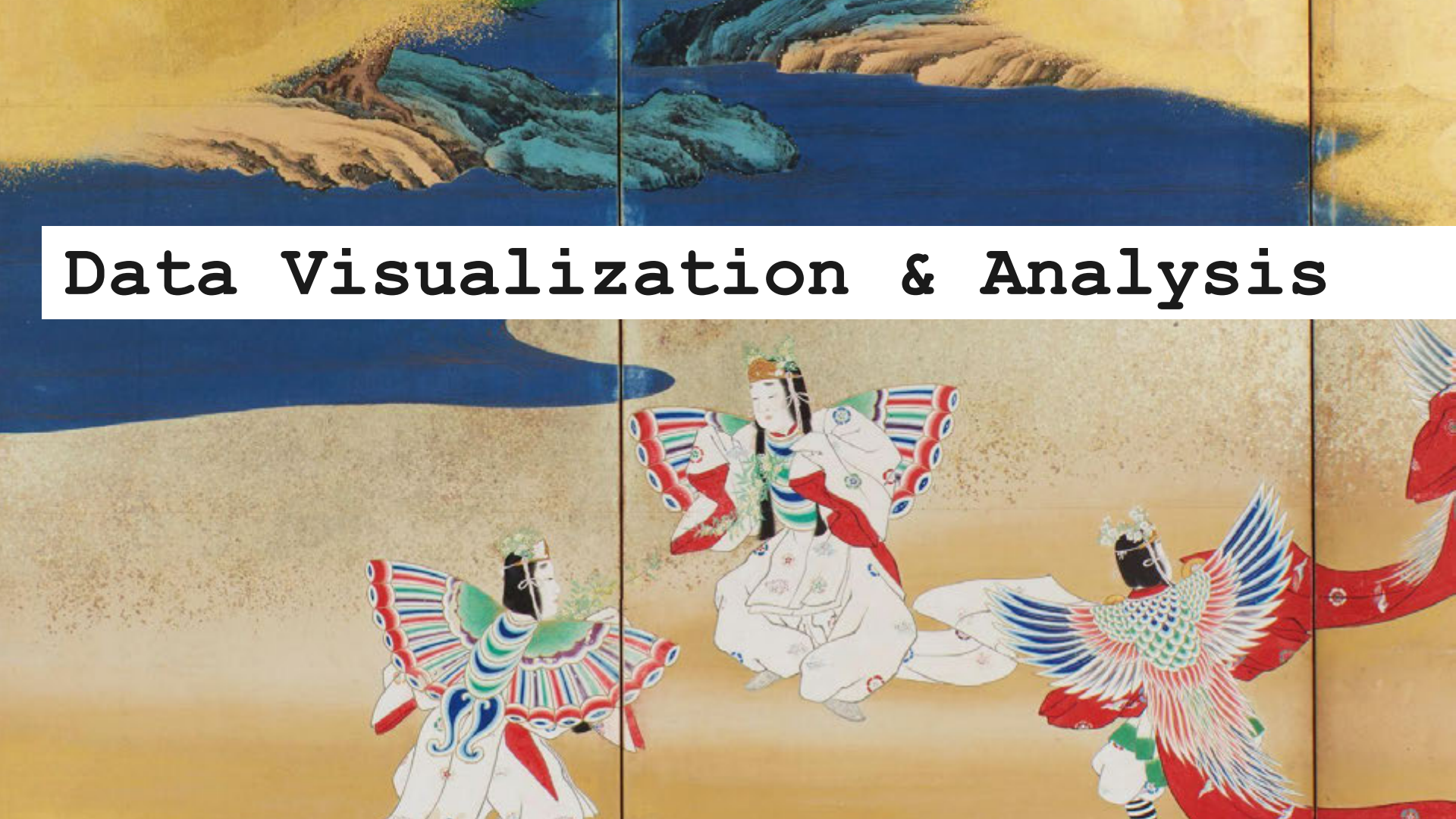


Data Construction Process

- Target: Tōgaku Chūshōkyoku（唐楽中小曲）
  - 93 pieces, short and mid-length, originated from China.
- Instruments Digitized:Hichiriki [篳篥], Ryūteki[龍笛] and Shō [笙]
- Total: 279 XML files.

Data Input

1. Manual Input: Fuji & Shōga character.
    - Current OCR doesn’t work well with vertical text, handwriting, or special characters, especially in complicated formats like music scores.
2. Tagging & Structuring:
    - Use Python to tag and convert to XML.
3. Final Review: Check overall XML.
    - Adding Hyōshi, repetition, etc.



Data Visualization & Analysis

Preliminary Data Visualization and Analysis

Purpose:

Confirm accuracy of constructed XML data.

Shows with numbers what performers know.

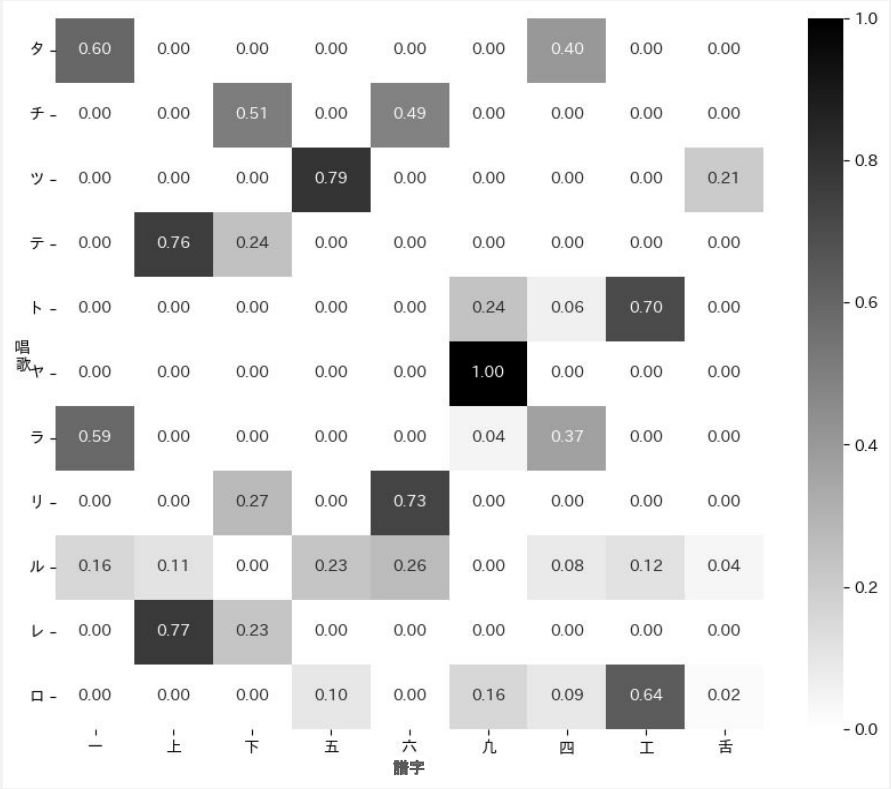
Data Summary：

	<cell>	<shoga>	<fuji>	<aitake>
Hichiriki [篳篥]	26,869	26,854	10,850	———
Ryuteki [龍笛]	30,953	31,060	14,686	———
Sho [笙]	14,185	———	———	15,164

<fuji> and <shoga> Co-occurrence

- Finding:
  - Specific Shōga are indeed used only with specific Fuji.

- Significance:
  - The analysis provides the first data-driven evidence of a clear relationship between Fuji and Shōga.

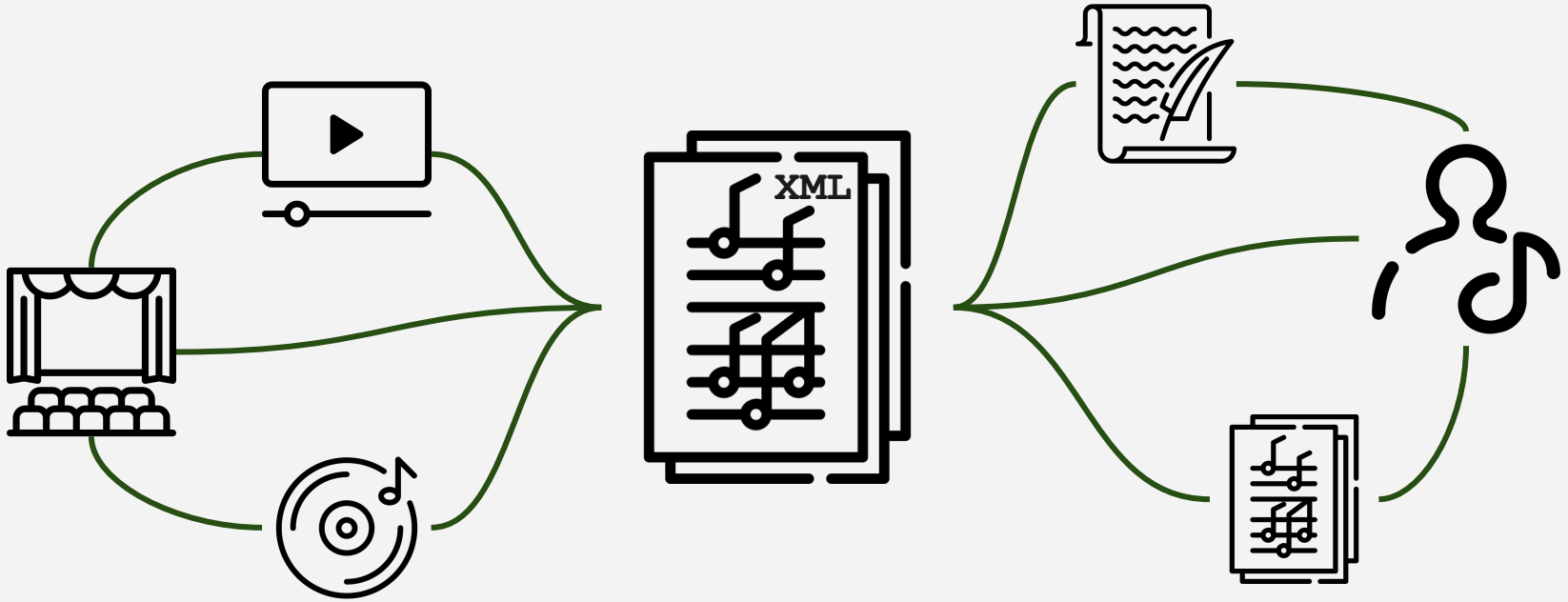


Contributions and Outlook

Contributions

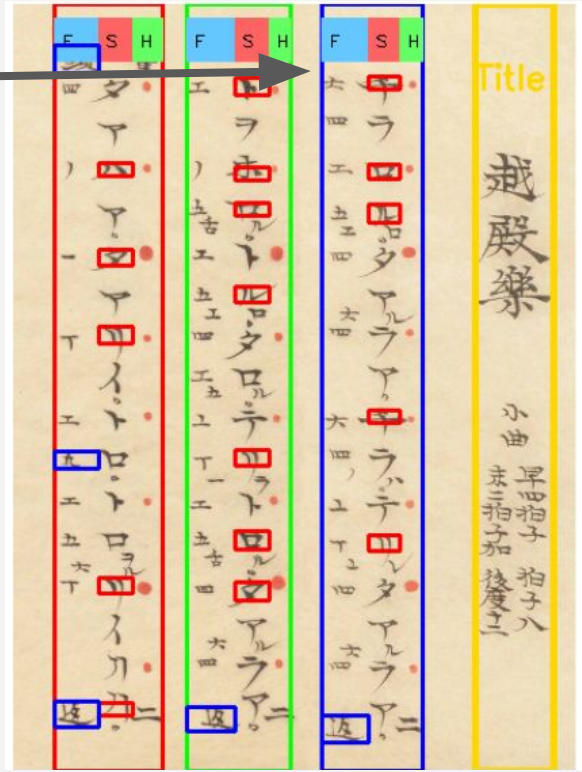
- **Digital Humanities**
  - **Digitizing non-Western music:** transforming Japanese traditional notation into machine-readable formats. It opens new capability for digitizing and analyzing other traditional music and historical documents.
- **[Computational] Musicology**
  - **Empirically validates Gagaku's musical structure** with XML data.
  - **First structured dataset** of Gagaku scores publicly available.
  - Expands the application of computational musicology to **traditional Japanese music.**

Future Outlook



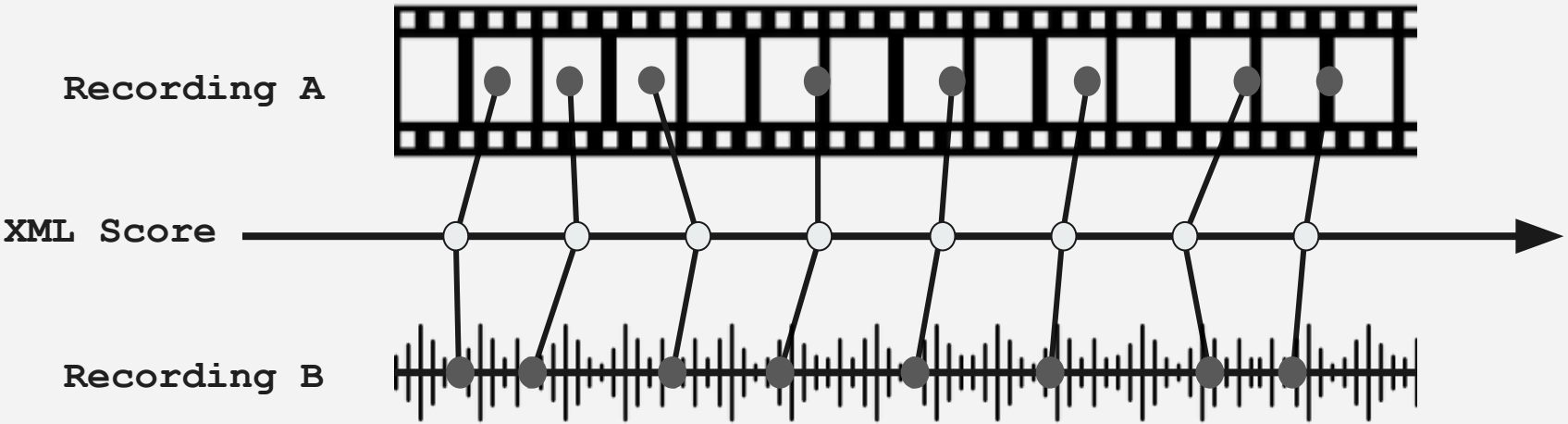
Integration of Image[IIIF] and XML

```
<gagaku>
<lb n="1"/>
<cell>
        <hyoshi type= "small"/>
        <shoga type= "large">チ</shoga>
        <fuji type= "large">六</fuji>
</cell >
<cell>
        <shoga type= "large">ラ</shoga>
        <fuji type= "large">四</fuji>
</cell >
<cell>
        <hyoshi type= "small"/>
        <shoga type= "large">ロ</shoga>
        <fuji type= "large">工</fuji>
</cell >
```



Result of Layout Analysis using Python

Integration of Time-Series Data and XML [with IIIF?]

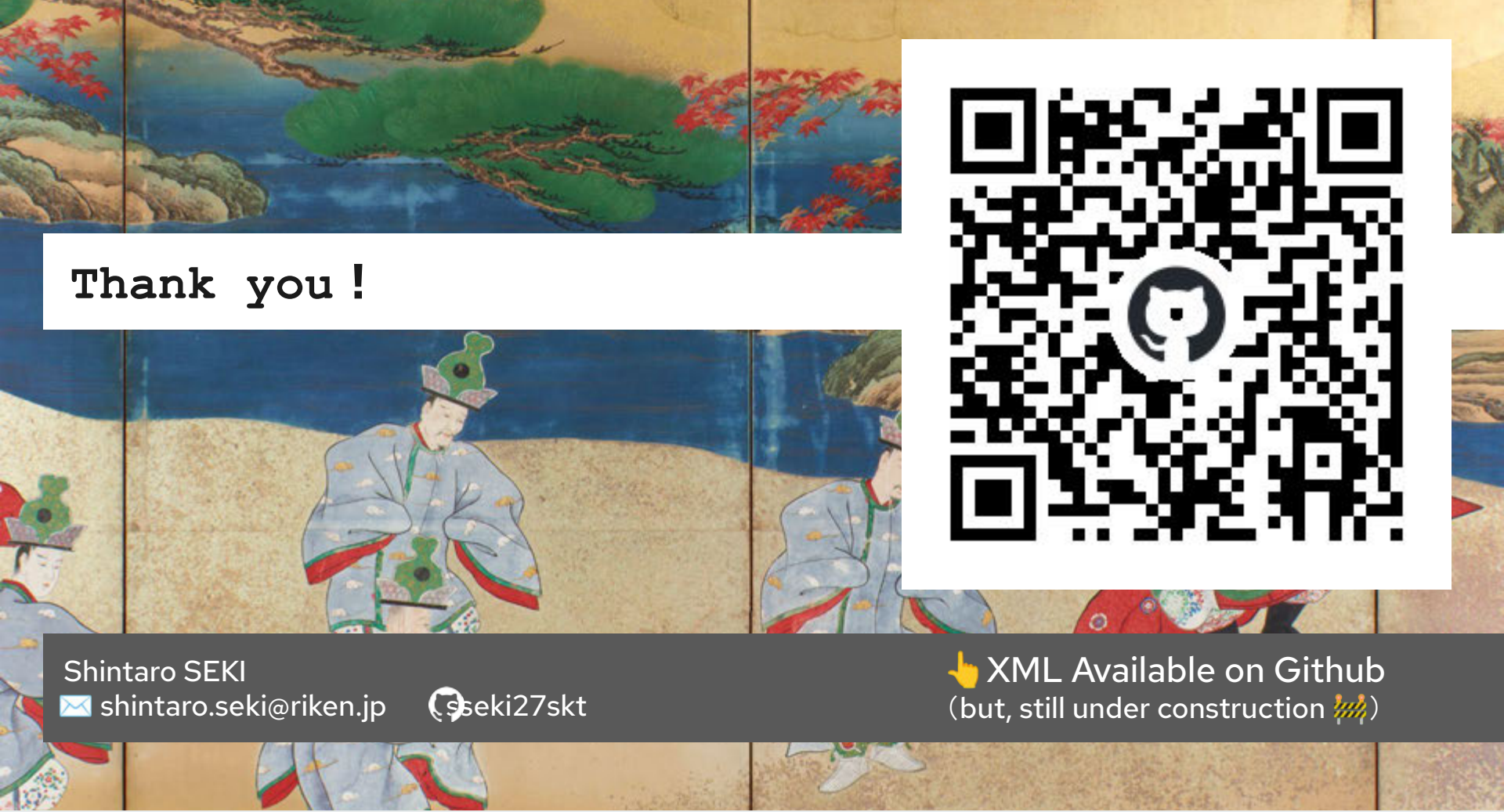


And More. . .

- Transcribing more Gagaku scores.
- Elucidating patterns not intuitively graspable by humans.
- A web application or interactive database with GUI.

Conclusion

- Digitized complex Gagaku scores, making them machine-processable.
- Revealed new insights into Fuji-Shōga relationships through data.
- Contributes to Gagaku, Digital Humanities & Computational Musicology.



Thank you !

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seki27skt

👆XML Available on Github
(but, still under construction 🚧)

This work was supported by JSPS KAKENHI Grant Number JP25KJ0407.

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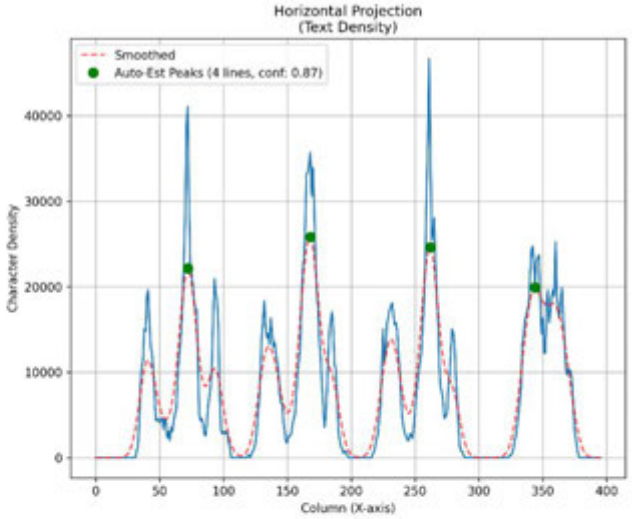
Slides

🚧 XML 🚧

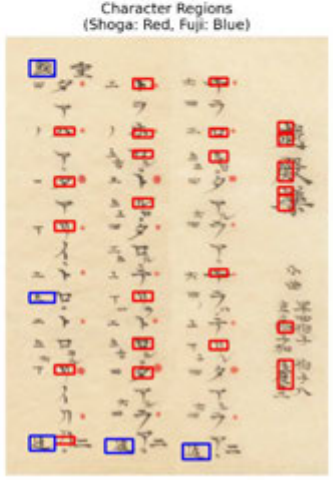
More Gagaku Score

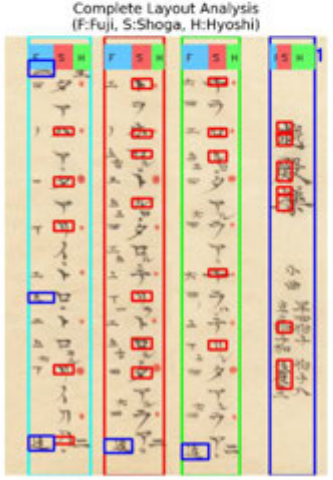
Original Score Image

Binarized Image


Horizontal Projection
(Text Density)
Smoothed
Auto-Est Peaks (4 lines, conf: 0.87)
Character Density
Column (X-axis)
0
10000
20000
30000
40000
0
50
100
150
200
250
300
350
400

Detected Text Lines
(Shoga/Fuji/Hyoshi Structure)


Character Regions
(Shoga: Red, Fuji: Blue)


Complete Layout Analysis
(F:Fuji, S:Shoga, H:Hyoshi)