# AMIGO: An Assistive Musical Instrument to Engage, Learn and Create Music


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## ABSTRACT
We present AMIGO, a real-time computer music system that assists novice users in the composition process through guided musical improvisation. The system consists of 1) a computational analysis-generation algorithm, which not only formalizes musical principles from examples, but also guides the user in selecting note sequences; 2) a MIDI keyboard controller with an integrated LED stripe, which provides visual feedback to the user; and 3) a real-time music notation, which displays the generated output. Ultimately, AMIGO allows the intuitive creation of new musical structures and the acquisition of Western music formalisms, such as musical notation.



## Author Keywords
Interactivity, Machine learning, Machine improvisation, Musical Notation.

## CCS Concepts
• **Applied computing → Sound and music computing**; Performing arts


## 1. INTRODUCTION
Existing generative music systems for educational purposes, such as *Andantino* [7], are rooted in improvisational musical practices, which have been greatly advocated by distinguished 20th century pedagogues (e.g., Dalcroze [3] and Swanwick [6]). A complementary approach focus on the use of computational tools to assist in the acquisition of formal principles from music theory and practice. *Flowkey* and the *Illuminating Piano* [2, 4] are representative examples, which use keyboards with lighted keys to drive user actions (i.e., performance).

AMIGO merges the aforementioned lines of research by expanding the latter approach to the generation of novel (improvised) musical structures beyond the reproduction of existing music. In this context, AMIGO is not planned to be an autonomous self-taught system, neither in its current version nor as a concept. The purpose is to complement and stimulate the music learning process. The intelligence of the system relies on its capability to derive probabilistic models of note transitions from existing musical examples encoded in the MIDI format. The model of note transitions is then used to interactively guide users through the selection of notes in a composition. A computer screen translates user actions into musical notation, which can be edited and retrieved at a later stage.




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**Figure 1. MIDI controller mounted with a LED stripe.**

## 2. AMIGO
Figure 2 shows the two main hardware and software component modules of AMIGO, which together with the user, establishes a closed feedback loop.

The hardware component is a MIDI keyboard mounted with an LED stripe on a wooden board and is used to provide a visual feedback to the user as shown in Figure 1. The software component is responsible for the analysis and generation of musical content and the graphical user interface (GUI) of the system as well as displaying the system output as musical notation. The human in the loop (representing the user perception, cognition, and action) is the primary driver of the system.

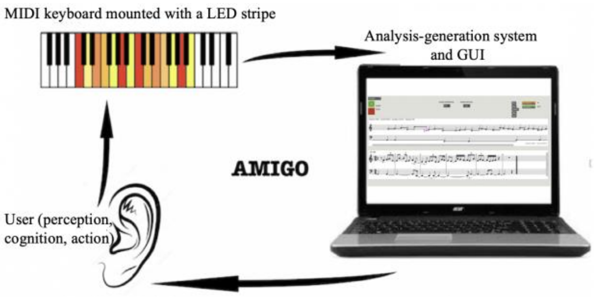


**Figure 2. AMIGO main component modules.**

AMIGO assists users in the selection of pitch content in a treble melodic line which is superimposed to an automatically generated basso ostinato, extracted from the MIDI input file. To this end, it indicates in the LED stripe the distribution of probabilities of all notes in a range of one octave according to the stylistic information of a musical example. The software component is responsible for modeling the pitch content of an input MIDI file (i.e., learning its pitch structure). Moreover, it includes the GUI of AMIGO, which shows the real-time music notation to the user. This visual feedback aims at indirectly acquainting users with the symbolic signs of music notation.

## 2.1 Analysis-generation system

AMIGO analysis-generation algorithm learns both the vertical and horizontal dimensions of input musical examples encoded as a MIDI file. It aims at creating a graph-based model that stores the probabilities of the 12 tones within an octave to 1) vertically align with a given bass note and to 2) horizontally succeed a previously selected note. Roughly, these two dimensions can be understood as capturing the harmonic and melodic structure of a musical example. These graph models are then mapped into a color code in the LED stripe, which guides the user action in the note selection process.

The modeling of musical structures relies on two algorithms: 12 note histograms to capture the vertical dimension and the transition table from a Markov chain algorithm for the horizontal dimension [1].

Histograms are used to represent the distribution of the observed data [5]. In the case of our system, for each of the 12 chromatic notes, represented numerically and sequentially from 0 (C) to 11 (B), a different histogram is created. For each bass note they represent the (frequency) distribution of vertical notes in the original example.

A square matrix storing transitions between sequential pairs of notes in the melodic (treble) line of the input MIDI file establishes the basis for creating the probabilities of transitioning horizontally (i.e., melodically). Similar to the representation used in the histograms, the notes are reduced to 12 values representing the total chromatic set within an octave. The resulting matrix is then used to predict transitions during generation, following the typical approach of Markov chains in symbolic music generation.

During performance, AMIGO linearly combines the vertical and horizontal probabilities. The computation of new probabilities is triggered either by a new bass note (which is automatically sequenced and generated by the system) or by the selection of a new note in the treble melodic line played by the user.

## 2.2 Keyboard controller with LED stripe

The MIDI keyboard in AMIGO is the main system component where user actions are performed. It captures note-on (onset) and note-off (offset) instructions from the user, which are then processed by the analysis-generation system. To guide these user actions an LED stripe was assembled on a wood bar and mounted on the keyboard. For each key there is a corresponding LED (see Figure 1). The LED stripe is connected to AMIGO via an Arduino that receives instructions from the analysis-generation system. During performance, every new set of probabilities cause the LEDs change color, ranging from shades of yellow to red, to inform the user the probability of a particular note 'fitting' the current bass note and melodic shape.

## 2.3 Graphical User Interface

We created a GUI for AMIGO, for which a screenshot is shown in Figure 3, to allow the user to visualize the musical output using music notation. This includes two main scores. The upper score displays the bass line and the note instructions from users in real time by associating time to spatial distances between notes. The lower score displays a metrical version of the musical output by quantizing the temporal information into rhythmic values within the time signature of the original MIDI file. Changes to pitch and duration can be done at later stages by user manipulations of both of these representations. Moreover, the GUI allows the user to export the scores as MIDI files.

**Figure 3. AMIGO's interface displaying the music notation feedback.**

## 3. CONCLUSIONS AND FUTURE WORK

We presented AMIGO, a piece of assistive musical technology for the intuitive creation of musical structures and the acquisition of Western music formalisms from exposure. We briefly detailed the algorithms and mechanics behind our system. In particular, we propose a technique that combines histograms and square transition matrices exposing harmonic and melodic structural features from musical examples to assist users in the generation of new structures. Ultimately, AMIGO aims to easily introduce users to the creation of structures that resemble existing music using an engaging method that can be applied to novice users or children in the initial music training phase. We believe that the possibility to have the music notation feedback can help user to become acquainted with some Western music formalisms. For further information and demos, please refer to the following link: https://sites.google.com/site/amigomusicalamigo/home/amigo

In future work, we plan to have a new iteration of AMIGO, which extends the analysis and generation from simple bass and melodic lines to more complex harmonic structures, aiming to promote a more engaging user experience. Furthermore, the GUI design will be studied, adapted and tested for specific target user groups. Finally, a thorough evaluation of AMIGO, to capture its potential in engaging users in music creation and the acquisition of formal music knowledge, will be pursued.

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