FugueGenerator - Collaborative Melody Composition Based on a Generative Approach for Conveying Emotion in Music

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ABSTRACT

This paper exemplifies an approach for generative music software. Therefore new operational principles are used, i.e. drawing melody contours and changing their emotional expression by making use of valence and arousal. Known connections between music, emotions and algorithms out of existing literature are used to deliver a software experience that augments the skills of individuals to make music according to the emotions they want. A user-study lateron shows the soundness of the implementation in this regard. A comprehensive analysis of in-game statistics makes it possible to measure the music produced by testers so that connections between valence, arousal, melody properties and contours and emotions will be depicted. In addition, temporal sequences of reaction patterns between music making individuals during their creative interaction are made visible. A questionnaire filled out by the testers puts the results on a solid foundation and shows that the incorporated methods are appreciated by the users to apply emotions musically as well as for being creative in a free and joyful manner.

1. INTRODUCTION

The widespread adoption of information technologies in the last century did not only lead to an understanding of IT systems opening possibilities for new interfaces for musical expression, but also for mediating roles to conceive and manifest musical ideas even for musically inexperienced users. Thus, such systems may help to mediate between human intention and musical implementation. In this regard, it is possible to either completely generatively create or modify music that fits to an emotion selected by users beforehand. In consequence, this would be an augmentation of the musical scope of individuals so that they are put in the position to implement a specific emotion they have in mind without the necessity of being aware of the various related musical construction parameters.

Especially in a collaborative setting such a mediating role is important, as it can help to communicate musical intent or to facilitate the realization of musical ideas. Furthermore, in the context of group creativity, the heterogeneity of individuals and their overall knowledge diversity, experience, and expertise are key elements [1]. The integration of these elements is also part of the mediating role of the computer. The related phenomenon of *Group Flow* [2, p. 158] is beneficial for social creativity, it is a motivator and means for the group to innovate in a creative task. The personal experience of Flow itself, defined as "a holistic sensation that people feel when they act with total involvement" [3], is an enabler for the empathical involvement with music and stimulator for the implicit learning process [4]. Group Flow it has been furthermore shown empirically to lead to more valuable results [5] and to take place in computer supported collaboration [6]. Thus, we see these social factors as highly beneficial for musical creativity.

Although approaches to modify interpretatively existing musical material exist [7, 8], not many efforts have been made to specifically support the collaborative creation of new music with respect to the desired emotional affect.

With this paper we would like to contribute to filling this gap. A software will be presented that implements an operational concept to support users to generatively making music by drawing melody contours and have the software system interpret these with respect to an emotional intend. Our generative approach is rule based inasmuch as it applies transformations that we have formulated beforehand to modify the users' input (cp. [9, p. 236-244] for a review of related systems). The method of drawing melody contours is inspired by Xenakis' work on the UPIC [10].

We will furthermore show the results of a user study that investigates whether this concept succeeds in conveying the emotional intend. Furthermore we will highlight what connections come up between desired emotions and melody lines and how users evaluate the additional benefit of the application for this collaborative setting. Within this contribution we do not focus on experienced emotion but the perceived emotion on structural and performative musical features.

2. RELATED WORK

This work is primarily related to research in the interdisciplinary area between music, psychology and in particular computer science. Emotions can be, in general, characterized in terms of valence and arousal. This model goes back to Hevner [11] and has been elaborated upon by Russel [12] in his well known circumplex Valence/Arousal model. In such a model any emotion can be positioned as a 2D coordinate in this valence arousal space.

Regarding recent research that applies such a view point to music, one can decide between a transforming and a generative approach.

The first one modifies either the score or performative features of existing pieces of music. The KTH Performance System [13], for example, modifies mainly performative (interpretative) aspects of a piece. In the Computational Music Emotion Role System (CMERS) [14] also structural (score) parameters of a piece are altered. Importantly, the research regarding CMERS involved comprehensive studies to inform about correlations between structural and performance features of music on the one hand and emotions on the other. These insights were applied in this contribution to formulate rules based on evidence to manipulate melodies towards their inherent valence and arousal values and their respective emotions. Complementary to this, Oliveira et al. [8] focuses on a knowledge based system that makes use of empirical data to derive a classification model for musical segments that can be then recombined and transformed towards a desired emotion.

The latter class of environments generates music with emotional content from scratch. In that context Wallis' Affective Music Generator [15] takes a coordinate within the two dimensional valence and arousal space as input parameter to produce purely generative produced music. Figure 1 shows the GUI of the Affective Music Generator. The construction takes into account structural and performative parameters related to rhythm, melody contour, harmony and articulation. Further user studies revealed that users assessed the generated music correctly [7]. Thus, one can conclude these generative mappings to be functional. As Wallis bases his rules on Livingstone's work, we used his implementation as guideline for our prototype.

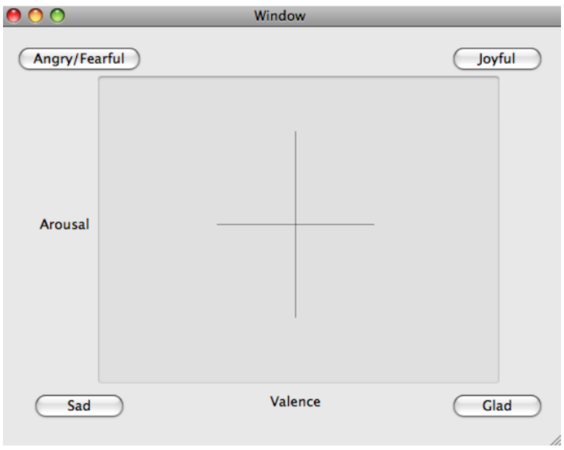

Figure 1. A user interface used by Wallis in [15] to produce generative music with respect to valence and arousal

To conclude, there are robust algorithms and consolidated knowledge to *systematically elicit emotional responses in users* [15, p. 1]. Nonetheless, we see lack of applied use cases and evaluations thereof, especially for the purpose of creativity support, entertainment or collaboration. So the question remains unanswered if such concepts offer a suitable approach to hide musical complexity for the end-user by means of a metaphor for high-level musical expression while still offering an experience that gives users joy in musical expression.

3. CONCEPTUAL FRAMING

As previously pointed out, the main idea is to support users to construct music based on their emotional ideas within some representation of the valence arousal space. Straightforwardly, to move within it, users could be presented a 2D surface to control their respective valence arousal vector similar to Wallis' Affective Music generator (see fig. 1). However, the question on what basis the musical events themselves are generated is thus far unanswered.

An important issue for collaborative creativity support systems, especially for musical applications, is fostering the users' engagement in the creative endeavor [16, 17], ideally leading to a direct connection to the musical output in form of an embodiment of music [18]. In this regard, we see value in giving the user the ability to shape musical events in a way that directly reflects an intended melody contour and that especially respects this melodic intend even when transforming it in respect to the emotional one. Thus we do not focus on stochastic processes, but rather simple means to create melodic content which is then represented in alternative emotional contexts.

Regarding the collaborative aspects, the application is designed for two collaborators, since this allows us to perform a focused evaluation towards certain aspects such as assessing the users' agreement on perceived emotion or turn taking patterns. We make use of a multi-touch table as shared interface, as this offers means that simplify social communication protocols [19, 20].

3.1 Implementation

In the following the implementation work for this paper called FugueGenerator will be laid out in detail. As the name tries to imply, the melodical basis is created by the user. The previously discussed shaping of melody contours is realized by directly drawing it on a 2D surface. The melody lines are continuously repeated while following a chord progression. The valence and arousal values can be controlled manually and thus modify the underlying scale, tempo, articulation and timbre accordingly. For collaboration, it is possible for two people to create their own respective melody within one shared workspace in parallel for polyphony. Furthermore, controls for valence and arousal are both part of the shared and private workspace of the respective user: valence is a global (shared) control and arousal is a private control for each user. This decision will elaborated upon throughout this section.

3.1.1 GUI and Operational Principle

The graphical user interface of FugueGenerator consists out of the following elements: surfaces for the melody contours (fig. 2,1) , controllers for the local arousal settings (fig. 2,2) , a global valence control (fig. 2,3) , a register control that indicates which melody is playing in a lower register (fig. 2,4).

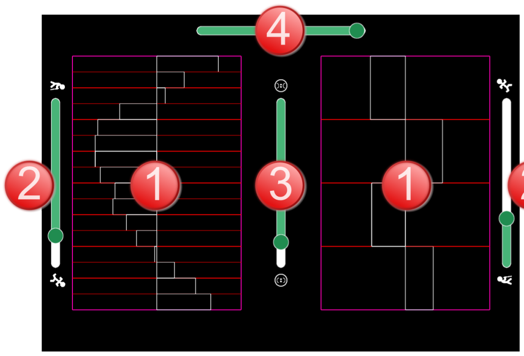

Figure 2. A screenshot showing the prototypical implementation of our application

The application is designed so that each player operates from his own side of the screen while standing at the regarding edge of the vertical touch display. Drawing the melody contour is done by touching and dragging within the melody surface as illustrated in figure 3. The height of each bar represents a note, it indicates the relative pitch to the underlying harmonic. The set of bars forms a sequence of notes with the currently played bar (note) being highlighted.

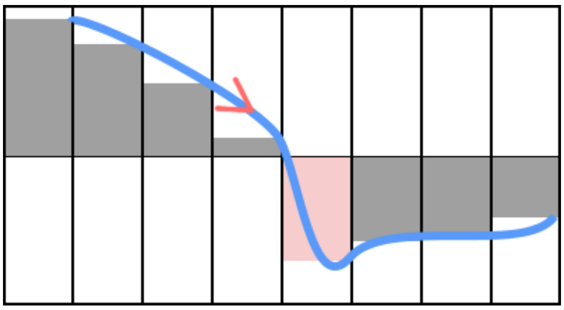

Figure 3. Schematic illustration of the way how drawing a melody contour on a melody surface is performed. The blue line shows the path of a drag gesture, the red arrow points into the direction. The bars adjust to the last touch position within the respective row.

3.1.2 *Melody Generation*

The number of bars in a sequence depends on the local arousal setting (see paragraph 3.1.4). The tempo is the same for both melody contours, while the divisions of a beat (the number of bars) are equivalent to note lengths; e.g. a sequence with two bars is made of two half notes.

The tonal system of the melodies is based on the fundamental note, which lies at the center line of the surface. The deviation upwards is equivalent to a positive deviation in regards to pitch from the root note and vice versa (cp. fig. 3). The amount of pitch deviation is also dependent on the local arousal (see paragraph 3.1.4) and the global valence settings (see paragraph 3.1.3). Such relative pitches are then steering the selection of absolute pitches as an arpeggio of the currently playing chord. The system uses a repeating chord progression (Tonic, Subdominant, Dominant, Tonic). The common tonal basis is a mode, which changes in accordance with the global valence value as described in paragraph 3.1.3. Nevertheless, the fundamental note always stays the same.

3.1.3 *Controlling Valence*

As previously mentioned, the valence value steers the selection of the mode. Livingstone [14] showed empirically the correlation between valence and happy major or sad minor modes, and Persichetti [21] suggested orderings of modes reaching from darkest to brightest. Following this, we implemented a correlation between valence and modes. This was largely influenced by the work of Wallis [15]. This ordering by ascending valence or brightness is the following: Phrygian, Aeolian, Dorian, Mixolydian, Ionian, Lydian.

3.1.4 *Controlling Arousal*

We based the structural and articulation related transformations again on the work of Livingstone [14], these are shown in table 1.

Arousal	**Low**	**High**
Rhythm	simple	complex
Articulation	legato	staccato
Tempo	slow	fast
Pitch Range	narrow	wide

Table 1. The influence of arousal on musical properties

The rhythm complexity and the tempo are influenced by arousal as an increase of arousal also increases the number of bars (and notes) on the melody surface. Therefore, the lowest arousal setting has two half, the greatest 16 sixteenth notes, this results in fast and agitating melodies at a high arousal setting. However, these local arousal values also influence the global tempo (weighted mean), such that agreement of users in the extremes of the arousal scale can further amplify the effect.

3.1.5 *Cross-Relations between Valence and Arousal*

Thus far, the transformation rules for valence and arousal only apply for separate concerns of the shared composition. In this section we will inform about additional cross-relations that have been additionally implemented and concern the timbre of the synthesized audio and rhythmic complexity. These are shown in table 2.

The synthesis is done with a simple two operator FM synthesis and additional effects. With increasing arousal, more harmonics are added to the synthesized sound. Valence is used to add distortion on low settings (dark mood) when combined with high arousal settings resulting to a timbre similar to a distorted guitar as apparent in music genres like Heavy Metal. Complementary, a dark mood in combination with decreasing arousal introduces more glide (slur) between notes, emphasizing a legato effect. For a bright mood, the timbral palette varies according to arousal between non-slurred clean sine to bright bell/chiptune-like tones. The articulation between staccato and legato can be continuously varied by modifying the amplitude envelope decay times with respect to the global tempo.

Valence **Arousal**	**Low**	**High**
Low	Timbre: slurred & low harmonics Rhythm: straight	Timbre: low harmonics Rhythm: swing
High	Timbre: distorted & bright Rhythm: straight	Timbre: clean & bright Rhythm: swing

Table 2. The influence of valence on musical properties

A further implementation aspect in this context is rhythmical complexity which is related to arousal and high valence [14]. For this, we make use of a measure of rhythmic complexity which has been shown to agree with human perception, the *Weighted Note-to-Beat Distance* (WNBD) [22]. Furthermore, we created the inverse function of this complexity measure to modify the note durations and onsets to have control over the swing added to a melody. An increase of the WNBD value for this inverse function leads to an increased shift of every second or forth note onset while reducing its duration by the same shift distance. It was implemented so that the the local arousal positively controls the shuffling of a melody but only for high valence values.

4. EVALUATION

For the evaluation we follow two objectives: first, we would like to know whether the devised systems help users construct simple music with a specific emotional intend. Thus, the question is whether the transformation rules hold and whether they overlap with the users' (subjective) perception. Second, it is of interest to evaluate to what degree this approach supports collaborative creativity and how collaborative turn-taking patterns manifest when a large degree of the control steers an emotive interpretation of melodic content.

For this we performed a user study that involved 16 people being paired into 8 groups. The age of the persons was between 20 and 35 years. They mostly had an academic background with varying fields of study, i.e. equal in humanities and technical subjects. They assessed their own musical talent as well as their knowledge and experience in music theory as being neither very advanced nor very bad on average, while excesses on both sides of the scales equally occurred.

4.1 Testing Procedure

We started each evaluation with a short introduction followed by two parts, where we asked the group to construct specific moods. The second part was unrestricted, giving users time to experiment. For the first part, users were asked to use the application to create the following moods: aggression, happiness, despair, being chilled, solemn, annoyed, graceful, relaxed exhilaration. Testers were given about two minutes for each emotion and had both to agree on the result. Afterwards the participants answered the first part of a questionnaire that asked about the users' inter-agreements and the agreement to the emotive content of the created generated music. The following free session took ten minutes so that users had time to produce musical output that the testers liked most. Again, this part concluded with a questionnaire, this time informing about the general assessment of the application and the users' demographic data.

4.2 Logging Data

Apart from the questionnaire another data source was logging data generated by the application that contained timed information about the characteristics of the melodies (the minimal, maximal and average heights of the melody bars and their mean deviation) and the controls for valence and (local) arousal values. This not only allows to compare the valence arousal values of the first part to the specified emotions but and to link valence and arousal to the shape of melody contours but also to reconstruct turn taking patterns or the emotive and melodic development within a session.

4.2.1 Emotions and Valence/Arousal

The valence and arousal positions for the specific construction of emotions in the first part of the evaluation can be seen in figure 4. These have been gathered using the logging data.

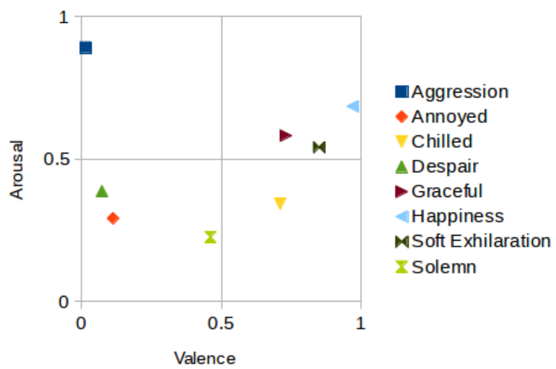

Figure 4. A plot showing the median of the valence and arousal coordinates gathered by user interaction during first part of the user study

The shown emotions represent the median value for all groups with valence being represented on the x-axis and arousal on the y-axis. This result corresponds to Livingstone's comprehensive outline. Emotions like aggression, annoyedness, happiness, gracefullness and solemnity show high degrees of similarity in their coordinates of the valence arousal space. Differences are most likely explained by the deviation in word meaning throughout the translation (to german) of the words describing these emotions. This was especially the case for "Annoyed" (ambiguously translated as "verdriesslich") and "Soft Exhilaration" (translated as "sanfter Rausch"). The latter was used as an German alternative to serene to fit better into the respective position within the valence arousal space. Chilled (translated as "beschwingt") was chosen as alternative to tender, which worked out very well in comparison to Livingstone.

To conclude, the results on average comply with the outline of the experiments collected by Livingstone. In this way, the transformation rules and the basic application concept is suitable for users to also construct music according to a given emotion rather than transforming existing pieces for an altered listening experience. Moreover, given the musical skills of our participants in general, it can be seen as a valid approach to augment the users' musical skills.

4.2.2 Emotions and Melody Properties

We now turn to the analysis of the logging data for the melody contours to see whether connections between melody properties and the implemented emotions exist. To answer this, it is at first necessary to define several characteristic properties of melody contours. For this purpose Livingstone suggests properties as some of them are listed in table 3 along with their adaptions to our logging data.

Livingstone	FugueGenerator
Pitch Height	Average Height
Pitch Range	Maximum Height – Minimum Height
Pitch Contour	Upwards: AHD>0 & Pitch Range>0 Downwards: AHD<0 & Pitch Range>0 Oscillating: AHD==0 & Pitch Range>0 Even: AHD==0 & Pitch Range==0

Table 3. Comparison of definitions as they appear in [14] and their adoption to our logging data from FugueGenerator. AHD means Average Height Deviation.

The definitions as shown in table 3 were applied to the logging data in the same manner as for valence and arousal previously, i.e. the pitch height, pitch range and pitch contour are calculated from the data setting at that time when both team members were in agreement about the implemented emotion. Thus, it is possible to group the median of all properties of the melodies by emotion. The pitch heights are depicted in figure 5 and sorted by descending valence. The pitch ranges are shown in figure 7 and sorted by descending arousal.

For both pitch heights and pitch ranges a certain trend can be identified. Concerning the former the pitch heights mostly decrease with decreasing valence, with aggressive emotion forming an exception. In contrast, the pitch ranges are generally relatively high for low arousal and and low for high arousal, while happiness is an exception.

Regarding the direction of the melody contour, one can differentiate between upwards, downwards, oscillating and even motions. For this, we used the rules given in table 3.

From figure 7 it is visible that the melodies tend to be directed upwards for low and downwards for high valence emotions, while oscillating or even melodies do generally seldom occur. Compared to Livingstone [14], these results are somewhat surprising as he stated that the melody contours are expected to have opposing directions compared to our findings [14, p. 46, Table 1]. Nonetheless, he also

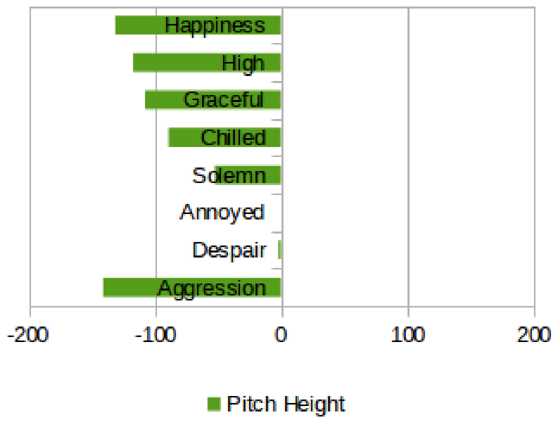

Figure 5. The median values of pitch heights for each emotion. Emotions are sorted by descending valence (see Figure 4). The value range of the scale is just for referential purposes.

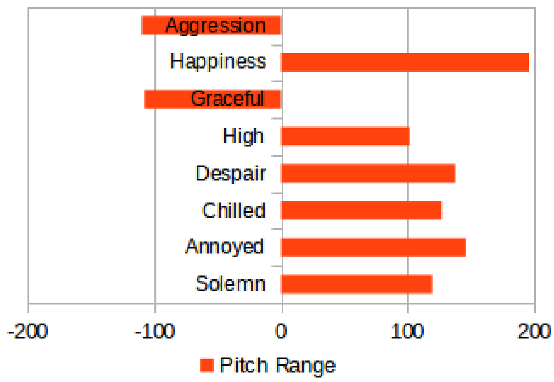

Figure 6. The median values of pitch ranges for each emotion. Emotions are sorted by descending arousal (see Figure 4). The value range of the scale is just for referential purposes.

makes it clear that this relationship is not deemed to be very strong because many deviations for different arousal settings exist and the outcome of his experiments regarding melody contours is generally ambiguous.

To summarize this, it is apparent that certain trends can be observed in the statistics, i.e. low arousal leading to high pitch ranges as well as high valence leading to low pitch heights and downwards directed melody contours. Nevertheless, these figures have to be treated with caution, since the exceptions themselves need further investigation and the small data set is by no means representative.

4.2.3 Free Game

In the second part of the test sessions, participants were given the opportunity to use the application freely, so observations concerning questions about if and how the collaboration and the interaction flow between the teammates takes place and how users value the application as a tool for expression.

First, we look again at the time series data from the logs to see whether common interaction patterns between par-

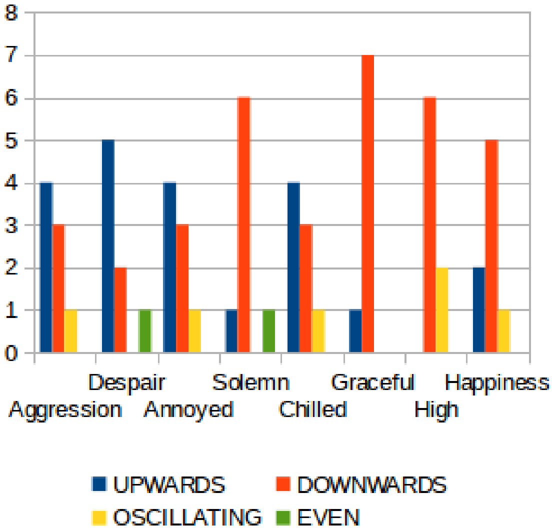

Figure 7. Graphical illustration of the number of how often certain melody contours were created respective to their intended emotions in the user study. The emotions are sorted by valence (see fig. 4).

ticipants of a group are apparent. In figure 8 the average heights of the melody bars are shown of an example group. With respect to the interaction flow, we highlighted situations in yellow, when simultaneous changes appeared for both melodies, and green, when the changes on both melodies occurred directly one after another.

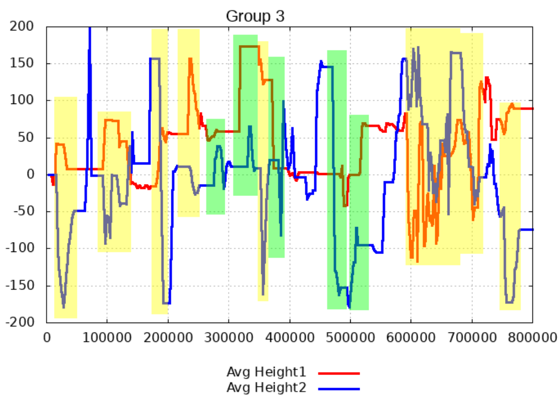

Figure 8. The average height (y-axis) of the bars for the melody surface of each user depicted over time (x-axis). A green background indicates consecutive and a yellow one represents two simultaneous changes of bar heights.

From this visualization it is evident, that most melody changes stand in an strong temporal connection with each other. The same applies to figure 9, that shows the global valence and the arousal values from each player (for another group).

The observed temporal connections are interesting, as such behaviors, namely prompt reactions to each other, are typical for other creative musical contexts e.g. especially jam-sessions. We discovered similar patterns in the other groups' interaction. In this regard, solely focusing on this data, it can be said that the application supports musical collaboration at least in terms of well-known patterns. Nonetheless, a quantifiable analysis of mutual influences in terms of statistical dependencies of changes in time would help to gain more reliable results by considering all test sessions in an objective way.

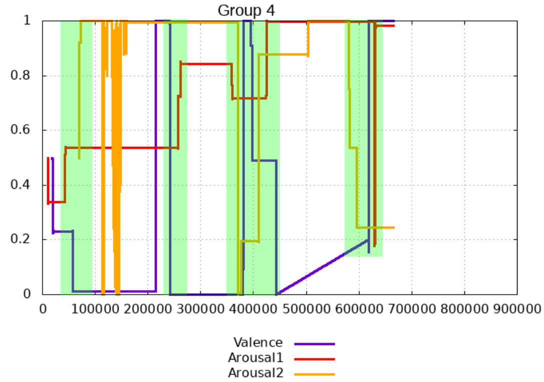

Figure 9. The global valence and local arousal values of each user (y-axis) depicted over time (x-axis). A green background indicates consecutive changes.

4.3 Questionnaires

We now turn to the questionnaire. It consisted of 40 multiple-choice questions. Most answers to the questions are expressed in a five-point Likert scale. We used the arithmetic mean of the answers for the evaluation. Besides this, some of these results are regarded with respect to two user groups, namely the group of users that described themselves as musically talented and the others. This distinction by self-assessment is based on their ratings of knowledge and practice in music theory (i.e. harmonics, circle of fiths, modes, rythmics); a user that rated himself with four or five in the respective fields is regarded as musically talented.

4.3.1 Appreciation

With respect to the appreciation of the application, we can distinguish between two aspects, namely if the software was found helpful to implement a given emotion and how the experience felt like during the creative part of the session. These aspects are depicted in Figure 10. It is apparent that the application was assessed as helpful. Yet, musically talented people stated a lower consent than musically not talented. In this context a loss of control about the musical construction parameters can be seen as reason as described later on. Concerning appreciation for the free and creative part of the sessions, all testers evaluated the experience as interesting and joyful and only marginally frustrating.

4.3.2 Collaboration

For assessing the collaboration we can again distinguish between the two parts of the user study. For the first test part it is not clear if interaction between two people is helpful to perform the musical task of implementing an emotion, since different opinions, approaches and musical skills between two individuals could lead to discrepancies

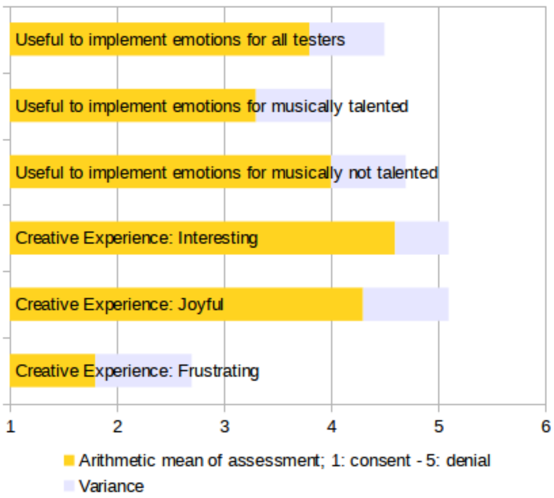

Figure 10. Results of a part of questionnaire regarding the general assessment of the application with respect to creativity support

that would distort the previously presented logging data regarding emotions. Figure 11 shows that in the present case this can be ruled out, as teammates found each other to be helpful solving the task. Furthermore, their agreement on the emotional assessment of their music as well as their mutual influence of their assessment were rated as positive. In addition, users stated that they see FugueGenerator to be suitable to fulfil the given task. These assessments indicate that the results of the previously discussed logging data are consistent and thus can been seen as reliable.

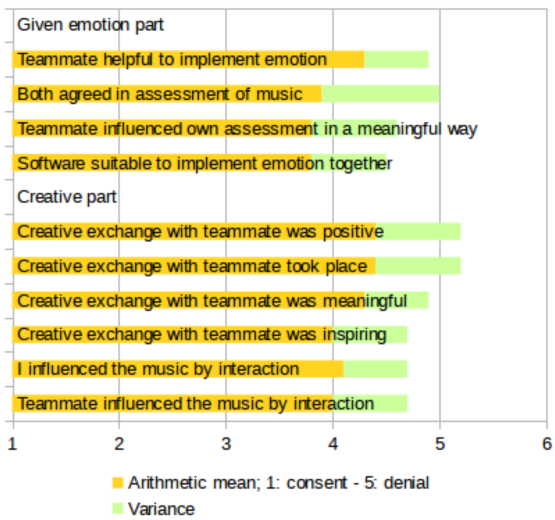

Figure 11. Results of a part of questionnaire regarding the assessment of the application with respect to implementing specific emotions

With respect to the free and creative part of the test sessions, it seems to be particularly interesting whether creative exchange between the teammates took place and how such processes were experienced. The testers regarded the exchange as very positive, active, meaningful and inspiring (cp. figure 11). This is also evident in their assessment that they and their teammates influenced the generated music by interaction with the other person. Again, this is consistent with the observations made in section 4.2.3, where changes in melody contours, valence and arousal values have a strong temporal relationship. Another aspect is that the interaction was evaluated as positive and inspiring and thus beneficial for creativity support.

5. CONCLUSIONS

As the evaluations clearly showed, the implementation work FugueGenerator delivers a creativity supporting generative music software, which is clearly appreciated as such by users. This can be considered as important due to the incorporation of new operational principles in this context, i.e. drawing melodies and particularly their expressional modification by valence and arousal. It can be claimed that these approaches are promising to augment the creative skills in a joyful manner for not least musically not talented individuals. Thereby collaboration was found out to be a beneficial feature, which makes the creative experience more valuable.

Moreover, the implementation allowed to gain various deep insights regarding the connection of emotions on the one hand and melody lines, valence and arousal on the other. While these relationships already were found by existing research, these hardly refer to generative music software. It was shown in this paper that reasonable methods exist to successfully augment the skills of individuals to create music according to valence and arousal and respective emotions. Thereby the valence and arousal settings of many emotions as known from previous research could be confirmed from a creative instead of passive point of view. Additionally, solid new methods were delivered to create, modify, measure and characterize melody lines, which makes them quantifiable for analysis in research regarding valence and arousal. Even though connections between melody properties and emotions have been found through user-studies, more research in terms of testing data is necessary to deliver more reliable results.

Last but not least it appears worthwhile noting that further logging data could be used to visualize the interaction flow between two creatively music making individuals. Reaction patterns showed a high mutual activity, which is similarly indicated by the questionnaires, too. However, these things were only inquired or exemplary demonstrated so that a quantifiable analysis of reaction patterns in creative music interaction would help gaining more reliable results. A software like the presented FugueGenerator would allow to do deep research concerning this and thus is advised by the authors. Following our previous research, the source code for the application is available online [1] .

Acknowledgments

We are grateful to Isaac Wallis for sharing his source code to base our prototypical implementation on.

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