

# Overview of NIME Techniques Applied to Traditional Korean Instruments

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## ABSTRACT

This article offers an overview of the technological advancements in traditional Korean music instruments, also known as Gugak. The projects detailed in this article show how sensors, physical controls, alternative designs and materials, and software development can be used to enhance performance options and adapt to modern performance settings and needs. Although there are fewer Gugak NIME projects and research available compared to Western instruments, this genre has the potential to inspire various areas of ongoing research, such as specialised signal processing, sensor applications, and interactive educational platforms. This paper is also the first review article that summarises the current state of technological advances and applications specifically for Gugak instruments and musical genres.

## Author Keywords

Korean-traditional music genre, Gugak NIME, comprehensive summary, augmented instruments, software, educational controllers, performance control

## CCS Concepts

- General and reference → Document types → Reference works
- Human-centred computing → Interaction design → Interaction design process and methods → Activity centred design
- Software and its engineering → Software notations and tools → Software libraries and repositories

## 1. INTRODUCTION

Although other forms of ‘national music’ genres exist across countries within East Asian cultures, the term ‘Gugak’ is specifically used to encompass the musical, cultural, and historical elements used within the Korean Peninsula. Throughout the formation and growth of the culture within Korea, there have been periods in history when foreign cultural elements from various countries were imported and absorbed. Influences from Chinese culture and Western cultural components have been introduced, integrated, and then individualised to the Korean people’s needs and cultural evolution. However, there has been a gradual loss of Korean culture preservation and an increased favouring of the more recent influx of contrasting differing Western cultural elements and values. Institutionalised efforts to recover and re-establish

traditional Korean cultural elements, such as Gugak [1], [2], [3], are continuously being. These efforts have acknowledged the changing technologically-heavy environment in which it competes [4], [5], and have adjusted themselves to fit within this modern context [6]. Modern Gugak has accommodated this by experimenting with digitalising Gugak timbre, recording methods, alternative musical instrument design and materials, as well as educational processes in order to support the changes within performance settings.

This article will summarise many of the existing NIME projects within the Gugak community today and discuss future research and methods. It also serves as an overview and foundational source for other English-speaking researchers interested in Gugak or other East Asian traditional instrument modifications that require non-westernized technological methods.

## 2. THE FOUR DEVELOPMENT CLASSIFICATION

Current Gugak NIME projects can be grouped into four key development spaces, which expanded from the preliminary research and development of Gugak alternative digital sound production methods via receiving and projecting acoustic sound.

### 2.1 Receiving and Projecting Acoustic Sound

Today’s performative and artistic setting has significantly changed compared to what was considered standard during the last century. Performance spaces have expanded into alternative spaces such as online, interactive, and outdoor venues [4], requiring acoustic instruments to adapt. The physical and acoustic design of Gugak instruments was not created to project the volume needed to fill today’s more extensive performance and fusion orchestration settings. Also, the growth of fusion orchestration, mixing Western instruments with Gugak instruments, created an issue of sound projection balance within these new ensembles.

While Gugak-specific microphone techniques and placement have been researched (in particular [7] and [8]), several NIME projects have experimented with embedding pickups onto traditional instruments for consistent amplified sound production. Pickups within these projects were either attached to an existing acoustic Gugak instrument, as in Seung-Gi Park’s electric gayageum [9], and Ajay Kapur et al.’s eHaegeum [10], or inspired the creation of a new instrument developed with the intention of embedding amplification technologies. Oriental eXpress, led by Young-Jun Choi, developed the iHaegeum and iJanggu to prototype Gugak instruments with embedded piezo



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disk pickups [10], [11], [12]. Dae-Hong Kim et al. removed both the physical resonant cavity and strings from its haegeum instrument design to allow the AirHaegeum to be a completely digital performative controller [11] [12]. Jae-Eop Yoo developed Arang-e [13], and Dong-Hyun Kim et al. created four electric Gugak instruments: the Supersound Gayageum [13], Geomungo, Haegeum, Ajaeng [14], and Janggu as commercial options for amplified Gugak instruments.

## 2.2 Physical Instrument Design and Materials Affected by Added Amplification Technologies

As seen in Choi [15], Kim [12], and Supersound's [13], [14] Gugak instruments, removing elements no longer necessary for the instrument's function allowed for an organic physical redesign of these traditional instruments. Due to the use of amplification technologies, such as piezo disks or electromagnetic pickups, the need for a physical acoustic instrument body was no longer required as they were replaced with digital libraries of instrument timbre sound production. Without the functional need for a quality wooden resonant cavity (Figure 1), several Gugak NIMEs opted for alternative designs and materials that only maintained a skeleton frame for the purpose of prototyping new technology [16].

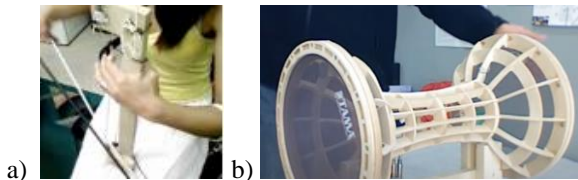


Figure 1. a) iHaegeum and b) iJanggu skeleton frame design allowed for technology prototyping

Carbon Fiber is also widely used in projects like Arang-e [17], [18] and the Supersound instruments [19] due to its durability, weight reduction, consistent manufacturing methods, and excellent sound propagation material. This lighter material allowed for more freedom on performance stages as they could be worn (Figure 2), rather than constricted to the traditional stationary sitting position [19]. The AirHaegeum [11] (Figure 3), utilised a 3D-printed plastic frame to allow flexible design possible without considering traditional bowing placement, pegs, bridges, and string fixtures [11].



Figure 2. These Supersound electric instruments demonstrate another example of the use of diverse materials and design compared to Figure 1



Figure 3. AirHaegeum removed the physical strings and bow, causing a considerable change to the instrument design and materials

Gugak NIME projects that maintained the original design of acoustic instruments have repurposed the optional resonant cavity for other functionalities (Figure 4). Some of them, like the eHaegeum, eJanggu [10], and Arang-e [15], have utilised the space to accommodate electrical components such as control units, boards, and batteries.

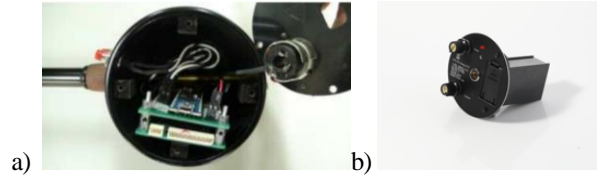


Figure 4. a) eHaegeum created a housing cover for the open end of the instrument cavity b) Arang-e created a separate electronics module that could be inserted into the cavity space

Although alternative designs and materials allowed for diversified performance controls and simplified instrument-building methods, they do have some disadvantages. Altering the overall look and familiar design and materials of the instruments often introduces the debate of whether the instrument is an extension of the acoustic instrument or a completely different instrument merely inspired by it. For example, Lamtham Hantrakul's the Fidular project [20] featured a modular instrument system intended to represent many variations of Asia's two-stringed bowed transverse fiddles, including the Korean haegeum. As seen in Figure 5, this project would more likely be more accepted than the AirHaegeum [12] or Supersound's instrument [19], which was created with the original instrument design in mind.



Figure 5. Fidular has interchangeable resonant cavities, soundboard skin plates, string materials, and pegs that can construct twelve variations of two-string-bowed fiddles from around Asia

## 2.3 Expanded Control Options

Many of the above-mentioned Gugak NIME projects have included volume control in the form of a physical or digital dial as a necessary component of digital sound production control. Apart from volume control, some projects such as eHaegeum, eJanggu, Arang-e, airHaegeum, iJanggu, daegeum [21] and janggu [22], take the sound produced by the instrument through an intermediary stage. This stage allows sound effects and parameters to be added to the raw signal before it is projected. The controls for these sound effects and parameters are an assortment of knobs, switches, and buttons displayed on the instrument (Figure 6). They can be reprogrammable and trigger various visual and sound effects while playing, thereby diversifying the player's capabilities [10].

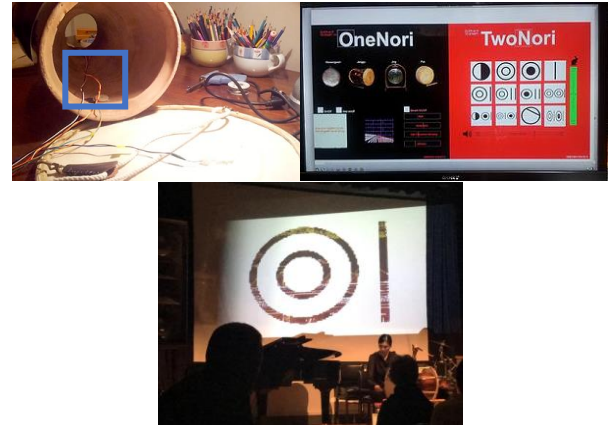


**Figure 6. a) eHaegeum and b) eJanggu controls featuring knobs, switches, and buttons to control performance effects. c) Arang-e had a supplementary case that featured two Bluetooth speakers and an onboard effects control unit d) A flat stone-like sensor apparatus with an accelerator and tilt sensor (used as a bow alternative) could be re-programmed to control alternative timbres and visual effects**

Interactive visuals controlled by Gugak NIME have been occasionally explored since Jin-Hi Kim's electric geomungo in 1998 [23], [24]. Choi's iJanggu was repurposed from a performative musical instrument to a programable controller for various settings, such as interactive gallery installations and interactive contemporary dance performances [25]. Other Gugak NIME projects, such as Young-Mi Kim et al. (Figure 7) [26] and Deborah Kim (Figure 8) [27], were initially created with the intention of using the instrument as a trigger for visual control.



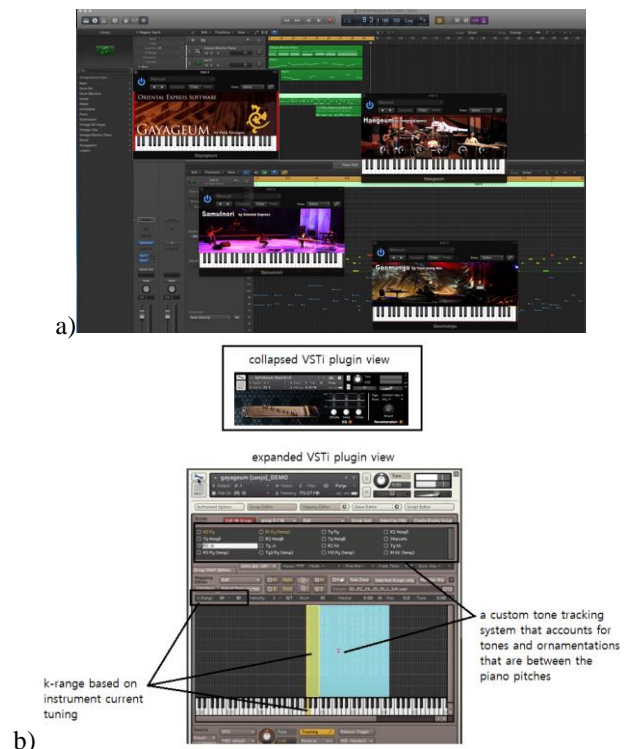
**Figure 7. By sensing the amount of air pressure applied through the attached mic on the daegeum, a traditional Joseon bamboo illustration's opacity and length could be controlled**



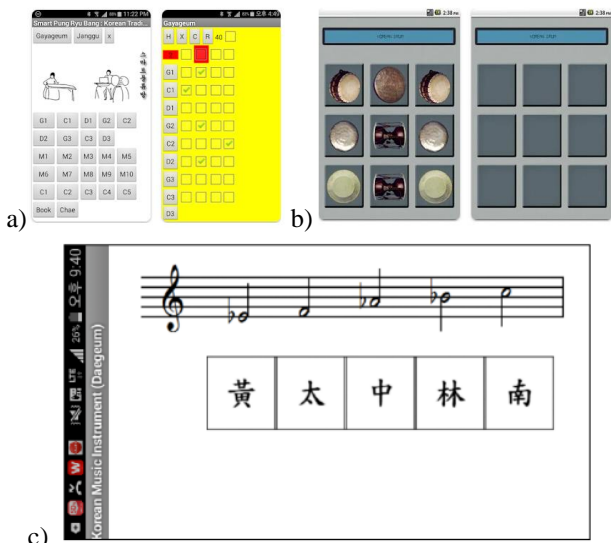
**Figure 8. Piezo sensor attached inside the Janggu allows the audience play a pattern that triggers changes to the electro-interactive music installation**

## 2.4 Supporting Software Development

In recent years, there has been a significant increase in the development of digital instruments for producing non-acoustic sounds. This has led to continued research into recording practices and guidelines for achieving the timbre of traditional Korean Gugak instruments. A growing interest in expanding this genre of music into the digital world has led to more efforts to officially record Gugak instruments and the creation of virtual instrument libraries [28]. For individuals who may not have access to Gugak physical instruments or players for their desired orchestration, virtual Gugak instrument library plugins for digital workstations (DAWs) and mobile apps were created by Oriental eXpress [15], Center for Arts & Technologies Seoul National University (CATSNU) [29], [30], Kyung-Gook Min [31], Young-Joo Park et al. [32] provide accessible options.

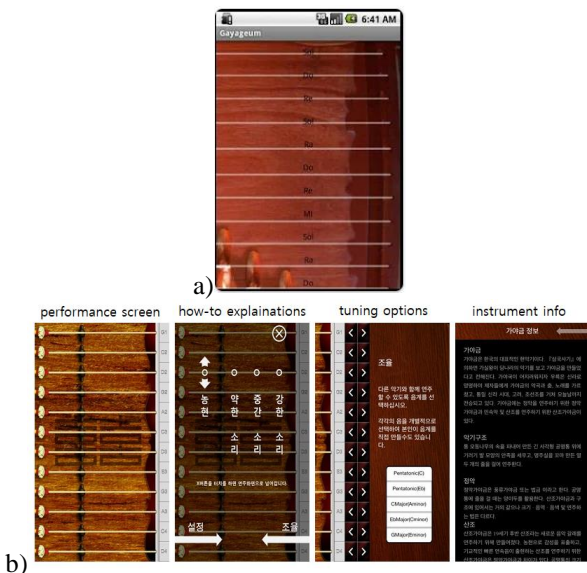


**Figure 9. a) Oriental eXpress and b) CATSNU Gugak VSTi plugins allow for Gugak instrument timbres in DAWs but feature a non-genre-compliant piano input method**

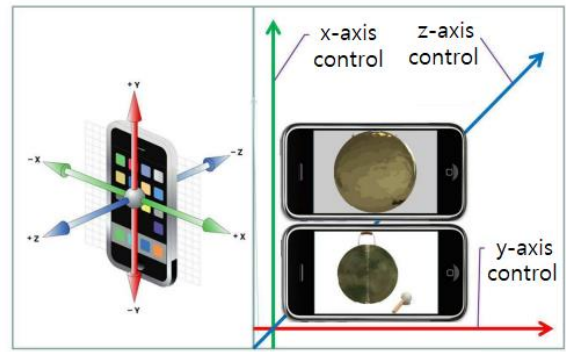


**Figure 10. Familiar Western systems while creating a) gayageum and janggu step sequencer app b) samulnori percussion app to target a global audience c) 5-staff notation**

The Gugak software examples discussed in this context showcase varying degrees of Westernized musical components instead of native Gugak parameters (Figure 10). It is understandable why these applications utilize universally familiar Western concepts such as piano keyboards (Figure 9), step sequencers, and AKAI MPC-style pads (Figure 10), considering their practical audience and use. However, there is a need for further exploration to create genre-correct, yet understandable, inputs to accurately represent the Gugak timbre and genre parameters.

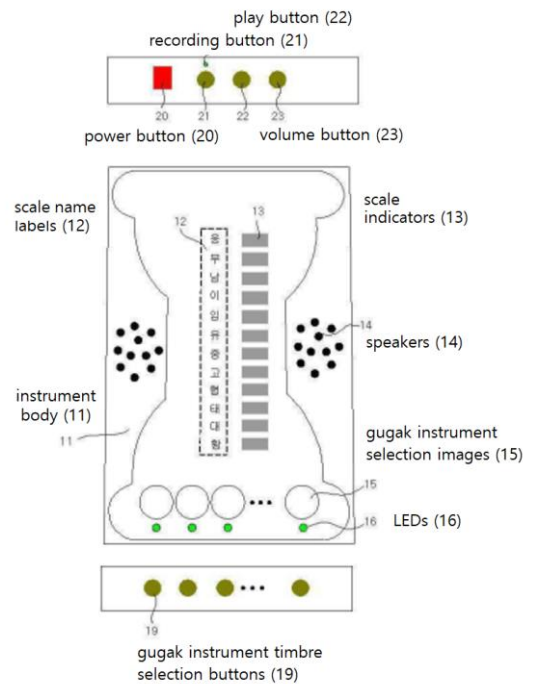


**Figure 11. A comparison example of a digital 2D performance instrument of the sanjo gayageum [a 12-string transverse instrument] created by a) Oriental eXpress b) CATSNU**

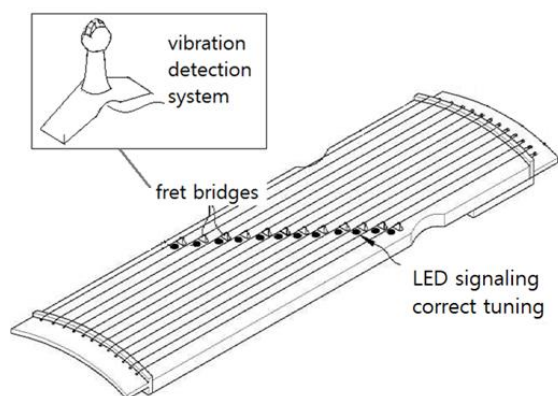


**Figure 12. Phone Gyroscope sensor used to control three tones and length of the resonant ringing of the jing (a gong)**

[33], [31] and [32] have demonstrated, in their respective projects, alternative options for mimicking live instrument performance parameters via mobile apps (Figure 12) while also including elements that educate users on Gugak-specific characteristics (Figure 11). Aside from these software-based education approaches, physical educational Gugak projects exist, such as Soo-Mi Kim et al., who created a physical multi-instrument Gugak controller intended for children to familiarise themselves with their country's traditional genre instrument timbre and music characteristics (Figure 13) [21]. Bo-Eun Kim's interactive tuning corrective system (Figure 14) [22], was developed to target specific Gugak-related musical concepts. Although these cannot be utilised directly to support performances, such projects encourage continued targeted research to fill the knowledge gaps within Gugak NIME. This allows for further globalisation, preservation, and diversification of the genre and expands the research of alternative forms of interaction and education.



**Figure 13. Multi-instrument Gugak scale controller that allows for interchangeable instrument timbre selection along with recording capabilities**



**Figure 14. Independent tuning detection units and notification systems on the gayageum to aid beginner players in maintaining their tuning while playing**

### 3. CONCLUSION AND FUTURE WORK

This article provides a summary of the current state of development and projects in Gugak NIME. It illustrates how Gugak NIME projects evolved once the development of Western digitalized audio techniques was reapplied to this ‘national music’ genre. The goal of solving acoustic amplification issues expanded into other fields of research, including embedded pickups, external physical control options for sound, multidisciplinary performance mediums, and alternative instrumental design and materials. We believe modern Gugak is currently in a period where it has drawn on foreign (Western) cultural and technical elements but has started to individualize them by developing systems and methods that fit the distinctive characteristics and needs of the Korean musical genre. Ultimately, in order to further promote and preserve this fading genre, educating the new generation of learners is crucial [34].

Although demonstrating specific Gugak techniques and musical elements has been made more accessible with the rise and accessibility of video-formatted instruction and recorded excerpts, most of these materials for beginner non-professional audiences are created in the Korean language, therefore limiting the accessibility for foreign learners. Many platforms have been developed for Western instruments, such as the piano, featuring a physical interface and complementary educational software (seen in [35]); there has yet to be an educational platform that allows interactive modules that provide personalised feedback on the curriculum material. We will address this gap by proposing an inclusive and authentic application and recognition of Gugak musical characteristics and components within a responsive digital interface.

The proposed Gugak education platform aims to implement effective subsystems that will enable novice learners to learn and self-correct Gugak musical features accurately while preserving the underlying cultural importance. While Western systems are familiar, they cannot fully encompass all aspects of the unique Gugak genre. By valuing the natural elements of Gugak, this alternative education approach will promote a new generation of performers who value the genre, thereby preserving this key Korean cultural element.

### 4. ETHICS STATEMENT

This paper's contribution consists of a review and synthesis of existing works, with no aspect of this work involving human or animal participants.

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