An Algorithm for Guiding Expectation in Free Improvisational Solo Performances

José Fornari, Stéphan Schaub

Núcleo Interdisciplinar de Comunicação Sonora (NICS) – Universidade Estadual de Campinas
Rua da Reitoria, 165 – 13083-900 Campinas, SP

tutifornari@gmail.com, schaub@nics.unicamp.br

Free improvisation lets the performer to openly explore musical outcomes unbounded by any musical structure or notation. However, the human mind is naturally constrained by its own built-in habits. As such, musicians usually develop, during years of practice and aesthetic predilections, a repertoire of self-known musical patterns which are intentionally, and sometimes unconsciously, retrieved and used by them during improvisations.

This work presents an algorithm that aims to retrieve in real-time similarities during sessions of free improvisation of certain specific sound features so the musician can better manage his repertoire of musical patterns instead of be unconsciously guided by habits.

There are several audio features in music that composers and performers manipulate in order to express its aesthetic intention. Some of the most basic ones (also known as lower-level or non-contextual features) are: Loudness (perception of sound intensity), Pitch (clarity and perception of sound fundamental) and Timbre (perception of the sound dynamic frequency spectral shape and distribution). Lower-level features are free of cognitive ground, also known as Context, thus occurring in a time frame smaller than the notion of “now” in music, also referred as Specious Present [1]. This introductory work focusses on the expectation of a single and simple lower-level musical feature: Loudness.

Equal-loudness contours, also known as Fletcher-Munson curves, empirically describe the relationship between intensity and frequency for a simple (sinusoidal) sound. Loudness is thus dependent on the intensity and frequency of each partial that creates sound. In music production, Loudness is loosely associated with RMS (Root Mean Square) of the intensity of an audio signal, despite the fact that RMS doesn't take into consideration the frequency of the fundamental (also known as F0) as well as the frequencies of the higher ones that together compound the sound we hear.

In this work we considered 4 Loudness Levels (LL), which are labeled by their musical terms, in Italian. From quiet to loud, they are: pp (*pianissimo*), p (*piano*), f (*forte*) and ff (*fortissimo*). As the musician performer, in our case, of a melodic musical instrument, carries out his/her improvisation, each note played will presents its own particular LL, that can be quantized into one of the 4 categories mentioned above. As the performance develops along time, the accumulation of LLs for each note played during improvisation is shown in a histogram, thus offering to the performer a graphical dynamic feedback depicting the frequency of each LL occurrence.

For each one of the 4 LLs, a simple Forgetting Curve was also implemented [2]. This function describes the decline over time of human memory as well as cognitive attention for a particular repeating event, such as the LL of sequential notes in an improvised melody. This algorithm, compound of LL histograms increased by similar occurrences of Loudness and decreased by the time lag between similar events (modulated by a simple forgetting curve), aims to introduce a simple model of melodic expectation based on LLs.

Music Expectation is a term used in the field of Music Cognition that refers to the study of listener's automatic (and sometimes unconscious) mental strategies used to predict musical events. The engagement in this continuous task of listening prediction is referred by David Huron as Anticipation [3]. There are several models of musical expectation described in the literature, such as: the Implication-Realization (I-R) [4], the system and contrast model [5], the Margulis's model of melodic expectation [6]. Huron's general theory of expectation introduces an event timeline known as ITPRA (Imagination, Tension, Prediction, Reaction and Appraisal) which offers an explanation for the fact that music is so efficient to engage the brain into formulating predictions (expectations) of future musical events while listening to music, thus evoking emotions in the listener through mental responses of reward or punishment respectively associated with correct or incorrect musical outcome predictions [3].

This simple algorithm was programmed as a patch in Pure Data (Pd), version 0.47. Pd is a well-known free software platform for the programming of real-time data processing (specially for live performances and multimodal artworks). The figure below shows the referred patch frontend with the implementation of the LL prediction model, within the subpatch (the box in the left side) entitled “loudness-layers”.

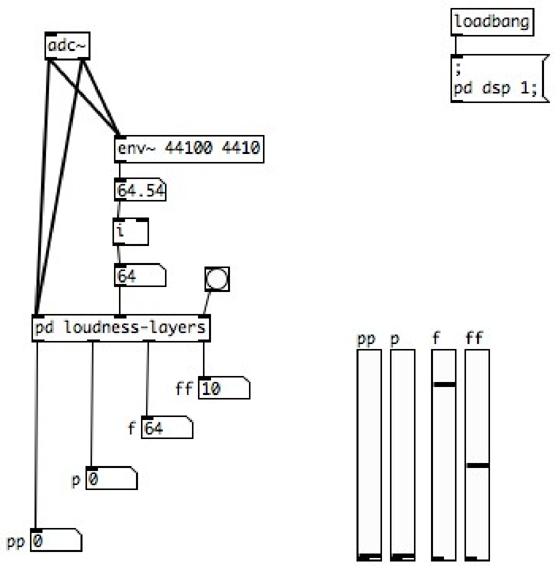

Figure 1: The loudness expectation patch

The four vertical slides, shown in the bottom right side of this figure, correspond to the LL histograms that show in real-time the increasing accumulation and decreasing forgetting factor of each LL during a musical performance.

This model intends to help the performer to guide the improvisation in order to avoid the excessive repetition of a particular sound feature state (in this case, Loudness), as well as to enable this performer to intentionally repeat a state in order to build up a particular intended emotional state generated by the listener's expectation. In future models other sound aspects can be researched and used to guide the performer during sessions of free improvisation, such as: pitch accumulation, timbre resemblance, pulse pattern detection, and so forth. With such set of tools the performer shall be able to better explore his/her musical endeavors during sessions of free improvisation in order to better manipulate and guide the cognitive process of expectation and anticipation present in the minds of all listeners.

References

[1] Andersen, Holly and Grush, Rick (2009) A Brief History of Time Consciousness: Historical Precursors to James and Husserl. Journal of the History of Philosophy, 47 (2). pp. 277-307.

[2] Loftus, Geoffrey R. (1985). Evaluating forgetting curves. Journal of Experimental Psychology: Learning, Memory, and Cognition. 11 (2): 397–406. doi:10.1037/0278-7393.11.2.397.

[3] Huron, David (2006). Sweet anticipation: music and the psychology of expectation. M.I.T. Press. ISBN 9780262582780.

[4] Narmour, Eugene (1992). The Analysis and Cognition of Melodic Complexity: the Implication-Realization model. University of Chicago Press. ISBN 0-226-56842-3

[5] Bimbot, Frédéric; Emmanuel Deruty; Gabriel Sargent; Emmanuel Vincent (June 2012). Complementary report to the Article "Semiotic structure labeling of music pieces: concepts, methods and annotation conventions (Proceedings ISMIR 2012).

[6] Elizabeth H. Margulis (2005). "A model of melodic expectation". Music Perception.