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Unveiling the Digital Treasure Trove: A Critical Edition of Čiurlionis' Piano Works*

Skaimeninio lobyno atodangos: kritinė Čiurlionio fortepijoninių kūrinių redakcija

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Abstract
This article presents the results of a 2022–2024 research project focused on the piano music of the renowned Lithuanian composer and painter Mikalojus Konstantinas Čiurlionis. The project aimed to prepare a critical edition of the composer's piano works and to publish it as an interactive database, reflecting broader trends in contemporary (digital) editing and publishing of musical works. The database includes both complete and incomplete piano works by Čiurlionis, as well as sketches and fragments. All musical texts are linked and presented alongside their autographs, contemporaneous transcriptions, previous publications, and detailed commentary. Additionally, a unique search algorithm was programmed and integrated into the database, enabling music information retrieval based on basic criteria and allowing for comparative analysis of the works and fragments contained within the system.
Keywords: Čiurlionis's piano music, critical edition, computational musicology, music publishing, conceptual modelling, visualization.

Anotacija
Straipsnyje pristatomi 2022–2024 m. vykdyto mokslo projekto, skirto žymaus lietuvių kompozitoriaus ir dailininko Mikalojaus Konstantino Čiurlionio fortepijoninei muzikai, rezultatai. Šio projekto tikslas buvo parengti kompozitoriaus fortepijoninių kūrinių kritinį tekstą ir jį paskelbti interaktyvioje duomenų bazėje, taip siekiant atspindėti platesnes šiuolaikinio (skaitmeninio) muzikos kūrinių redagavimo ir leidybos tendencijas. Suformuota duomenų bazė apima baigtus ir nebaigtus Čiurlionio fortepijoninius kūrinius, jų eskizus ir net fragmentus. Visi muzikos tekstai susieti ir pateikiami kartu su jų autografais, amžininkų nuorašais, ankstesnėmis kūrinių publikacijomis ir detaliais komentarais. Šiai duomenų bazei taip pat buvo realizuotas ir integruotas unikalus paieškos algoritmas, leidžiantis atlikti muzikos informacijos paiešką pagal bazinius kriterijus ir taip pat lyginamąją šioje sistemoje esančių kūrinių ir jų fragmentų analizę.
Reikšminiai žodžiai: Čiurlionio fortepijoninė kūryba, kritinė redakcija, kompiuterinė muzikologija, muzikos leidyba, konceptualus modeliavimas, vizualizacija.

Development and Challenges in the Digital Humanities

In the second half of the twentieth century, the rapid development of computer technologies, combined with advancements in the humanities, led to the emergence of an interdisciplinary approach to the humanities—digital humanities— which has recently gained global prominence. With a primary focus on textual analysis, this has driven intensive digitization efforts, the development of new analytical methods, and the creation of interactive text editions, databases, and digital archives. A wide range of text encoding tools, analyzers, segmentation, and visual output programs have already been developed for working with verbal texts.[1] However, the digitization and analysis of musical texts, on an international level, remain in a phase of intensive development.[2] Notable projects have been dedicated to some of the world's most renowned composers—Mozart, Beethoven, and Chopin.[3] These projects are based on innovative, digital methods of preparing and presenting

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critical texts, integrating XML code to create interactive texts, provide instant access to primary sources, and enable synchronous comparison and analysis. As Samuel Huskey has noted, the presentation of contemporary critical editions is largely defined by their methods of visualization. Three types of visualization are distinguished:

1. [Re]presenting traditional critical editions;
2. [Re]presenting critical editions digitally;
3. [Re]presenting critical editions as databases (Huskey, 2022).

It has been observed that digital critical text publications increasingly aim to move beyond printed formats and fully utilize the possibilities of new technologies. According to Huskey, "some (e.g., Heslin 2016; van Zundert 2016; Keeline 2017) argue that the very concept of a critical edition is outdated in an era when technology allows users to browse digital images and transcriptions of the available witnesses and sources for a text, and that we should spend our time developing interfaces and tools for processing, visualizing, and analyzing that data in ways more suitable to a digital paradigm" (Huskey, 2022: 116). Moreover, with the intensive development of digital versions of critical texts, particularly in the creation of interactive databases, there is an increasing need for a unified semantic encoding vocabulary that is accessible and understandable to the international community. This includes the standardization of symbols, such as abbreviations and expressions (Huskey, 2022: 125). In any case, we can conclude that existing digital critical text editions can be broadly categorized into two types:

1. Local systems, which operate independently of internet networks, often as closed computer programs or CD-ROMs. The material is presented in a stable format that is not editable or modifiable by the user. Local systems are created in two ways:
   1) Scanning previously prepared and physically printed text (PDF, JPEG, TIFF);
   2) Using a combined method, where newly typed text is integrated with existing printed and scanned material (PDF).

2. Interactive online systems, which operate exclusively on the World Wide Web (WWW) and, in some cases, allow the user to edit or modify the provided material. These are also created in two ways:
   1) Computer-typed and/or appropriately coded text (TEI/MEI, XML);
   2) Interactive text that includes not only verbal text but also sound and video (all formats are used in combination—HTML, TEI/MEI, XML, RDF, PDF, JPEG, TIFF, MPEG, MID, etc.).

Meanwhile, when considering contemporary digital editions of music (DEM) in general, the role of the user and their working principles are emphasized. Sometimes these principles are flawed—users often habitually prefer to print everything on paper—but at other times, they actively contribute to and encourage the further development of DEM. For instance, Lisa Hooper, who identifies four categories of DEM (scholarly edition, e-score database, downloadable files of a self-publishing composer, and a vendor's self-publishing service), argues that users' tendency to print everything on paper undermines the original concept of DEM (Hooper, 2013). In contrast, John Rink categorizes DEM differently and highlights the positive contributions of users, particularly the potential of "dynamic editions". Other DEM categories identified by Rink include "plain" scores available in PDF or similar formats, digital scores expressly enhanced for performers, and other initiatives that problematically claim DEM status (Rink, 2021).

Digitizing Čiurlionis's Music Works

The development of digital humanities in Lithuania is primarily hindered by the slow digitization of primary sources (which is often difficult to integrate into scientific projects), a shortage of appropriately skilled researchers, and a general inertia within humanities research that favors traditional methods. As an exception rather than the norm, only a few philological projects by researchers at Vilnius University have been realized in this field.[4]

The studies of Mikalojus Konstantinas Čiurlionis's (1875–1911)—Lithuania's most renowned composer and painter—represent one of the most significant topics in Lithuanian art history and encompass a multilayered and diverse field of research that spans more than a century. Examining Čiurlionis's life and work reveals not only the unique patterns of an individual artist but also the broader trends in the development of Lithuanian and European art. Cultural and artistic phenomena of the past two decades have further validated Professor Eero Tarasti's observation that "close examination of Čiurlionis's work may perhaps one day reveal something central to the problematics of the interrelationships of arts" (Tarasti, 2012: 368). The phenomenon of Čiurlionis is undeniably established as a central figure in modern Lithuanian music. His works have attracted international scholarly attention, with half of today's researchers in this field being foreign scholars—highlighting the global significance and relevance of these studies.

The process of editing and publishing Čiurlionis's music works has spanned over a century. As a result, some pieces have been published in eight to ten different editorial versions, and his music is catalogued using as many as

five different types of numbering systems. Paradoxically, despite this extensive history, Čiurlionis's music still lacks a fully prepared and published critical text. A canonical version—that is, a comprehensively examined, scientifically commented, and argued text of the works that addresses textuality and presents the most plausible interpretation and reconstruction to meet the needs of current Čiurlionis researchers and performers remains absent.[5] Over the past century, publications by various editors have either become historically outdated (factual and proofreading errors), unreliable (with new Čiurlionis manuscripts discovered, some editions proved entirely incorrect), or insufficiently informative (relying on a single source, lacking extensive text variant commentary, not distinguishing editor's notes). Efforts to prepare and release some of Čiurlionis's music urtexts from 2000 to 2020 revealed that contemporary users are looking for much broader and deeper information [6]. This has highlighted the need for a qualitatively new approach to text preparation and presentation: a digital critical text based on precise textual analysis, incorporating all known sources, supplemented by extensive text commentary, and presented in an appropriately prepared interactive database or archive.

In 2025, Lithuania will celebrate the 150th anniversary of the birth of Čiurlionis. To mark this occasion, the Lithuanian Academy of Music and Theatre has initiated a critical edition of all of Čiurlionis's musical works. As a prelude to this edition, the authors of this article secured funding from the Lithuanian Research Council for a project focused specifically on Čiurlionis's piano music. Conducted between July 2022 and December 2024, this project aimed to perform a critical revision and analysis of Čiurlionis's piano repertoire based on the Music Encoding Initiative (MEI). This means that all (over 200) of Čiurlionis's piano works were revised, produced, and presented for the first time in the form of a digital system (an interactive database), including primary sources (autographs and accompanying documents, letters, sketches, etc.) and all existing editions, connecting them through a specially designed interactive database. Furthermore, the critical edition incorporates a unique search algorithm that enables the recognition and comparison of texts, both as complete works and as individual text elements or code.

Creating Čiurlionis's Interactive Database: A Methodology

The initial step of the research involved determining the encoding standard to be used and developing both the back-end and front-end of the system. The research showed that that both music XML and MEI would be necessary (Bogdanienė et al. 2024), Verovio was used as a third-party solution, integrated into the web application to display notes and to provide most of Verovio's standard functionality. Existing online catalogues and digital editions of other composers served as valuable examples during the development of Čiurlionis's database. These included The Catalogue of Carl Nielsen's Works (2018), the Digital Interactive Mozart Edition (2019), and the Online Chopin Variorum Edition (2017). The primary idea for implementing a search tool for musical themes was drawn from the Themefinder Project (Huron & Sapp, 2000).

While these existing solutions offered valuable insights and ideas, Čiurlionis's database required additional functionality and modifications to standard Verovio functionality (in the form of overlay code), etc. In the first phase, a MongoDb database was created, Express was used for requests, and Vue js was employed to develop the interface. A file server was established to store all the digitalized material, and an administrative tool was developed to simplify record manipulation and data uploads. As a result, users can compare the edited critical text with various manuscript versions (e.g., sketches, drafts, clean copies) as well as with previous editions. The data structure, described in Bogdanienė et al. (2024), is designed to be easily modifiable, allowing for the addition of more parameters, implementation of multilingual support, etc. This structure was prepared with expectations for future development in mind, aiming to eventually incorporate all of Čiurlionis's work, not just his piano music.

Search Tools in Čiurlionis's Interactive Database

The developed interactive database enables users to search for Čiurlionis's piano works using various key options, such as title, year, and city, as well as through a selection tool. This functionality scans all the MEI files stored on the file server to find exact matches (Bogdanienė et al., 2024). The digital archive extends beyond traditional text-based queries by incorporating a digital piano interface. This feature allows users to enter musical notes directly, enabling searches based on musical content rather than solely textual metadata. This expanded search capability enhances the usability of the digital critical edition, enabling researchers, educators, and performers to quickly identify and compare piano works based on their musical features. Users can perform extensive note-based searches, as shown in Figure 1. The search interface provides options to select the clef (2) and octave (3) and view the resulting search fragment (5). Furthermore, users can modify the note search type (1), choosing from retrograde, inverse, retrograde inverse, and transposition. These changes are then displayed alongside the original selection (6), making note entry

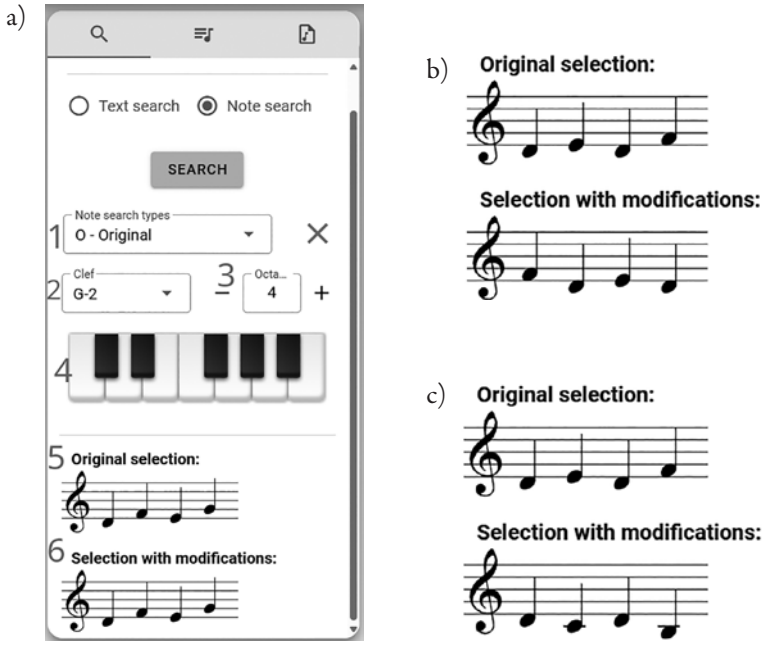

Figure 1. The search function by notes using an interactive piano interface: a) the available search options, b) an example of a retrograde search, and c) an example of an inversion search.

more user-friendly. The search algorithm supports searches across all octaves, allowing for deeper analytical possibilities for musicologists.

An existing selection tool was further improved to streamline the search process. Users can mark a desired selection area, with the notes being highlighted in color to indicate the selection. This selection is also displayed on the left side of the search area, facilitating an extended search workflow. Users can adjust the selection by typing notes and modifying the search type without needing to re-enter all details from scratch (see Figure 2). This functionality is particularly useful for large selections.

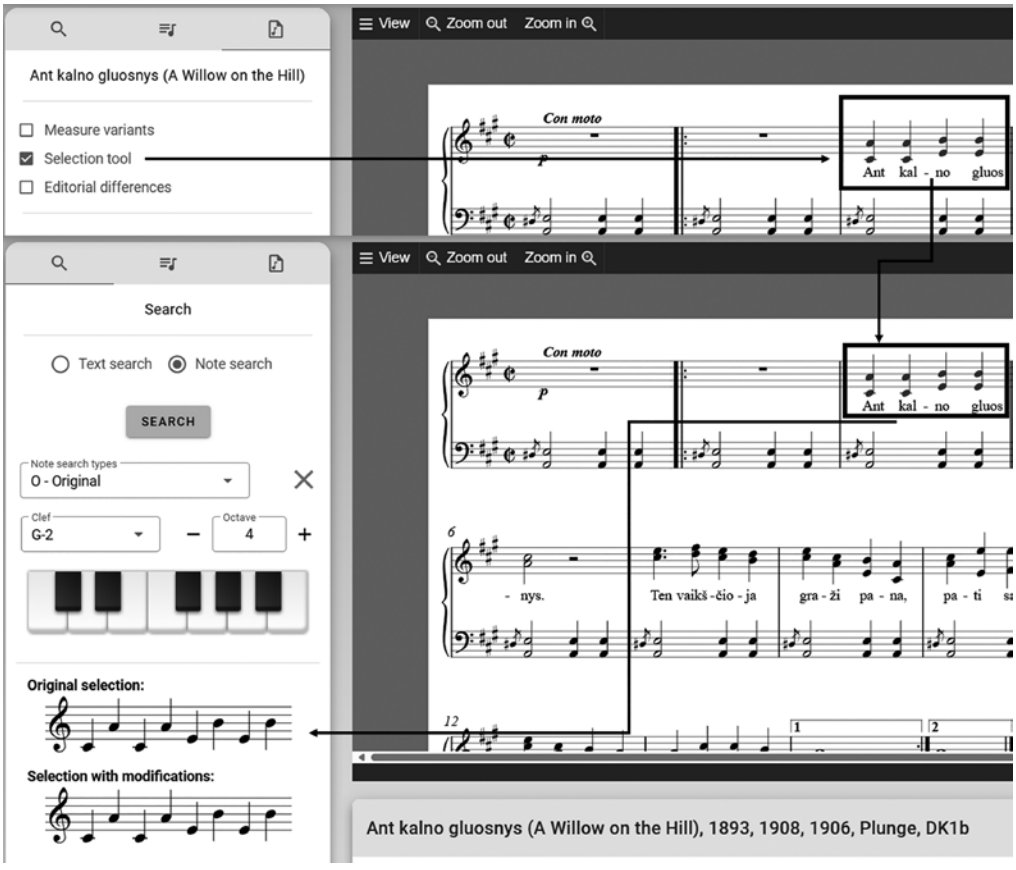

Figure 2. Improved note selection tool and search.

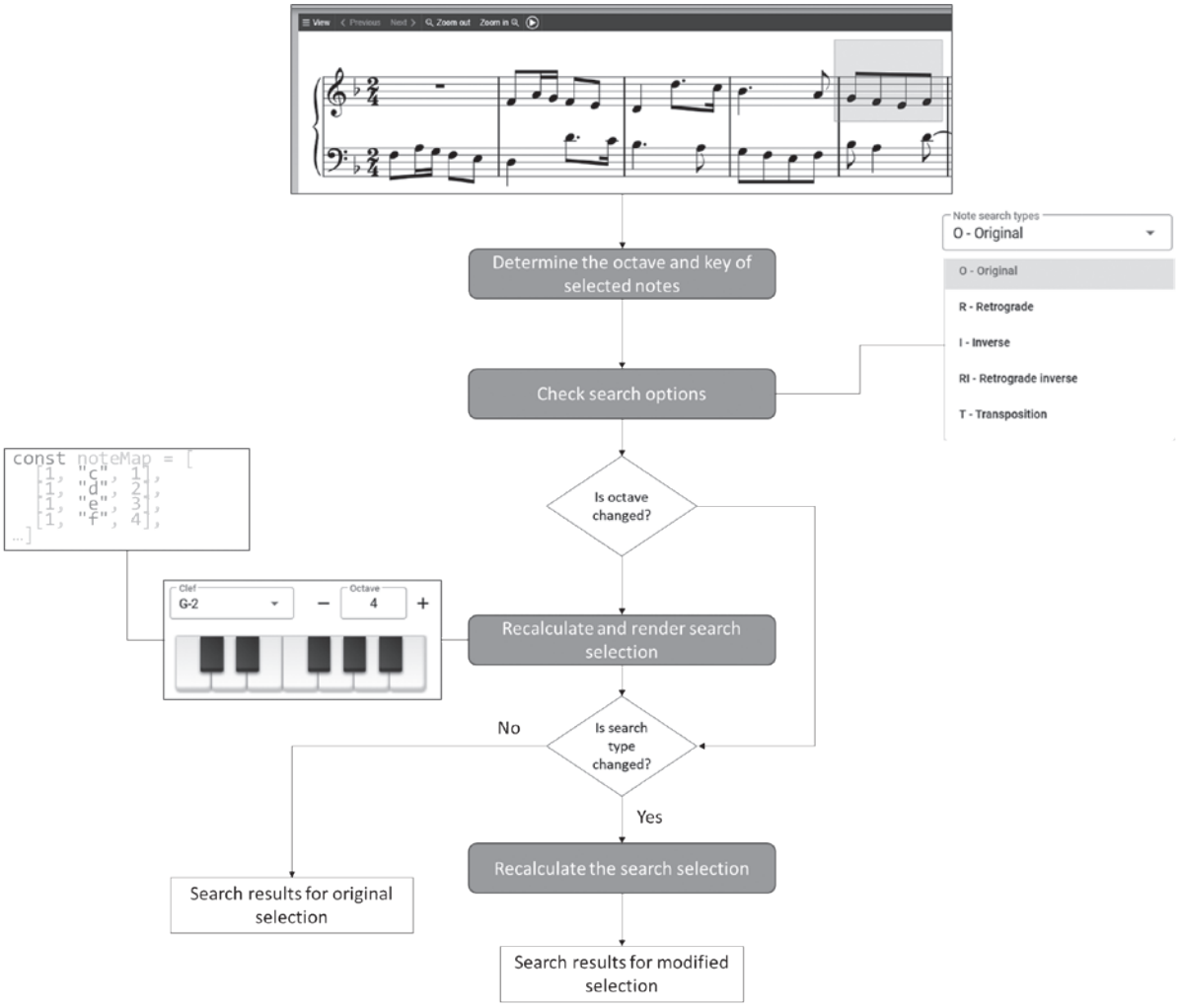

Figure 3. Improved search for an in depth-analysis.

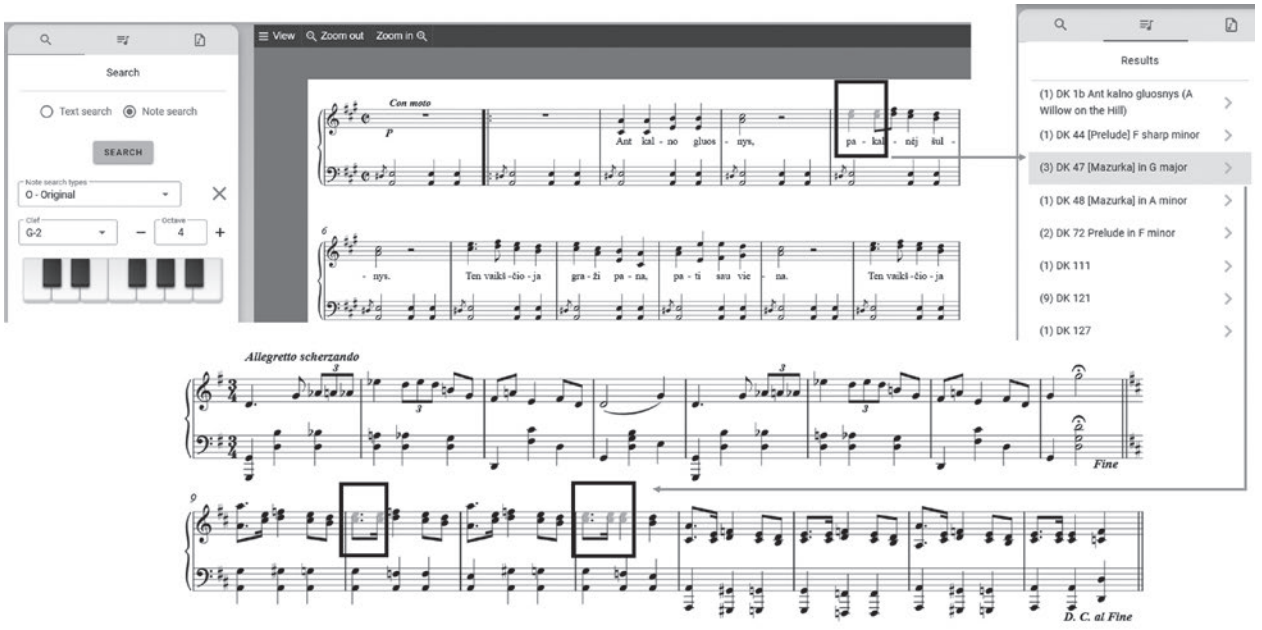

Figure 4. Search results and matching selection.

Čiurlionis's Interactive Database and Tools for Comparative Analysis

The primary focus and challenge during this phase of development was to create an algorithm that enables users to search for a modified selection. The logic behind the algorithm is shown in Figure 3. As previously described, the improved selection tool allows users to either select a fragment of interest or enter notes using a digital piano keyboard. In both cases, the notes are displayed as the original search fragment. Once a fragment is selected or entered, the original octave and key are extracted from XML files—Verovio displays .mei files. All possible notes are mapped into an array, ensuring that if there is a change in octave, all selected notes are appropriately shifted based on these mapped notes. For retrograde, inversion, or retrograde inversion options, the calculations ensure that after the shift, the search notes are displayed and recalculated correctly. For transposition, all possible transpositions within a one-octave range from the first note are animated and displayed. The search is performed for every transposition, storing all modifications in an array. Subsequently, the results are displayed in a list format for user convenience, and when a user selects a specific work from the list, the selection is highlighted in a different color, as shown in Figure 4.

The system also supports multilingual functionality, currently offering content in both English and Lithuanian. Furthermore, its flexible structure allows for the seamless addition of more languages in the future (Bogdanienė et al. 2024).

Presentation of the Search Algorithm: A Case Study

The final complete piano work by Čiurlionis, Fugue in B-flat minor (or *in B-flat*, catalogue number according to Landsbergis VL 345, and Kučinskas DK 293) was selected to demonstrate the application of search algorithm. Using the "Note search" tool, users can mark a desired fragment in the music score—such as a single note, chord, or group of notes. By selecting the "Transposition" option in the "Note search types" field, the activated search examines all material available in the database. For instance, marking the first five notes of the fugue subject at the beginning of the Fugue initiates a search that identifies corresponding fragments within the Fugue and in Čiurlionis's other piano works stored in the database (see Figure 5). Figure 6 highlights several matching examples. For example, we may see the same five-note motive appearing outside the subject of the Fugue in the bass melody in bar 11, as a result of the descending three-note sequence (Figure 6, a). Examples b, c, and d display single matches in the Preludes VL 259 / DK 152 and VL 261 / DK 155, both dated 1904, and Prelude in D minor VL 322 / DK 288, dated 1908.

This demonstration of the search algorithm highlights its ability to significantly accelerate the analysis and comparison of musical works. The tool enables researchers to identify recurring motifs in unexpected ways, providing matching results across disparate compositions and offering insights into the evolution of the composer's creative process.

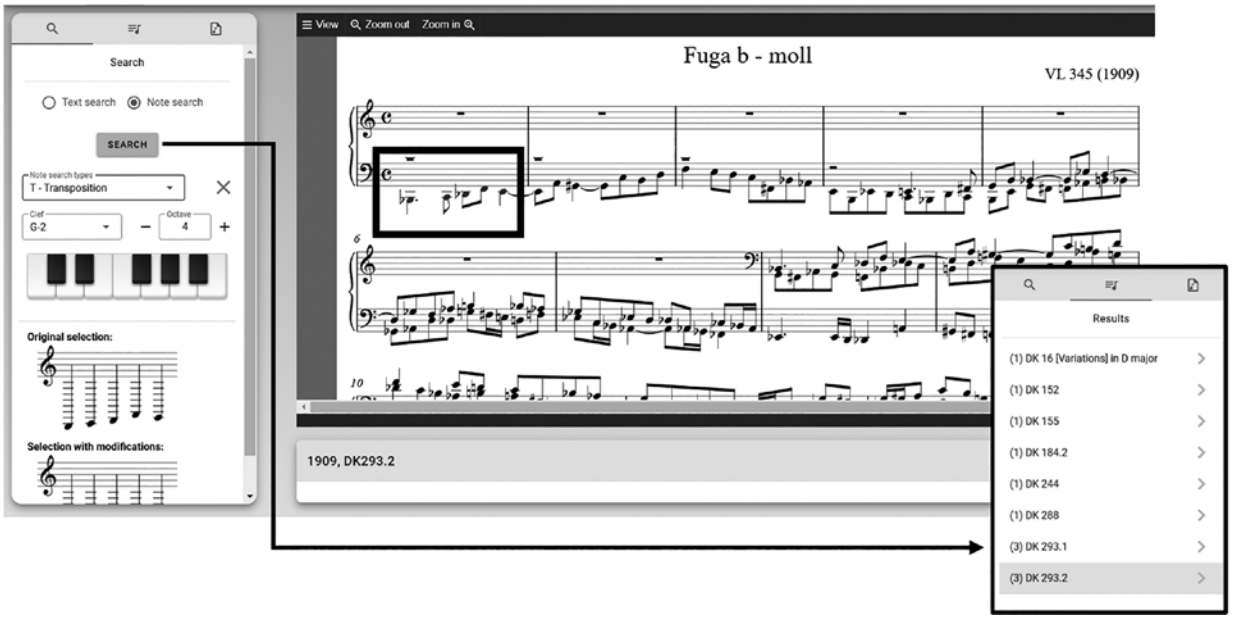

Figure 5. Selected fragment in the Fugue VL 345 / DK 293 and search results in other compositions.

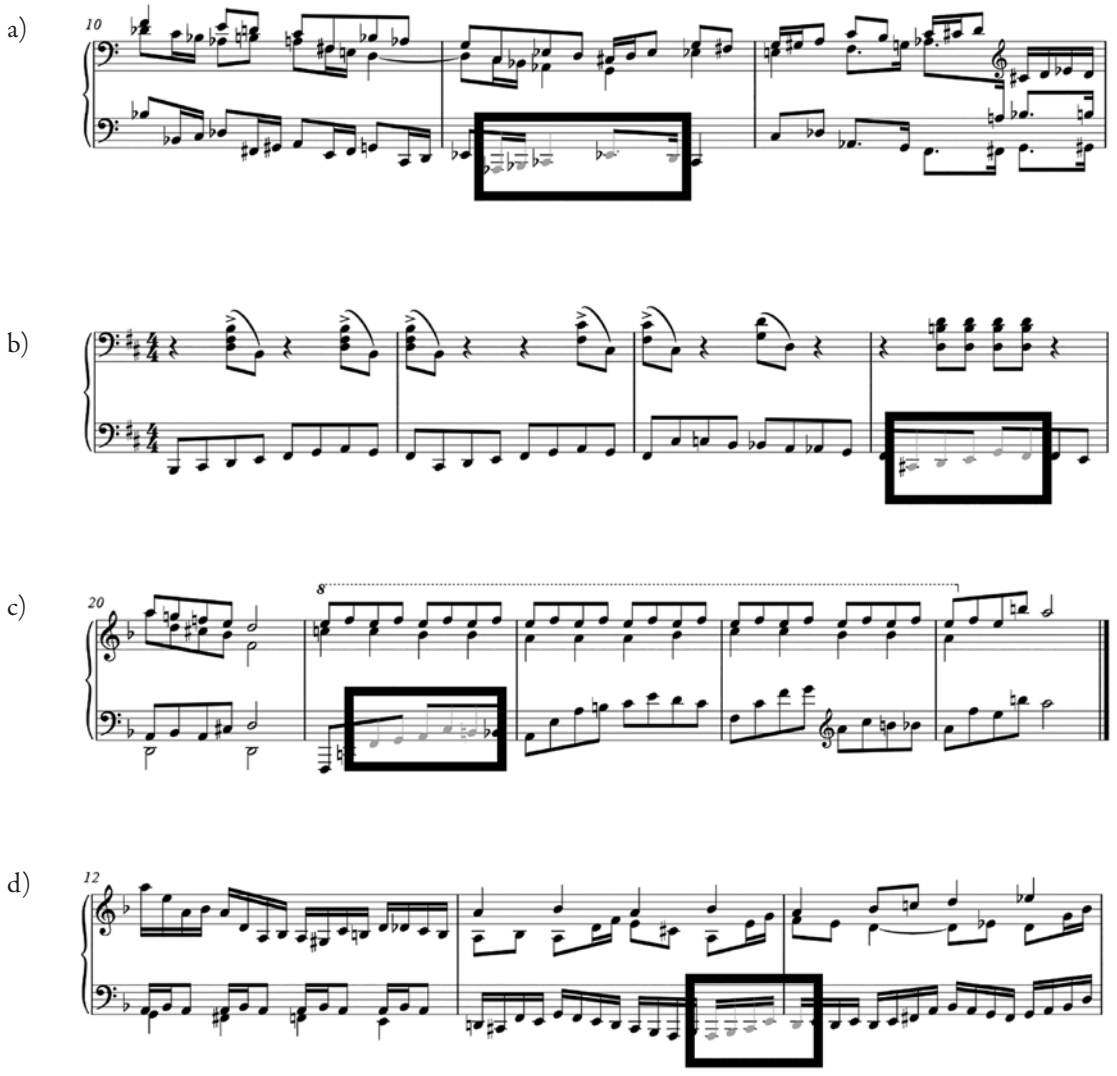

Figure 6. Examples of matching results of the five-note fragment: a) Fugue VL 345 / DK 293, bar 11; b) Prelude VL 259 / DK 152, bar 4; c) Prelude VL 261 / DK 155, bar 21; d) Prelude VL 322 / DK 288, bars 13–14.

Conclusions

A comprehensive online catalogue of Čiurlionis's piano music has been developed. This digital archive includes primary sources such as autographs, accompanying documents, letters, sketches, and all existing editions. The database structure is designed for scalability, allowing for the future inclusion of other types of works and additional materials related to Čiurlionis's compositions. All files are stored on a dedicated file server, with only the links to these files maintained in the database. This approach optimizes database management, reducing the overall storage requirements. Moreover, a unique search algorithm enables the recognition and comparison of texts, both on a holistic and granular level, down to individual bars or specific selections. The digital critical text of Čiurlionis's works, accompanied by musicological commentaries, is available in both Lithuanian and English, ensuring accessibility and promoting international dissemination via MEI platforms. From a global perspective, this open-access database will open up a wide array of opportunities for utilizing the research results, lay new ground for the further exploration of Čiurlionis's music texts, and strengthen the international visibility of this exceptional Lithuanian composer.

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[1] The majority of researchers working in this field have joined the Text Encoding Initiative (TEI) community.

[2] Specialists in this area connect through a similar network, the Music Encoding Initiative (MEI). This network was initiated in 2004, but the first results were only published between 2012

and 2014 as conference and seminar materials, and the presentation of relevant projects (https://music-encoding.org).

3 The digital edition of Mozart's works (https://dme.mozarteum.at/en/music/edition), the textual analysis and critical text publication of Beethoven's manuscripts and works (https://beethovens-werkstatt.de), and the critical and digital editions of Chopin's primary sources (https://humdrum.nifc.pl; http://www.chopinonline.ac.uk/ocve).

4 Digital critical texts and archives dedicated to Balys Sruoga and Maironis can be found online at the following links: http://www.sruoga.flf.vu.lt, http://www.pb.flf.vu.lt.

5 As a scholarly genre, the critical text has been highlighted by musicologists such as Georg Feder and Hubert Unverricht ("Urtext und Urtextausgaben." In *Die Musikforschung*, 1959, vol. 12, p. 432–454); James Grier (The Critical Editing of Music. Cambridge: Cambridge University Press, 1996), as well as textual scholars like Paulius Subačius (Tekstologija. Vilnius: Aidai, 2001).

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Santrauka

XX a. antroje pusėje spartus kompiuterinių technologijų vystymasis ir humanitarinių mokslų plėtra paskatino naujos humanitarinių mokslų šakos – skaitmeninių humanitarinių mokslų – formavimąsi. Pagrindinis dėmesys skiriamas kompiuterinei tekstų analizei, leidžiančiai naujais pjūviais pažvelgti į tą patį tekstą ir gauti naujų duomenų ir rezultatų tolesnei teksto interpretacijai. Muzikos tekstų skaitmeninimas ir analizė, net ir tarptautiniu lygiu, yra intensyvaus vystymosi etape. Čia galima rasti tik kelis rezultatyviai plėtojamus projektus, skirtus pasaulinio garso kompozitoriams (Mozart, Beethoven, Chopin), kuriuose remiamasi inovatyviais skaitmeniniais medžiagos parengimo ir apdorojimo metodais, integruojamas XML kodas, formuojama momentinė prieiga prie visų pirminių šaltinių ir sudaroma sinchroninio palyginimo galimybė. Šiais būdais rengiami skaitmeniniai kritinių tekstų leidimai, kurie gali būti skirstomi į du pagrindinius tipus: a) vietinės sistemos, veikiančios nepriklausomai nuo interneto tinklų (dominuoja PDF, MIDI formatai); b) interaktyvios interneto sistemos, veikiančios tik pasauliniame tinkle (dominuoja XML formatas, bet taip pat naudojama nemažai kitų tipų dokumentų).

Lietuvoje skaitmeninių humanitarinių mokslų plėtrą stabdo lėtas pirminių šaltinių skaitmeninimo procesas, atitinkamos kvalifikacijos tyrėjų stoka ir bendras humanitarinių mokslų tyrimų inertiškumas, kai taikomi daugiausia tik tradiciniai tyrimų metodai. Siekiant ištrūkti iš šio „užburto rato" 2022–2024 m. straipsnio autorių buvo realizuotas Lietuvos mokslo tarybos finansuotas projektas, skirtas Čiurlionio fortepijoninei muzikai. Siekta parengti Čiurlionio fortepijoninių kūrinių kritinio teksto redakciją, suformuotą muzikos kodavimo principais (MEI – *music encoding initiative*) ir pateiktą kaip vientisa šaltinių ir

ankstesnių leidimų integrali duomenų bazė. Ši skaitmeninė kritinė kūrinių teksto redakcija buvo išplėsta unikaliu paieškos algoritmu, leidžiančiu atpažinti ir lyginti tekstus ir jų atskirus parametrus tiek viename kūrinyje, tiek visoje duomenų bazėje.

Tinkamam sprendimo realizavimui reikėjo atsižvelgti į daugelį veiksnių, tokių kaip tinkamos žymėjimo sistemos parinkimas, skaitmeninės medžiagos dėjimas ir susiejimas, duomenų bazės bei duomenų struktūros identifikavimas ir formavimas ir kt. Muzikos kūriniai turi ne vieną žymėjimo sistemą, jos skiriasi įvairiuose regionuose ir perioduose. Tyrimas parodė, kad norint pasiekti tikslus reikalingi formatai yra „musicXML“ ir „MEI“. Sukurta sistema yra žiniatinklio tipo, dėl universalumo ir intuityvaus dizaino ji užtikrina patogią vartotojo patirtį ir funkcinio efektyvumo palaikymą. Išoriniam programavimui pasirinkta „Vue.js“, o dėl lankstumo ir galimybės greitai plėsti bei modifikuoti duomenų struktūrą pasirinkta „MongoDB“ (NoSQL duomenų bazių sistema). Užklausoms valdyti naudotas „Express“. Realizuota paieškos funkcija smarkiai praplečia įprastas tekstines užklausas – vartotojams suteikiama galimybė ieškoti ne tik pagal tekstinius metaduomenis, bet ir pagal muzikinį turinį. Skaitmeninė fortepijono sąsaja leidžia tiesiogiai vesti natas ir atlikti tam tikras transformacijas. Taip pat realizuotas muzikinio segmento parinkimo įrankis, leidžiantis grafiškai pažymėti norimas natas. Šis pasirinkimas iš karto atvaizduojamas natų paieškos skiltyje, kur vartotojas gali papildomai redaguoti pasirinkimą ir atlikti transformacijas. Paieška atliekama per visas oktavas, taip atrandant tolimas, iki tol nežinomas sąsajas. Ši išplėstinė paieškos galimybė leis tyrėjams, pedagogams ir atlikėjams greitai atpažinti ir palyginti fortepijoninius kūrinius pagal jų muzikines ypatybes.

„Verovio“ buvo pasirinktas kaip trečiosios šalies sprendimas, integruotas į žiniatinklio programą, kad būtų rodomos natos ir teikiamos standartinės funkcijos, kurias numato „Verovio“. Redakciniai skirtumai rodomi kita spalva, o kiekvienas taktas susietas su muzikiniu fragmentu iš skirtingų šaltinių (jei toks yra priskirtas). Prie kiekvieno kūrinio vartotojas gali peržiūrėti skaitmeninius rankraščius, publikacijas, PDF failus. Taip pat pateikiamas redakcinių skirtumų skaičius ir kritinis fortepijoninės muzikos tekstas. Atlikus paiešką pagal muzikinį fragmentą, rasti sutapimai vaizduojami kita spalva, nurodant, kiek tokių fragmentų rasta kiekviename kūrinyje. Įgyvendinta duomenų struktūra leidžia nesudėtingai pridėti papildomus atributus, jei atsirastų poreikis, ir įtraukti vertimus ne tik lietuvių ir anglų kalbomis. „Docker“ buvo naudojamas programoms sudėti į konteinerius ir paleisti kiekvieną atskirai, savo aplinkoje. Be to, visos šios programos buvo sujungtos į vieną konteinerį, sudarant vientisą sistemą.

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