Control of Affective Content in Music Production

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Abstract. This research intends to design a system to control affective content in music production. This is done by taking into account a knowledge base with mappings between affective states (happiness, sadness, etc.) and music features (rhythm, melody, etc.). The knowledge base is grounded on the state of the art done in areas of Music Psychology. An emotional description specified by the user is used to select mappings from the knowledge base. Music is retrieved from a music base (recorded sound and MIDI files) according to similarity metrics between music features (of mappings and music base). Afterward, selected music can be subject to transforming, sequencing and remixing algorithms and then played. To assess the system, listener emotional state is analysed using psychophysiological or self-report measures. The methodology underlying this system is essentially founded on Affective Computing topics.

1 Introduction

Although emotions are essential to human life there is not yet a universal definition for them. According to Scherer [1] emotional states can be described as particular configurations of bodily and cognitive components. For a long time, Cognitive Sciences have been studying the foundations of emotions. More recently computational models have also been proposed and are being applied in several domains (e.g., music, dance and cinema). Music has been widely accepted as one of the languages of emotions. Nevertheless, only recently scientists have tried to quantify and explain how music influences our emotional states.

Our work intends to design a system to produce music with appropriate affective content in two stages. Firstly, studies of the relations between emotions and musical features are examined, to select mappings useful in our computational context. Secondly, a computer system that uses these mappings to control affective content in music production is designed, implemented and assessed.

Possible applications of this system will be Music Therapy and production of soundtracks for entertainment activities (e.g., cinema, theater and dance). The purpose of this system in each of these possible areas of application is the induction of an emotional experience in human listeners by using music. The next section makes a review of some of the most relevant contributions to generate affective music, as well as some inherited problems. Section 3 presents aims and objectives of this research. Section 4 presents our methodology, and finally section 5 makes some remarks about contributions of this research.

2 Big picture

Affective Computing is a discipline that deals with the design of devices used to process (recognize, simulate and express) emotions [2]. One thing that has to be cleared up is what we understand by emotions, moods and other types of affect. We accept Scherer's suggestion [3] that affective states result from the combination of 5 types of affect: emotions, moods, interpersonal stances, preferences and affect dispositions. The main distinctive differences between these states are their duration and intensity. This research like most of the works reviewed in this section focus on emotions. The aim of this section is to discern common approaches and techniques used to generate music with appropriate affective content.

2.1 Affective Music Generation

There are essentially 3 approaches to solve the open problem of generating music with appropriate affective content. The first one is based on the manipulation of musical features according to some relations established between emotions and music features. The second approach is based on interactive music applications that control the generation of music by using psychophysiological (e.g., heart rate) and/or physical data (e.g., hand clapping). The third approach is usually concerned with the generation of music adequate to the emotional state of virtual environments. The more appropriate approach was selected for those research works that could belong to more than one of the considered approaches.

Musical features manipulation Starting from results of previous work [4] [5], Livingstone and Brown [6] established relations between music features and emotions. Both emotions and a set of music-emotion structural rules were represented in a 2 Dimensional Emotion Space with an octal form. A rule-based architecture was designed to affect the perceived emotions of music, by modifying the musical structure. Livingstone et al. [7] made a list of performative and structural that can could be changed and their emotional effect. For instance tempo, mode and loudness are structural parameters, and tempo variation, melody accent and note accent are performative parameters.

A MIDI-based software named REMUPP (Relations Between Musical Parameters and Perceived Properties) was designed to study aspects of musical experience [8]. This system allows the real-time manipulation of musical parameters like tonality, mode, tempo and instrumentation. This system has a music player that receives music examples and musical parameters. Music examples are composed by MIDI data and a set of properties. Musical parameters can be used to control the sequencer, to control synthesizers or to employ filters and effects on MIDI stream. Winter [9] built a real-time application to control structural factors of a composition. Models of musical communication of emotions were reviewed to get an insight of what musical features are relevant to express emotions. Pre-composed musical scores were manipulated through the application of rules. These rules have some control values for different musical features: mode, instrumentation, rhythm and harmony.

Interactive music applications Physiological and expressive gesture data can be used to synthesize music [10]. This work used sensors to measure muscle tension, respiration, heart rate, galvanic skin response (GSR) and temperature. Performer's gestures and breathing signals were mapped to real-time expressive effects by defining musical features (beats, tempo, articulation, dynamics and note length) in a musical score. Kim and André [11] made a music composition system to manipulate user's emotional state. To validate the emotional impact of the system on user they correlated user's impression with physiological responses (Electrocardiogram, Electromyogram, Galvanic Skin Response and Respiration).

Chung and Vercoe [12] developed a system to generate real-time music based on intended listener's affective cues. The goal of this system was to correlate musical parameters with changes in affective state. Both affective states (engaging, soothing, boring and annoying) and musical parameters (rhythm and harmony) were represented in a 2 Dimensional Emotion Space (valence and arousal). Music files were generated in real-time by music composition/production, segmentation and re-assembly of music. The analysis of listener's affective state was based on physiological data (skin arousal), physical data (foot/hand tapping, hand clapping and other gestures) and a questionnaire.

Virtual environments MAgentA [13] is an agent that automatically produces real-time background music for a virtual environment. This environment has an emotional state, which is given to the agent through the perception module (cameras, etc.). The emotional state is used to select an algorithm from a database of affective composition algorithms. These algorithms try to match the emotional state to musical features (harmony, melody, tempo, etc.). Eladhari et al. [14] developed a system for real-time composition of affective music. The main objective of this system was to create soundtracks that could reflect the mood of specific game characters. Character's affective state was described by using 4 concepts: personality, emotions, mood and sentiments. Musical features like harmony and time signature were used to express appropriate moods.

2.2 Problems and inherited solutions

The central problem of our research is to find a way to control affective content of produced music is such way that an intended emotional description can be expressed, perceived and induced. We intend to face this problem through the selection of pre-composed music that can be transformed if it doesn't fit the intended emotional description. So, our central problem can be splited in two other problems: selection and transformation of appropriate affective music.

There are also other problems essentially related to our methodology like: the construction of a knowledge base relating emotions and musical features; the representation of the emotional description (dimensional, discrete or both); the detection of listener's affective states; the extraction of music features; and eventually the composition of appropriate affective musical pieces.

Our research work intends to boost the control of affective content in music to promote a more effective expression, perception and induction of emotions.

We adopt an approach, similar to Wingstedt et al. [8], based on musical features selection and manipulation. After the selection of music, the manipulation is done in a way similar to Livingstone [7], Winter [9] and MAgentA [13] in which a set of mappings between emotions and music features is taken into account. Then, music is subject to music algorithms (sequencing, remixing and synthesis) like in REMUPP's music player [8]. Like in referred interactive music applications, psychophysiological data will be used in our research to detect listener's induced emotion.

3 Aims and objectives

The principal objective of this research is to build a computational model of music production that may express and induce intended emotions. This objective can be splited in the following two objectives:

1. Examine studies of the relations between emotions and musical features, to select mappings useful in our computational context;
2. Design, implement and assess a computer system that uses these mappings to control affective content in music production.

Generally speaking, models of music perception and expression founded on research works from Music Perception, Music Cognition, Music Performance, Music Theory and Music Therapy were examined. With this knowledge, relations are established between musical features and emotions. Computational modeling and simulation of human emotions, emotion recognition and emotion expression are also studied by reading Emotions Psychology and Affective Computing works. Through this multidisciplinary review we intend to employ a holistic approach that bring together scientific, technological and artistic background into a computational model. Music manipulation algorithms will be used to create arrangements of pre-composed music with appropriate affective content. The plan of our work also includes the analysis of induced emotions.

There are also other objectives to be achieved: build a music base, compose music (instrumental mainly), extract music features (high level features from both audio and symbolic music) and segment music. Now we will present some premises used to guide our objectives.

Music has emotional information [5] Music is characterized by distinct music features (e.g., rhythm and melody). The systematic variation of these features is closely related to variations in listeners' emotional states. So, music affective content can be changed, through the transformation of music features, to evoke intended emotions. Relations between emotions and music features are grounded on a state of the art done in areas of Music Psychology.

Music induces emotional states In situations, where we are playing computer games, specifically the ones which have action, when a sudden sound/music is perceived, an emotion can be induced. Roughly speaking, after being perceived, this sound/music is transmitted to our brain nerve cells, which will communicate with our limbic system that will interact with our motor system to send signals to specific parts of our body. There are some patterns that can be detected by using psychophysiological techniques, like Electromyography, Galvanic Skin Response and Heart Rate allowing us to predict induced emotion.

Music can be a way of healing As it was said before, music can be therapeutic by healing your mind (cognition and emotion) and body (physical). For instance, music can be used to stimulate our body to dance, and as a result cause the motion of our body in ways that can heal it. This premise can also be supported through the use psychophysiological techniques.

Our work, when compared with works described in the previous section, intends to bring together the following ideas:

1. Build a knowledge base with relations between emotions and musical features that evolve in such a way that can be used by Music Psychologists/Therapists;
2. Create an autonomous affective DJ-like application;
3. Produce music with appropriate emotional content;
4. Establish a music production framework that can be used by musicians;
5. Use music to psychomotor therapy through the induction of appropriate emotional states.

4 Methodology

This section presents the methodology of our work: scope, proposed computational approach and architecture, and validation.

4.1 Scope

Both emotions and music are of multidimensional nature. This work is focused on music content, so other dimensions are not studied. Social variables like context, human listener experience and other sociopsychological variables are not considered. Moreover, editorial and cultural metadata and songs' lyrics are not meant to be analysed. The central attention of this work is on the role of high level features (acoustic metadata) in the induction of emotions.

4.2 Computational Approach

Our computational approach deals with the problem of inducing emotions with music. A brief overview of our approach is presented with the aid of figure 1.

The input is the description of the emotional experience that the system is intended to induce in the listener. A Knowledge Base with mappings between emotions (calm, anger, sadness, happiness, fear, among others) and musical features (harmony, melody, rhythm, dynamics, tempo, texture, loudness, among others) allows the system to retrieve the more appropriate music from the music base. Then, music is played and the emotional state of the listener can be analysed using psychophysiological and/or self-report measures.

Techniques and Algorithms The Knowledge Base (KB) is like a white box module with mappings between emotions and musical features. This means that all represented mappings are always visible. This option derives from the fact that this KB can be used in the future by Music Psychologists and Therapists. Both Case-Based and Rule-Based techniques are known to be adequate for this kind of representation. Semantic networks and frame/analogy-based systems can also be helpful.

Some algorithms will be developed: music transformation, music sequencing and music remixing. Others will be adapted from third party software/algorithms: music composition, music selection (energy, timbre, etc.), music mosaicing (automatic remixing) and music synthesis. All these algorithms take into account the control of music affective content.

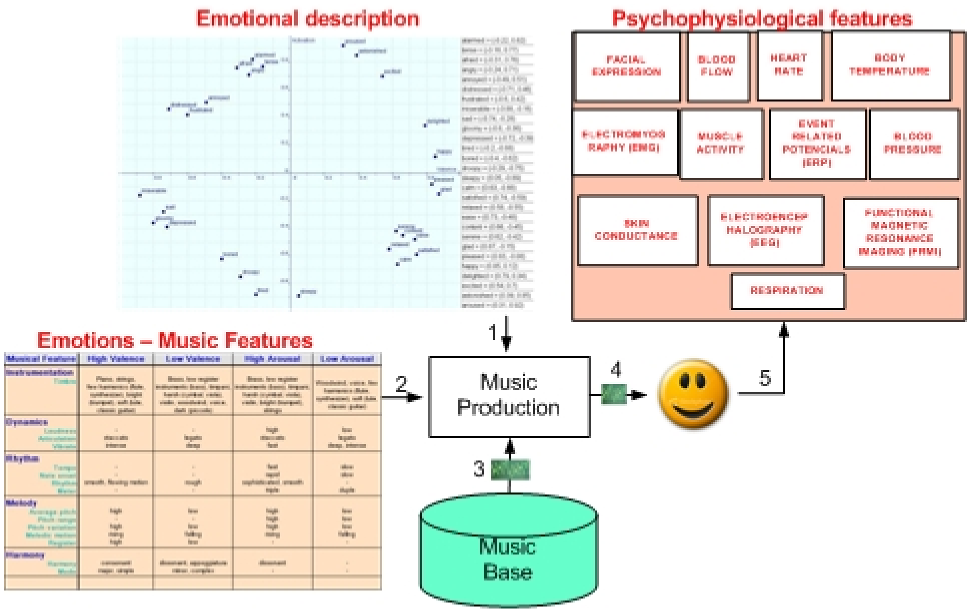

Fig. 1. Computational Approach

4.3 Validation

Figure 2 presents the assessment methodology to be used in this system. Music with specific features is selected according to the intended emotions descriptions and then emotional playlists are generated. Musical features are previously selected from the mappings of the intended emotion. After the play of the emotional playlist, emotions are identified using psychophysiological and self-report measures. Then, there will be comparisons between recognized and intended emotions. These comparisons will be used to refine the mappings in the KB. Techniques that were previously referred are known to be adequate for this kind of operation.

Sessions planning For each session we need to define the number of participants and what affective states we intend to evoke. To decrease the effect of exogenous variables each participant rests a period of time before the experiment. Then, each participant is subjected to a number of musical stimuli that induces one affective state (e.g., happiness). Later, other musical stimuli are used to induce other affective states (sadness, tenderness, etc.) sequentially. For these stimuli, both audio and MIDI music will be used. Playlists that will be used can comprise music chunks that last more than 20 seconds and less than 10 minutes. These music chunks will be automatically taken from the music base.

The audience is not limited to any stage of human development. However, it will be easier to do some tests with people in stages of adolescence or early adulthood, which are almost non-musicians.

4.4 Present and Future Work

To date, relations were established between emotions and music features grounded on Music Psychology works. The proposal of a computational architecture to control the affective content in music production was also made. The process of selecting appropriate music features has already started by taking into account available third party music feature retrieval software.

The central part of this work, that can lasts 1 year, consists in the implementation of algorithms to control the affective content of musical pieces. To do so, music affective selection will be done with the adaptation of third party software. New algorithms will be developed to transform music affective content by taking into account affective music generation algorithms of other works. The computational systematization of mappings between emotions and music, and the implementation of the emotional description can take around 4 months. Finally, the validation of our system will be done, with an appropriate audience, in around 8 months.

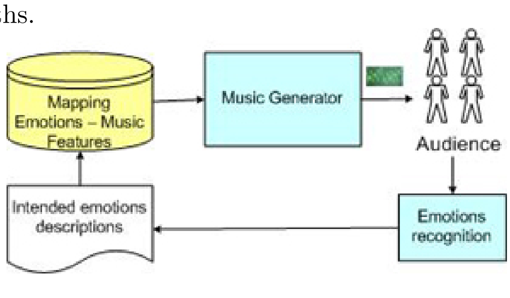

Fig. 2. Validation

5 Contributions

This research intends to adopt an holistic approach that can brings together scientific, technological and artistic background into a computational model that can foster the expansion of Affective Computing, namely in the domain of automatic music production according to an emotional description. We intend to foster a computational systematization of the relations between emotions and music, which can contribute to a high affective control in the selection and transformation of both structural (e.g., harmonic mode) and performing features (e.g., beat accent). With this in mind, some algorithms will be designed to transform and select discrete pre-composed music (e.g., MIDI).

We intend to tune our system with users to promote a reliable induction and expression of emotions by using music. This way, our system can be applied in areas that intend to produce music given an emotional input. The production of soundtracks for arts, movies, dance, theater, virtual environments, computer games and other entertainment activities are some examples. Another one is Music Therapy as a way of emotional, cognitive and physical healing. Musicians can also benefit from this system as an affective music production tool or as an autonomous affective DJ-like application.

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