# A Research on Music Generation by Deep-Learning including ornaments

## - A case study of world harp instruments-

Arturo Alejandro Arzamendia Lopez, Akinori Ito, Koji Mikami

Tokyo University of Technology

g312200180@edu.teu.ac.jp, akinori@edu.teu.ac.jp,
mikami@stf.teu.ac.jp

**Abstract.** In this research, we explore the application of deep learning techniques, including recurrent neural networks and LSTM, to traditional Paraguayan music known as "Guarania". This style is characterized by specific playing techniques and ornaments such as arpeggios and glissandos, which are executed using the Paraguayan harp. The learning and generation processes are performed individually using the TensorFlow and Keras libraries comparing the different results from different architectures to identify which one generates the most accurate or similar harp music that captures the intricacies of "Guarania" style. Furthermore, in future work, we demonstrate the capability of these techniques in other world harp music styles, such as Meiji period music employing the Koto, and western music from the 19th and 20th centuries incorporating the concert harp.

**Keywords:** LSTM, Guarania, Musical Ornaments, Glissando, Arpeggio, Tremolo.

## 1    Introduction: Paraguayan Identity

Paraguay, a landlocked country nestled in the heart of South America, has its own unique history and culture, which may not be as widely recognized externally but is deeply rooted in the hearts of Paraguayans. This identity, referred to as "Paraguayidad" (Paraguayan-ness), is shaped by a history of war and immigration, bilingualism (Guarani and Spanish), geographical isolation, among other factors. The primary means of expressing this Paraguayan national identity is through folkloric music [1].

Despite the deep-rooted and widespread nature of this Paraguayan identity within the country's culture, its music is barely recognized outside its borders and there are few examples of scientific research dedicated to it. This situation has led to the initiation

of this research, which focuses on Paraguayan music and employs contemporary deep learning techniques for music generation. The aim is to raise awareness about the existence and beauty of Paraguayan culture while simultaneously exploring the capabilities of deep learning in a slightly different context.

## 2    Paraguayan Music Styles: Guarania and Paraguayan Polka

In the Paraguayan folkloric repertoire there are two major musical styles: Guarania and Paraguayan Polka.

The Paraguayan Polka is a rhythmically lively song, with a 6/8-meter, diatonic harmony, and the use of hemiola and syncopation in rhythmic patterns [2]. Due to its lively nature, it is more popular in rural areas, as it is well-suited for dancing and festive celebrations.

On the other hand, Guarania, it was created by musician José Asunción Flores in the early 20th century as a way to express the character of the Paraguayan people [3]. While it shares melodic and harmonic features with the Paraguayan Polka, Guarania is slower and imparts a more nostalgic, sentimental feel resonates predominantly in urban areas.

Both styles, can be performed in various ways, including orchestra arrangements, guitar renditions, and vocal interpretations. However, the most cherished and traditional instrument in Paraguayan culture for playing them is the Paraguayan harp (Diatonic Harp), known for its charming melodies, driving rhythms, and rich ornamentation. Some of the best know Guarania pieces include "Recuerdos de Ypacarai" (Memories of Ypacarai) [4] and "Mis Noches sin Ti" (My Nights Without You) [5]. For the Polka, a representative piece is "Pájaro Campana" (Bellbird) [6].

## 3    Musical Ornaments

Musical ornaments, in music, refer to additional notes added to a melodic line to enhance interest, variety, and expressiveness in a song or musical piece. For string instruments like the harp, some common ornaments are:

- Glissando: A glissando is a rapid slide between two or more notes, played fast and in succession. It creates a smooth and sliding effect, producing a seamless transition between pitches.
- Tremolo: Tremolo is the rapid reiteration of a single musical tone or the alternation between two different tones, producing a trembling or quivering effect.
- Arpeggio: An arpeggio is a broken chord, where the individual notes of a chord are sounded one after the other in a progressive rising or descending order.

## 4      LSTM Model Experiment

In this experiment, the Guarania piece "Lejania" composed by Herminio Gimenez was utilized. The model was designed with an LSTM layer containing 512 neurons, followed by a 3-neuron dense layer outputs for predicting the pitch, duration of the note, and step time.

The pitch was represented by an integer value ranging from 1 to 128, which corresponded to all possible MIDI note values. The duration of the notes was measured in seconds, while the step represented the time interval between the start of the previous note and the current note, also in seconds. Each note in the sequence was represented by these three values.

For training the model, various experiments were performed with sequences of 25,12 and 5 notes that was fed into the neural network, which then outputted a prediction for the next note. The objective was to enable the model to learn the patterns and structures present in the Guarania piece and generate music that resembled the style of the original composition. The following section presents the best results.

**Table 1.** Additional Hyperparameters.

| Hyperparameter | Value |
| --- | --- |
| **Optimizer** | Adam |
| **Epochs** | 1000 |
| **Loss (Pitch)** | Sparse Categorical Cross entropy |
| **Loss (Duration, Step Time)** | MSE |

## 5      Results

After training the model with the mentioned Guarania music and the specified hyperparameters, a generation test was conducted to evaluate the effectiveness of the model in creating similar Guarania music.

Throughout the training process, the loss function was monitored, and it showed a decreasing trend as the epochs increased, indicating that the model was learning from the data. However, for the 25-note sequence, the resulting MIDI file exhibited sparse notes scattered randomly, failing to form any recognizable melody or musical structure. On the other hand, the 5-note sequence displayed a greater variety in note durations and even included some short notes resembling an ornament known as an appoggiatura (a short note before a longer note).
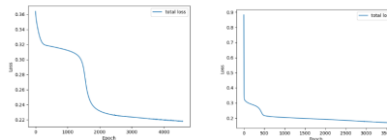


**Fig. 1.** Loss Reduction for 25 and 5-Note Sequences Over Epochs.
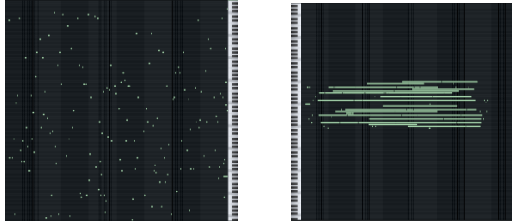
**Fig. 2.** Results for 25 and 5-Note Sequences.

## 6    Exploring Solutions for Improved Music Generation

One of the key challenges in deep learning for music generation is the requirement of a large dataset to capture all the intricate details, including the ornaments. These details are often scattered throughout the music, making it essential to have numerous examples for the machine to learn and replicate accurately.

Another challenge lies in the model used for music generation. The current model only considers a limited size note input during the generation process, neglecting the context of the entire music piece. This limitation can make it difficult for the model to capture and generate the intricate nuances, such as ornaments.

To tackle these challenges, we are exploring alternative models, including transformers or models with attention mechanisms, and expanding the dataset with additional Guarania music.

## 7    Future Work

In the future, we plan to explore and compare the effectiveness of alternative models in music creation. We will investigate how different architectures perform in generating music, including harp music from the 19th and 20th centuries and Japanese koto music.

## References

1. Krüger Bridge S. 2019. Paraguay: History, Culture, and Geography of Music Sturman JL. The SAGE Encyclopedia of Music and Culture :1661-1663 Sage.
2. Krüger, S (2019) Paraguay: Modern and Contemporary performance practice. In: Sturman, JL, (ed.) Sage International Encyclopedia of Music and Culture. Sage.
3. 「The Rise of the Guarania a musical style that is Paraguay's own」, https://soundsandcolours.com/articles/paraguay/the-rise-of-the-guarania-a-musical-style-that-is-paraguays-own-4321/, last accessed 2023/08/02.
4. "Recuerdos de Ypacarai"., https://youtu.be/uYjOtUimp20, last accessed 2023/08/02.
5. "Mis Noches sin Tí"., https://youtu.be/ddD57JxMHaA, last accessed 2023/08/02.
6. "Pájaro Campana ". https://www.youtube.com/watch?v=RrsyNPxqnCI, last accessed 2023/08/02.