New Interfaces for Traditional Korean Music and Dance

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ABSTRACT
This paper describes the creation of new interfaces that extend traditional Korean music and dance. Specifically, this research resulted in the design of the *eHaegum* (Korean bowed instrument), *eJanggu* (Korean drum), and *ZiOm* wearable interfaces. The paper describes the process of making these new interfaces as well as how they have been used to create new music and forms of digital art making that blend traditional practice with modern techniques.

Keywords
Hyperinstrument, Korean interface design, wearable sensors, dance controllers, bowed controllers, drum controllers

1. INTRODUCTION
The age of the microchip has enabled ubiquitous computing to permeate culture internationally. Many new devices including smartphones, multi-touch tablets/iPads, and depth camera's Kinect, have changed the way in which we interact with each other, while putting new tools in artist's hands to create novel modes of creative exploration. However, as a society, as we move further into the future, we must continue to look in to our past to extend traditional techniques into modern practice.

In the NIME community, the advent of the hyper-instrument has been a strong technique of bridging past with the future. Machover's hypercello [1], Truman's Bossa [2], Young's Hyper Bow [3], Bahn's sBass [4], Overholt's violin [5] are a few instruments that inspired musicians to look at their traditional performance practice, and find new ways to extend possibilities by adding sensors, microcontrollers, and custom software for audio signal processing. Through many of the hyperinstruments are based on Western music, there have been explorations into music forms from the rest of the world, and how they can be digitized in a similar fashion. The first author developed a series of Indian classical based instruments known as the *eTabla* [6], *eDholak* [7] and *eSitar* [8], while others like Diana Young's Aobachi wireless stick worked on extending Japanese drumming [9]. Combining the rich performance practices from around the world with new music techniques lays the framework for a future of interdisciplinary experimentation.

The goal of the research described in this paper is to design new interfaces inspired by traditional Korean music and dance forms. Specifically, Section 2 gives a brief overview to traditional Korean music. Section 3 describes the design of a hyper-instrument called the *eHaegum*, a modified Korean bowed instrument. Section 4 describes the design of the *eJanggu*, a modified Korean drum. Section 5 describes the design of the *ZiOm*, a wireless gesture capturing system for both music and dance. Section 6 describes how all these new instruments were put together into a production called *Rabbit in the Moon*.

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2. TRADITIONAL KOREAN MUSIC
Korean traditional music [10] can be divided into two types: The first are folk traditions that include musical groups performing percussion bands and folk songs; The second comes at the professional end, being more classical in nature. This classical music has two major genres including, *p'ansori* (epic storytelling for solo singer accompanied by *puk* drum) and *sanjo* ("scattered melodies" for solo instrument and *Janggu* drum accompaniment). Shaman music is situated between the two, performed by professional ritualists, but identified closely with the people.

Over 65 instruments are used in Korean traditional music today. Some were originally imported from China, and survive today in court rituals, while others are Korean inventions. Korean instrumental timbres tend to be soft, but always incorporate elements of noise: the plucking of a silk string- rather than metal; the sound of a plectrum hitting wood after a string is struck; the sound of air on a wind instrument typically using oversize blowing holes or oversize reeds.

In Korean traditional music, rhythm can be more important than melody. Rhythmic cycles, constantly repeating patterns with fixed downbeat and an internal code of stresses and accents, underpin virtually all music, and ensure no musician gets lost. Rhythmic cycles are metrical and the most common time signatures are 6/8 and 12/8, giving a waltz-like groove to the music.

Pentatonic scales are often used in Korean Music, with even more restricted scales with three basic tones characterizing folksongs in the Southwest. The Chinese system on which Korean court modes are based, actually includes all 12 semitones of Western music, but from this palette specific tones are chosen. The exact tuning of notes varies from instrument to instrument. Precision is relative, and this gives Korean music a plaintive sound. Melodic contour is less important than the treatment of individual tones. Thus, every vocal and instrumental line is full of ornamentation, particularly before or after the main pitch of a tone. Korean music has virtually no harmony. However. Different instruments use different ornamentation, which when combined can sound heterophonic.

3. HAEGUM INTERFACE DESIGN

3.1 Traditional Haegum

The *Haegum* [11] (shown in Figure 1) is a two-stringed fiddle-like traditional Korean string instrument. It is played vertically held on the left knee, with a bow scraped against two silk strings with the right hand. It produces a nasal tone and piercing sounds, as it has no finger board and musicians pull the strings to get to the desired pitch. *Haegum* is traditionally said to be "*pal-um-gu-bi* (八音具備)" and "*bisa-bijuk* (非絲非竹)," literally meaning "made with eight materials (metal, rock, thread, bamboo, gourd, soil, leather, and wood)" and "non-string, non-wind." Though in structure and playing method, it looks like a string instrument, in orchestral contexts it is considered to be more like a wind instrument because of its ability to sustain tones.

Figure 1 - Picture of traditional Haegum

3.2 eHaegum Interface Design

The design of the *eHaegum* had many challenges. First of all, the *Haegum* has a very small cavity to install electronics, so the design incorporated the Arduino micro and two small custom built shields to connect the sensors and buttons. A key design element was to encase the electronics in the instrument itself, (rather than have an electronic box off the instrument) so that the *eHaegum* was easier for a traditional player to just pick up and plug in a USB cable and a TRS cable (rather than some strange assortment of cables leading to a box next to the computer).

Figure 2 shows the sensors layout for the *eHaegum*. An accelerometer was installed inside the body of the instrument, and a second accelerometer was installed on the leather strap of the bow. A force-sensing resistor (FSR) was installed to fit underneath the bridge to gather data on how the left hand squeezes the strings while manipulating pitch. A series of buttons and switches were installed into the shell of the instrument to make it easy for the musicians to change patches and settings. Our team worked with a *Haegum* maker to modify the instrument and install the electronics. Figure 3 shows the completed design.

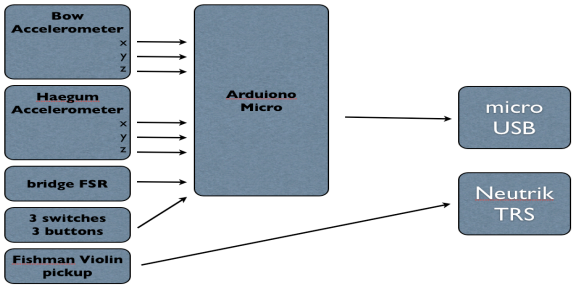

Figure 2 - *eHaegum* sensor layout

Figure 3 - *eHaegum* final design with electronics installed inside the traditional instrument.

4. JANGGU INTERFACE DESIGN

4.1 Traditional Janggu

Janggu [11] (shown in Figure 4) is the most widely used instrument for *jangdan* (rhythmic pattern) among the Korean drum family. It is used in practically every form of Korean music. It consists of an hourglass-shaped body with two heads made from animal skins. The two heads produce sounds of different pitch and timbre, which are believed to represent *yin* and *yang*. Different sizes are used for different types of music: *A-ak* (a large sized version of the *Janguu)* is used in folk music, while *Jeong-ak* (a small sized version of the *Janggu*) is used with dancers, who carry it suspended from one shoulder, held diagonally to their torso.

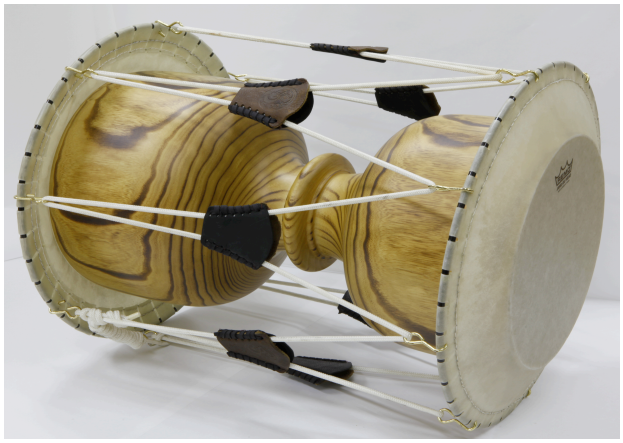

Figure 4 - Traditional Janggu: two sided Korean Drum

4.2 eJanggu Interface Design

The design of the *eJanggu* involved many experiments with how the modification would effect the sound the instrument. One major test involved using a laser cutter to construct a custom plug inside the instrument to separate the sound of the left and right cavities to eliminate cross talk from the two microphone installed on either side. It was found, as expected, that this greatly effected the bass response of the instrument. However it did greatly improve the isolation of each microphones as clean signals in the mid-frequency range.

Figure 5 shows the sensor layout of the *eJanggu.* Sensors were embedded into the *eJanggu* in a similar fashion to the *eHaegum*. Knobs and buttons were embedded directly into the shell of the instrument, as seen in Figure 6. Because the *Janggu* has a much larger cavity, the Arduino MEGA was chosen as the microcontroller with options for many more analog-to-digital converters and digital pins for design. The accelerometer was embedded, so that when the *eJanggu* was

used with a dancing performer, they would get control of 3-axis of acceleration data. Two infrared sensors were installed as shown on right of Figure 6. This configuration was chosen to capture data about how the *Janggu* is performed traditionally. There is a technique where the left hand crosses the drum and performs both sticks on the right hand skin. The infrared sensors were installed to sense what direction the hand is moving (left to right , right to left) so that the software can have intelligence on weather both hands are on the right hand skin or if each hand is on either side of the drum.

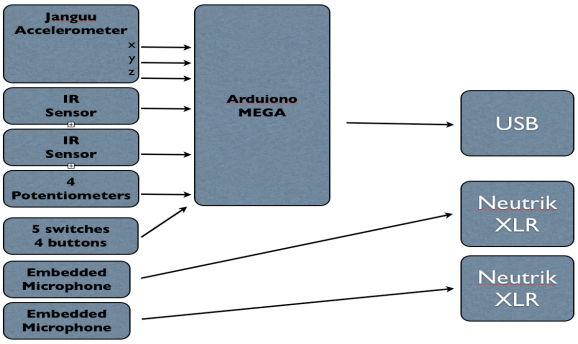

Figure 5 - *eJanggu* sensor layout

Figure 6 - *eJanggu* showing placements of embedded USB jack, knobs, switches, buttons, IR sensors

5. ZiOm INTERFACE DESIGN

The *eHaegum* and *eJanggu* were interface designs for specific instruments. However, our team has the desire to accelerate the impact of this hyperinstrument paradigm and interaction of technology with traditional Korean musicians. Thus a design for a wearable sensor that can be worn by all performers, regardless of instrument was designed. This was inspired by the first authors early work in building the *KiOm* [12]. The problem with the *KiOm,* (a wearable accelerometer to MIDI controller) was that it had a heavy 9-volt battery and had to be wired by a MIDI cable. The *ZiOm* is a modernization of this technology; a wireless wearable interface for musical gesture extraction.

As seen in Figure 7, the *ZiOm* uses a 3-axis accelerometer connected to an Arduino Fio to send signal to the computer via XBee. The *Fio* is built to work with a lightweight lithium rechargeable battery, which makes the *ZiOm* very user friendly. Figure 8 shows the *ZiOm* fully assembled. A Velcro strap-able wristband was designed with two pockets that could hold the lithium battery and the *Fio* assembly. Thus, any musician could easily strap the *ZiOm* to their wrist and perform their instrument, getting a gesture signal and an audio signal. A dancer could also use these devices to send gesture signals to control sound and visuals. The *ZiOm* had so many possible uses that our team built four *ZiOm*s that could all wirelessly send data to one XBee receiver. These four units are shown in Figure 8.

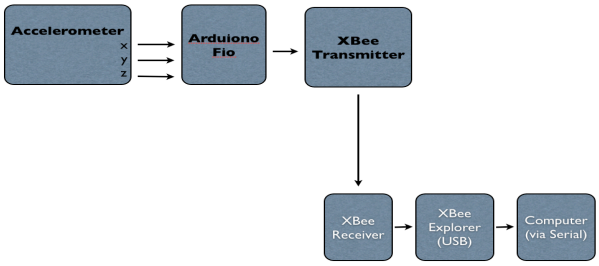

Figure 7 - *ZiOm* signal flow via XBee wireless communication

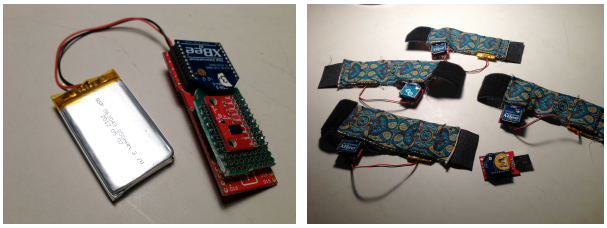

Figure 8 - *ZiOm* assembled with custom strapable wrist bands

6. PERFORMANCE

The most important part of making an interface, is using it in a performance. This allows the research team to "complete the circle" and fully test all issues that may arise from the first generation of an instrument design. To accomplish this goal, our team created a production called *Rabbit in the Moon.* This story is based on the Korean Buddhist fable from the *Jataka Tales*. In the story, a rabbit sacrifices himself for the betterment of the society, and a spirit permanently inscribes a rabbit image into the face of the moon for all to remember. In our abstract rendition of this story, the rabbit represented tradition, and the moon represented technology, and the merging of both at the end of the show is essential in creation of a future path.

In this production all the interfaces were used in conjunction with professional Korean performers. The *eHaegum* was performed by Eun-Il Kang who with the help of Han-Shin Kim's Max-MSP patch, was able to create octave shifted signals whose resonances' were controlled by the accelerometer data from the body of the instrument. The *eJanggu* was performed by Yong-Tae Lee, again with the help of Han-Shin Kim's Max-MSP patch, was able to create a new form of repeating cycling loops that he could switch on and off from the interface itself. He also used the infrared sensors to control parameters of filter effects through out the piece. Figure 9 shows pictures of these two performances.

Figure 9 - Eun-Il Kang performing *eHaegum*; Yong-Tae Lee performing *eJanggu*

The ability to use the *ZiOm* to work with traditional Korean dancers was a huge motivation for the third author. Inspired by *PikaPika* [13] and the ability to use accelerometers to control sound and visuals seemed a great way to delve into a path of modernization of Korean dance. Three experiments blending Korean choreography and technology were implemented.

The first piece was a collaboration with a *Salpuri* [14] is dancer. *Salpuri* is a Korean dance form that involves slow traditional music that a dancer performs with a light scarf as seen in Figure 10. In this piece, we simply put a *ZiOm* on the right hand wrist of the performer, and used the data to control real time video effects of the live film of the scarf being projected on the screen behind the dancer.

In the next piece a single dancer had the ability to use *ZiOm's* strapped to each hand to control robotic events on the KarmetiK robotic instruments: MahaDeviBot and RattleTron. This piece started with the performer in the audience, moving their arms to make abrupt robotic strikes. Slowly the performer comes visible to the audience and it becomes clear that she is in control. She finds her way to the robots, and when she touches them, they magically awake and start playing a rhythm. The performer realizes that with each hand, she can control the velocity of the drum stokes. This exploratory interaction takes place until the dance disappears off stage.

In the third piece called "whisper" (shown in **Figure 11**), three dancers control the robots. One at a time the dancers enter the stage, controlling the arms of the robots assigned to them. As the dancers interlock and start to perform together, the robots fast pulsing rolls start to interlock together. As the piece continues, the choreography gets more united as the robots begin to play louder and louder based on the gestures of the dancers. The Korean dancers used traditional techniques throughout this piece in this successful blend of tradition and modern technique.

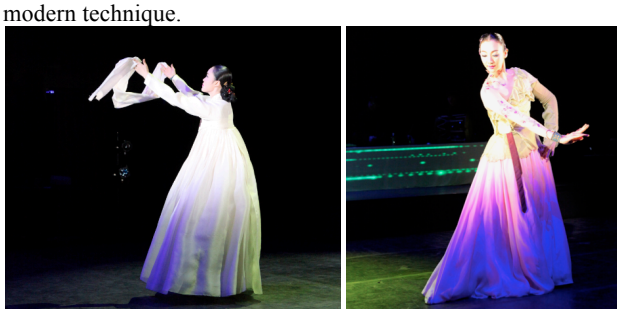

Figure 10 - Salpuri dance

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Figure 11 - Three Dancers performing "whisper" controlling robotic events with their movements

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