Strategies for Narrative and Adaptive Game Scoring

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Abstract. In this paper we briefly introduce the narrative concepts of interactive media music. Therefore, an organic correlation between music and the interactive scenario is essential. We elaborate and discuss the two basic strategies to enable an adaptive musical accompaniment. The real-time arrangement of precomposed music incorporates innovative musical structures, but often lacks flexibility, whereas an automatically generated musical soundtrack opens up great potential for the application of automatic composition systems, although their results are often said to be of minor artistic quality. Thus, we will furthermore introduce a third so far sparsely regarded approach—the hybrid combination of artistically qualitative precomposed music and flexible generative techniques. These open up new and prospective perspectives for the field of adaptive and interactive music.
This paper structures the innovative upcoming field of non-linear music with special regard to game scoring. A contrastive discussion will compare the potentials and limitations of the compositional and generative approaches and the newly introduced hybrid approach. For a stronger musical coherency we elaborate structure protective adaption principles.

1 Introduction

Film scoring is said to be the role model for computer and video games music. But while films are static and linear, computer and video games are generally interactive and non-linear. From this ontological difference, two major qualitative drawbacks emerge:

1. Music, as a linear art form as well, is hardly able to organically follow an interactive scene. To the disadvantage of coherency of musical flow and content, abrupt cuts are largely used to resynchronize music and interactive scene.
2. The musical linearity is one of the major obstacles that prevent a closer linkage to the interactive scene in respect of content. There is a considerable lack of media theoretical awareness on the narrative functions music is able to perform. Thus, game developers rarely tap the full potential of music as an instrument of expression, narration and comment.

The adjacent section 2 will give an introduction to the historically evolved functions of media music and lead to a wider range of narrative responsibilities in interactive media (e.g., computer/video games). Therefore, an adaptive and organic musical accompaniment is essential. Sections 3 and 4 will describe the two conventional basic strategies to tackle this problem, i.e., precomposed and algorithmically generated music. A further minor explored approach will be introduced and discussed in section 5. Section 6 concludes this paper.

2 Narrative Music

Combining music with different media is not new. This so called media music can be found in the earliest forms of appearance of music. Its traditional connection to movement, dance and text is well known and bred famous classical art forms like ballet, theater and opera. To an increasing degree, the composers see their role not only in decorating and duplicating non-musical content, but in mediating its deeper meaning and reflecting on it with musical means.

A typical example can be found in Felix Mendelssohn Bartholdy's oratorio Elijah. To mediate the primitivity of the prayer to the false god Baal, he used a simplistic harmonical language and counterpoint in contrast to Elijah's musically sophisticated prayer to his god. Another famous example is the final chord of Johann Sebastian Bach's St. Matthew Passion with an upwardly resolving dissonance—untypical in baroque music and thus extraordinary flashy to the coeval ear—suggesting resurrection and Easter [7, 12].

In theater, and its descendant the film, music plays a more subconscious role. In both, visual layer, sound and dialog are dominating and consciously perceived while music has to be subordinate to them in terms of its structure and development. However, this subconscious perception does not imply a minor importance within the dramaturgy. The more subconscious music acts, the more it can condition the audience in a desired manner and stimulate their perceptual direction.

Its suggestive power can sensitize the audience to emotional and analogous contents of the visuals [26]. Furthermore, its combination with images and words spans an association space of amazing unambiguousness [21]. Schneider calls this a *semantization process* [26]. Music becomes meaningful as a narrative medium that does not just express emotions and mood, but becomes a means for the expression of associations and non-verbal comments.

It can even challenge the meaning of the visuals as Eisenstein, Pudowkin, and Alexandrow describe in their famous Manifesto [11]. They distinguish between audio-visual *parallelism* and *counterpoint* in terms of the relation between music and image. Parallelism comprises those musics that follow the visual content. They express contents that are also visible in the scene (e.g, its mood, themes related to visible characters, micky mousing etc.), whereas the audio-visual counterpoint describes music that controverts the scene. It enriches or even changes the superficial meaning of the images: A happy scene accompanied by scary dissonant music seems to hide a serious invisible danger. In this way, the music acts as the speaking tube of the author. Several musicologists, like Pauli [25] and Thiel [27] supplemented this classification by a third class, comprising those musics, which add new non-visible content but do not controvert the scene, *affirmative picture interpretation and illustration*.

A more detailed contemporary classification of musical narrative functions is given by Johnny Wingstedt [29]. He distinguishes the following six classes of functions.

Emotive Class:
- emotionalize content and acting;

Informative Class:
- communication of meaning;
- communication of values;
- establishing recognition;

Depictive Class:
- describing settings;
- describing physical activity;

Guiding Class:
- attention guidance;
- masking (out) of unwanted or weak elements (e.g., projector noise, bad acting);

Temporal Class:
- provide continuity;
- define structure and form;

Rhetorical Class:
- comment, make a statement, judge.

In connection with the temporal functions, Wingstedt states: "In interactive non-linear media, such as computer games, music's ability to provide continuity is an important quality with strong potential."[29] Music helps to integrate the disrupted episodicness of the cut scenes to a whole. It connects visually separate locations of a virtual world into a bigger continuous and more believable whole.

Current computer and video games rarely apply at least a few of these functions and pauperize at a banal entertaining, at best a parallelism-based score concept. Thus, the pool of musical narrative means is extremely underdeveloped.

However, since background music in games is perceived and understood in the same way as film music [19], it can by all means perform all its narrative functions and even more. It can expand the bandwidth of information flow by disencumbering and complementing the visual channel, and support the user/player in controlling and managing complex structures (e.g., in strategy games) [19]. Its associative power can furthermore be used to influence his playing behavior and decision process. Afterwards, music can convey a response in terms of a moral comment etc.

In this role, it does not just refer to an actor on screen but to the player himself and reaches him on a more personalized and intimate level than ever. Music can take a stand on interaction as an *audio-interactive counterpoint*. This, amongst other educationally interesting potentials, lies idle today. In [2], we give a detailed discussion of this narrative concept which is only possible in interactive media.

For the success of such more sophisticated and ambitious narrative concepts the *dialectic unity of form and content*—well known to every artist—is essential. It is not enough to play a suitable piece of music and stop it when the scene ends. Like film music, interactive media music has to organically correlate with the development in the scene. Asynchronously cut music—as widely used even in contemporary up-to-date top-selling games—destroys inner-musical coherency and flow. The indifferent relation between music and scene is conspicuous; its functions seem enforced and contrived, not organic and plausible. A new type of music (not necessarily style!) is needed that is able to organically follow an interactive scene, a non-linear music that can automatically and flexibly be adapted. *Adaptive music* is needed. The following sections will discuss the three strategies to tackle this problem.

3 Precomposed Music

The musically coherent scoring of interactive scenes is a problem that the computer and video games industry is aware since approximately two decades. Hence, some of the most important solutions arose from this context. The scientific interest on this topic is much younger and began to sprout in recent years.

The so far most impressive and qualitatively best solutions incorporate not just a technical but also a compositional treatment of the problem. Precomposed music does not necessarily have to be static and linear. It can feature special structural attributes that abet a formally more open and unsealed musical layout. The performer—in this case the computer or more precisely the music engine—can deal with precomposed material and rearrange it in realtime, even during the performance.

It is at the responsibility of the composer to invest these structural attributes within his musical conception and enable such an automatic arrangement. This can feature three different characteristics: (1) a manipulation of performance-related means of expression, (2) the arrangement of the timely sequential order of musical sections, and (3) the arrangement of simultaneously playing tracks/parts.

3.1 Expressive Performance Manipulation

Without changing the composition in any way, its character of expression can already be varied by a change of its performance style. A smooth cantabile melody may appear romantic; the same melody in a faster tempo and a staccato articulation appears snappy. The potential of such performance means is used extremely rare.

One of the earliest examples of such music adaptions can be found in the classic arcade game *Space Invaders* (Toshihiro Nishikado, 1978). A repetitive stepwise descending four-tone sequence illustrates the approaching of hostile UFOs. The closer they come, the more increase speed and difficulty of the game. Likewise, the tempo of the four-tone sequence accelerates and mediates an increasing suspenseful precipitance.

The MIDI-based system *REMUPP*, presented by Wingstedt et al. [30], allows tempo changes as well. Additionally, a couple of further performance parameters can be edited, namely: articulation, reverberation, pitch transposition to different octave levels, and a timbre change by selecting different predefined instrumentation sets. These changes are applied while the playback proceeds uninterrupted.

Thus, the work with performance aspects includes the use of tempo, articulation, timbre, acoustical and technical effects, as well as, the change of dynamics (loudness) and time signature based emphasis schemes. Applying these aspects to a given piece of music premises a suitable and in detail editable representation format; wave based audio formats (e.g., Wave, MP3, and Ogg Vorbis) are inapplicable. The MIDI format is a better choice, although its direct use in games scoring decreased during the past decade because of the deficient and varying sound synthesis quality of home computer soundcards. However, this problem can be overcome by sample libraries (e.g., the famous *Vienna Symphonic Library* [28]), since they are already widely used in film scoring and the studio production of games music.

3.2 Sequential Arrangement

In the tradition of classical musical dice games (well-known is that of Mozart [24]) most adaptive game musics are composed as a rearrangeable sequence of musical sections. Examples can be found in *No One Lives Forever 2* (Monolith Productions, 2002, scored by Nathan Grigg) and *Unreal 2* (Legend Entertainment, 2003, scored by Jeremy Soule).

If interactive events necessitate a music change (e.g., the player enters a different location or is attacked), the currently playing music section will continue uninterrupted to its end where the first section of the new music joins seamlessly. Of course, the composer has to take care of the melodic, harmonic, and metric connectivity of all possible consecutive sections. To furthermore smooth this change, the developers of *Gothic 3* (Piranha Bytes, 2006, scored by Kai Rosenkranz) retouch it with different percussive effects.

More elegant is the approach of the *iMuse* engine created by Land and McConnell [20]: Jump marks can be defined at every position in the piece. They can be activated during the playback and trigger a continuation on a different position in the same or another piece. Furthermore, every mark can reference to a specialized transitional cue that leads smoothly from the particular musical context to the other piece. Applied in MIDI, these marks can also trigger changes of instrumentation, velocity, tempo, transposition, and stereo panning. The *iMuse* engine is the most sophisticated representative of the sequential arrangement that approaches and demonstrates its manifold abilities in lots of famous Lucas'Arts computer games (e.g., Monkey Island 2–4, X-Wing, and Tie Fighter).

3.3 Arrangement of Simultaneous Tracks

To get a smooth transition between two pieces of music one might be tempted to cross-fade them. Unfortunately this does not work in general. During a cross-fade both musics are hearable. The metrical and harmonic overlays of independent unsynchronized pieces generally sound quite confusing and unintentionally dissonant to the listener.

Nonetheless, cross-fading is an expedient tool for music transitions, provided that the music meets some special demands: All tracks have to be played back synchronously and are composed bearing in mind that they have to harmonize with each other. Now a cross-fade appears more appropriate although the second music, to which the cross-fade bridges, will usually not start at the beginning. But since it emanates coherently from the musical flow, it will still sound believable.

The aforementioned *REMUPP* system uses multiple tracks to change the harmonic and rhythmic complexity of a piece of music by adding or muting several parts and percussion tracks. In [3] we furthermore incorporated a distance attenuation model into the fading mechanism to automatize location-based music transitions. Since the synchronous tracks have to be musically compatible, cross-fade transitions tend to be relatively local; the change cannot be as drastic as it might be wished sometimes. Therefore, we applied the sequential arrangement strategy for further music changes which can be triggered, amongst others, by story related events.

These examples show that the creative application and combination of all the arrangement techniques for precomposed music opens up a wide range of possibilities. Since all music is precomposed, a high compositional and artistic quality can be ensured. But this is expensively paid with higher compositional effort, complexity, and a limited flexibility. Often, the music change is a long time coming because the playback has to finish a section or meet a jump mark first. These drawbacks may be less distinctive when music is generated in realtime according to interactive events or the state of the virtual world.

4 Generated Music

Generative concepts, in contrast to precomposed ones, also incur the music composing. Since most composition systems generate static concluded pieces, they are of secondary interest for the scoring of interactive scenarios. Thus, this elaboration will concentrate on those systems that stand exemplary for realtime music generation concepts that include interactivity in some way. Generally, music changes are triggered by modifications of parameters or templates.

A typical example is Biles' *GenJam* [4] that plays in duet with a human performer and improvises via a genetic algorithm approach on his musical input. Another example is Chapel's fractal-based *Active Musical Instrument* [8]. The user defines iterated functions and modifies their parameters during playback. Although aesthetically very interesting, complex, and consistent due to the nearness to serial music, this system as well as *GenJam* incorporate an actively co-performing user to continuously affect and support the system with new inspired musical ideas and material. A subconsciously listening user is insufficient.

With regard to the autonomous generation of an adaptive continuous musical accompaniment, Casella's *MAgentA* system [6] seems promising. It incorporates multiple composition algorithms and maps them to specific emotions (e.g., one for happy music, another one for sad music). If the state of the virtual scene changes, an appropriate algorithm is selected and continues the generation of background music. This concept bears great potential and leads to a new problem. For a smooth and proper transition between the musics of two algorithms (i.e., two different compositional styles!), methods for a progressive style modulation [10] are needed.

This problem as well as the description and modelling of compositional styles are widely unsolved today. Composition systems only apply contrapuntal characteristics but miss the manifold variety of meta-structural features that express the style establishing way a composer handles them to achieve a specific expression. Furthermore, orthography and grammar are not enough to create a senseful expressive natural language text. The creative process of music composition is more than a contrapuntal optimization problem; it includes the definition of a piece-specific contrapuntal material and the structure establishing application and breaking of this material in an innovative new-creating way. With the words of Harold Cohen: "Creativity is not a random walk in a space of interesting possibilities, it is directed."[9]

The human artist, whether composer or performer, is still indispensable! His inclusion as an inherent part of the concept is what the well-deserved success of *GenJam* is based on [5]. And this is the promising potential of *MAgentA*—the different composition algorithms can be procedural descriptions for very specific well-composed pieces of music that include, for instance, variation and adaption techniques. E.g., Hörnel's neural-network-based melody variation techniques can be applied for this [17, 18, 16]. Thinking about such an equal combination of human and machine leads to the new, so far sparsely regarded, hybrid approach.

5 Hybrid

Both previous concepts—precomposed music that is automatically arranged, and generated music—have their benefits and drawbacks. There is high artistic quality but limited adaptiveness on the one hand, and high flexibility but weak meta-structural coherency on the other hand. The idea arises to combine both concepts and overcome the drawbacks of one by the advantages of the other one: high quality precomposed music that is not just arranged but can be flexibly adapted. Up to now, few research has been done in this direction. Hence, there is only a small number of approaches on music adaption.

5.1 Music Adaption

In 1968 Mathews et al. had the idea to represent the pitch and rhythm of melodies as functions of time and demonstrated a running arithmetic interpolation between two folk tunes [23]. They started with *The British Grenadiers*, turned it into *When Johnny Comes Marching Home*, and ended back with the Grenadiers. Although the authors describe their results as "nauseating" and "jarring", they are not uninteresting, especially for serial music. Of course, since this interpolation does not conveniently consider, e.g., tonality or motific patterns, it is hardly suited to bridge classical and popular tonal melodies or polyphonic structures.

The idea to achieve music transitions by some kind of interpolation was renewed by the *MusicBlox* concept of Gartland-Jones [13, 14] and the Music Morphing strategies of Wooller and Brown [31]. Given the start and end patterns of the transition that belongs to the corresponding precomposed musics: during the transition the start pattern is repeatedly played and with every iteration gradually reshaped towards the end pattern. Gartland-Jones realizes this with an evolutionary approach. Wooller and Brown describe three further approaches: the *interpolation* which is conceptually much alike that of Mathews, the *mixture* of start and end pattern fragments, and the *markov morphing* which might be better understood as an alternating use of two different transition matrices that describe the voice leading characteristics of the two patterns and generate a new one from them.

A further music adaption concept is presented by Livingstone et al. [22]. They suggest to change the character of expression of the one running piece of music by editing specific musical parameters, e.g., tempo, articulation, mode, harmonic and rhythmic complexity. In contrast to the aforementioned *REMUPP* system, they realize these changes with a rule-based approach: nontrivial, considering, e.g., the complex harmonic, melodic/motific, rhythmic, articulation—generally speaking meta-structural—interrelationships that have to be kept to ensure musical coherency. Again, style modulation is a challenge to be addressed.

5.2 Structure Protective Adaption

So far, really coherent music adaption is not achieved. The few recent projects concerned with this challenging and even musicologically interesting topic open up a number of promising starting points. Nonetheless it must be clarified that adaption techniques will violate the composition and cannot succeed if they do not consider the music's immanent structural features. For an adequate adaption of precomposed music that can even pass before its composer, its meta-structure has to be incorporated to give inconsistencies no chance and save musical flow.

For a stronger coherency, we suggest the application of music adaptions at the running musical material. The repetition of sections during the transition conflicts with the postulate of organic flow and has to be refused. Instead, the piece of music has to continuously play on.

Adaptions have to be structure protective and cause as little change as necessary to realize different expression characteristics or to allow a seamless transition and connection to the destination music.

Such changes should not be applied from any position in the piece but at structural boundary points. A halfway played theme or motif should not be changed or at least very carefully and unobtrusive, but its next appearance can. The starting points for the variation of a melodic phrase are its beginning, its cumulative/gestural destination points (e.g., melodic peaks), and its end (which is usually the beginning of a new phrase)—likewise, harmonic progressions. Furthermore, metrical changes (e.g., tempo changes) should only be applied at boundary points or lead to them target-oriented (e.g., ritardando and accelerando).

Hence, these macro-structural boundaries give information about appropriate starting points for the application of adaptions. Furthermore, the structure characteristics of the particular meta element give clues and limitations for protective variations. E.g., a melodic motif may be defined by the diatonic intervals and interval directions between its single notes. A rhythmic variation, a transposition, or even small interval changes in the semitone space would not destroy its motific structure but are mighty instruments to adapt the motif to a different harmonic base.

Generally, the musical morphology differentiates variations by two aspects [1]:

Subject of Variation: The *direct variation* is applied to the theme/motif, whereas the *indirect variation* retains the theme/motif unchanged but varies its accompaniment.

Type of Variation: The *strict variation* saves the harmonic and architectural characteristics of the theme/motif. Its shape and gestalt quality stay unchanged. On the other hand, the *free variation* changes not just melodic and rhythmic aspects, but also harmonic and formal. Each one of such variation can afford new gestalt and quality.

Moreover, the example showed that meta elements provide lots of clues that can help to strengthen the target-orientation of variations. Strict variations are best suited for structure protective adaptions. To furthermore appear subtly unobtrusive, the variations should be indirect, whereas direct variations are suited to connect melodic lines and ensure their melodicity.

Therefore, a sufficiently extensive knowledge of the music's meta-structure is necessary. It can be provided by additional meta files that contain the results of, e.g., an automatic analysis. Since ambiguity is a common problem, we suggest a semi-automatic analysis, as described in [15].

6 Conclusion

In this elaboration we presented a systematization of the so far sparsely developed field of adaptive music. We differentiated three basic approaches that weight the role of the human composer and the music arranging or generating machine very different. The noticeably serious differences between precomposed and automatically generated music in terms of artistic quality and adaptability/flexibility make the hybrid approaches—although in their infancy—seem very promising. They leave the art creating process at the real artist, i.e., the human composer, and employ the machine beyond the humanly possible—the immediate adaption in response to interactive events in a virtual environment.

We have discussed the problems of the hybrid music adaption approaches with regard to inner-musical coherency and flow. The music's immanent meta-structure has to be considered to a much higher degree! Otherwise, adaptions and variations will perturb it. Therefore, we presented a new conceptional approach towards a structure protective music adaption technique.

Finally, a flexible musical accompaniment—whether precomposed, generated, or both in combination—is essential for an organic linkage with the manifold possible details and narrative aims of the interactive scenario and smoothes the way for interactive media music to become the weighty narrative instrument that its ancestor, i.e., linear media music, already is. Like film music, which had to develop appropriate structures for the connection to moving images half a century ago, interactive media music has to find its way, too.

References

[1] G. Altmann. *Musikalische Formenlehre—Ein Handbuch mit Beispielen und Analysen.* Schott, Mainz, Germany, 8th revised edition, jan. 2001.

[2] A. Berndt and K. Hartmann. Audio-Interactive Counterpoint. In *Sound, Music and the Moving Image*, University of London, England, sept. 2007. Institute of Musical Research.

[3] A. Berndt, K. Hartmann, N. Röber, and M. Masuch. Composition and Arrangement Techniques for Music in Interactive Immersive Environments. In *Audio Mostly 2006: A Conf. on Sound in Games*, pages 53–59, Piteå, Sweden, oct. 2006. Interactive Institute, Sonic Studio Piteå.

[4] J. A. Biles. GenJam: Evolutionary Composition Gets a Gig. In *Proceedings of the 2002 Conference for Information Technology Curriculum*, Rochester New York, USA, sept. 2002.

[5] J. A. Biles. GenJam in Transition: From Genetic Jammer to Generative Jammer. In *Proceedings of the 5th International Conference on Generative Arts*, Milan, Italy, dec. 2002.

[6] P. Casella. Music, Agents and Emotions. Licentiate thesis, Engenharia Informática e de Computadores, Instituto Superior Técnico, Universidade Técnica, Lisboa, Portugal, july 2002.

[7] E. Chafe. J.S. Bach's St. Matthew Passion: Aspects of Planning, Structure, and Chronology. *Journal of the American Musicological Society*, 35(1):49–114, spring 1982.

[8] R. H. Chapel. *Realtime Algorithmic Music Systems From Fractals and Chaotic Functions: Towards an Active Musical Instrument.* PhD thesis, University Pompeu Fabra, Department of Technology, Barcelona, Spain, sept. 2003.

[9] H. Cohen. A self-defining game for one player: on the nature of creativity and the possibility of creative computer programs. *Leonardo Music Journal*, 35(1):59–64, feb. 2002.

[10] P. Dickinson. Style-modulation: an approach to stylistic pluralism. *The Musical Times*, 130(1754):208–211, apr. 1989.

[11] S. M. Eisenstein, W. I. Pudowkin, and G. W. Alexandrow. Manifest zum Tonfilm. In F.-Z. Albersmeier, editor, *Texte zur Theorie des Films.* Reclam, 3rd edition, 1998. 1st release 1928.

[12] J. Freeman-Attwood. Review: St Matthew Passion. *The Musical Times*, 131(1767):265, may 1990.

[13] A. Gartland-Jones. MusicBlox: A Real-Time Algorithm Composition System Incorporating a Distributed Interactive Genetic Algorithm. In G. Raidl, editor, *Proceedings of EvoWorkshops/EuroGP2003, 6th European Conference in Genetic Programming*, pages 490–501, Berlin, Germany, 2003. Springer.

[14] A. Gartland-Jones and P. Copley. The Suitability of Genetic Algorithms for Musical Composition. *Contemporary Music Review*, 22(3):43–55, 2003.

[15] K. Hartmann, D. Büchner, A. Berndt, A. Nürnberger, and C. Lange. Interactive Data Mining & Machine Learning Techniques for Musicology. In *Conference on Interdisciplinary Musicology 2007 (CIM07)*, Tallinn, Estonia, aug. 2007.

[16] D. Hörnel. *Lernen musikalischer Strukturen und Stile mit neuronalen Netzen.* Shaker Verlag, Aachen, 2000.

[17] D. Hörnel and P. Degenhardt. A Neural Organist improvising baroque-style melodic variations. In *Proceedings of the International Computer Music Conference*, pages 430–433, Aristotle University, Thessaloniki, Greece, 1997. International Computer Music Association.

[18] D. Hörnel, J. Langnickel, B. Sieling, and B. Sandberger. Statistical vs. Connectionist Models of Bebob Improvisation. In *Proceedings of the International Computer Music Conference*, pages 244–247, Beijing, China, 1999. International Computer Music Association.

[19] K. Jørgensen. On the Functional Aspects of Computer Game Audio. In *Audio Mostly 2006: A Conf. on Sound in Games*, pages 48–52, Piteå, Sweden, oct. 2006. Interactive Institute, Sonic Studio Piteå.

[20] M. Z. Land and P. N. McConnell. Method and apparatus for dynamically composing music and sound effects using a computer entertainment system. United States Patent Nr. 5,315,057, may 1994. filed nov. 1991.

[21] Z. Lissa. *Ästhetik der Filmmusik.* Henschel, Leipzig, Germany, 1965.

[22] S. R. Livingstone, R. Muhlberger, and A. R. Brown. Playing with Affect: Music Performance with Awareness of Score and Audience. In *Australasian Computer Music Conference*, Queensland, Australia, 2005.

[23] M. V. Mathews and L. Rosler. Graphical Language for the Scores of Computer-Generated Sounds. *Perspectives of New Music*, 6(2):92–118, Spring–Summer 1968.

[24] W. A. Mozart. Musikalisches Würfelspiel: Anleitung so viel Walzer oder Schleifer mit zwei Würfeln zu componieren ohne musikalisch zu seyn noch von der Composition etwas zu verstehen. Köchel Catalog of Mozart's Work KV1 Appendix 294d or KV6 516f, 1787.

[25] H. Pauli. Filmmusik: Ein historisch-kritischer Abriß. In H. Chr. Schmidt, editor, *Musik in Massenmedien.* Schott, Mainz, Germany, 1976. modified in 1977 and 1981.

[26] N. J. Schneider. *Handbuch Filmmusik I: Musikdramaturgie im neuen Deutschen Film.* Verlag Ölschläger, München, Germany, 2nd edition, 1990.

[27] W. Thiel. *Filmmusik in Geschichte und Gegenwart.* Henschelverlag Kunst und Gesellschaft, Berlin, Germany, 1981.

[28] Vienna Instruments, 2007. http://www.vsl.co.at/.

[29] J. Wingstedt. Narrative functions of film music in a relational perspective. In *ISME Proceedings—Sound Worlds to Discover*, Spain, 2004. International Society for Music Education.

[30] J. Wingstedt, M. Liliedahl, S. Lindberg, and J. Berg. REMUPP—An Interactive Tool for Investigating Musical Properties and Relations. In *NIME -05—New Interfaces for Musical Expression*, pages 232–235, Vancouver, Canada, 2005. NIME -05.

[31] R. Wooller and A. R. Brown. Investigating morphing algorithms for generative music. In *Third Iteration: Third International Conference on Generative Systems in the Electronic Arts*, Melbourne, Australia, dec. 2005.