

Designing an AI Emotion-Based Adaptive Fuzzy System for Evaluation of the Computer Music

Dr. Mladen Milicevic, Author
Loyola Marymount University, Recording Arts
7900 Loyola Bd., Los Angeles, CA 90045, USA
MMilicev@LMUmail.lmu.edu

ABSTRACT

This paper focuses on a design of a template for an AI emotion-based adaptive fuzzy system that analyzes music and simulates the audience's emotional reaction. This system may possibly aid computer music composers in creating music that is more appealing to the wider audiences. Conceptual design of the proposed system is based on the most recent findings in understanding of how the human brain processes musical patterns. This could be summarized in the following statement: Any deviation from the musical pattern predictability, in listeners mind, tend to weaken subsequent pattern anticipation and thereby undercut the impact of further musical deviations. Every single mismatch in musical pattern anticipation is countered by adjustments to the next expectation. When too many deviations fall together, the listener loses track of the underlying musical stability and ceases to anticipate the coming patterns forcefully. With too many deviations, music becomes increasingly incoherent. With too little, music becomes cold and mechanical.

1. INTRODUCTION

Music, unlike the language, is a fuzzy concept. If you hear the words "Puntius Tetrazona" and are unaware that they refer to a kind of tropical fish, your brain will not respond at all—making a bivalent decision. On the other hand, essentially all music spawns at least some meaning to a brain. Even music that we have difficulties comprehending, such as Eskimo Inuit singing or highly original computer music, will sound like something to humans. Listening to this kind of music represents a fuzzy concept containing high noise capacity or high percentage of fuzzy entropy.

What makes the primary difference between our species and all others is; our reliance on cultural transmission of information, and hence on cultural evolution. Animals do interchange information but in a biological rather than a cultural context. Bird mating calls certainly fall under the category of sonically transmitted information that is specific to a given species, but those species have limited intelligence and undoubtedly no bird-culture. This does not mean that animals have no minds, it simply means that

by human standards those "primitive" minds produce no cultural history.

Dawkins' meme, has a peculiar but powerful role to play in our understanding of human culture. This is the way he defines it:

Examples of memes are tunes, ideas, catch-phrases, clothes fashions, ways of making pots or of building arches. Just as genes propagate themselves in the gene pool by leaping from body to body via sperm or eggs, so memes propagate themselves in the meme pool by leaping from brain to brain via process which, in the broadest sense, can be called imitation. If a scientist hears, or reads about, a good idea, he passes it on to his colleagues and students. He mentions it in his articles and his lectures. If the idea catches on, it can be said to propagate itself, spreading from brain to brain. [4]

The important rule for memes, as for genes, is that they must constantly replicate. This replication is a mindless process not necessarily for the good of anything; replicators flourish that are good at replicating—for whatever reason. Meme X spread among the people because X is a good replicator. [5] Let's take a moment and look at one particular meme case—the success of a four-note meme at the beginning of the Beethoven's Fifth Symphony. It certainly has much less to do with the absolute value of its pitch-set "internal" design, i.e. the way a musical motif is compositionally structured, but much more to do with the design this meme presents to the world, its phenotype, the way it affects the minds and other memes in a particular socio-cultural environment. This is greatly influenced by the way the piece is structured and presented to the audience.

2. COMPUTER MUSIC AUDIENCE

It is very logical to assume that humans intelligently create musical pieces (potential memes) rather than producing them as random innovations. But, looking at the state of affairs in computer music will show more examples of innovations than creations. Let me clarify the distinction between the two. Quality of computer music and for that matter the quality of anything does not depend exclusively

on its structural organization, but it is rather rooted in the transaction that occurs between the music and the audience. To evaluate music, is to find the quality of transaction between the musical configuration and its cultural response. If that response is positive, meaning ecologically prudent for the given cultural environment, then it may be called creation. On the other hand, an innovation being just randomly new and not holistically related to the environment will certainly render a negative cultural response.

In order to expand the audiences for computer music it is necessary to look at the minds of the people who constitute those audiences. Why in the minds? Because the minds are the habitats of the memes. Minds are in limited supply, and each mind has only a limited capacity for the support of memes, therefore there is a considerable competition among memes for entry into as many minds as possible. This competition is the major selective force in the infosphere just as it is in the biosphere. One way to look at the music is through the memetic competition among musical compositions for admission into the minds of the audiences. Randomly presenting new musical pieces (potential memes) to these minds is like playing by the rule of evolutionary biology known as *the survival of the fittest*. It is well known that this game is ruthless and will in its process discard the vast majority of its participants. Being the only intelligent species on this planet, it is certainly wise not to play by the rules of the very game that created us, because if we do so—we may easily become a casualty of the same mindless evolutionary process. For that reason, it would be preferable to turn this game around to our advantage, redefining it slightly, and calling it—*the survival of the wisest*. Since humans have the brain that is capable of intelligent thinking it would be tremendous waste not to use it in determining our own future, and the future of computer music. How can this be achieved? One way may be through an AI adaptive fuzzy analysis system that could help computer music composers in reducing the high noise capacity when making their musical pieces. By reducing its fuzzy entropy, the computer music may become more appealing to the audiences and possibly help them in making positive emotional responses while listening to it. Let me explain why.

3. HUMAN BRAIN AND MUSIC

The most dangerous thing is to make generalizations, but I am going to make some anyway. Nobody with the sane mind would agree any more that music represents a universal language. However, the research tangibly shows that there are some things that appear universally. In order to make sense from the vast sonic events that enter its auditory cortex, the brain had to become a master of simplification. This process is nothing like filtering

unwanted information, because such a mechanism would be tremendously complicated and utterly inefficient. What brain actually does, is a search for familiar devices and patterns. [7]. It latches on things that are in some respect already known, disregarding most of the unfamiliar information. The reason that human (but also animal) brain is doing this; lies in the fact that previously processed information can be very quickly reconstructed from the data stored in brain's long-term memory. Then, that reconstruction can be efficiently processed and compared with the similar incoming information, giving it the most pragmatic interpretation that fits the situation at hand.

Conversely, to create a musical pattern in human brain it is necessary to have a some sort of repetition of the sonic event in question, thus it can be remembered and used in the future. Composing a piece of music (a meme), that will exhibit an appeal to the minds of the audiences, requires the existence of some sort of a clearly recognizable musical point of reference. Human beings, on large, will not make positive emotional responses to anything which produces one unconnected innovation after another, never going back and reevaluating what has gone before in relation to what is going on now. Thus, when the brain receives sequences of musical tones, it does what it does with other "new" information: it attempts to "interpret" it by using the "old" already processed and digested information stored in its long-term memory about previous, similar music experiences. This information may allow some aspects of a future musical signal to be anticipated—as it happens when we hear the first line of a familiar song. The ability for predicting incoming patterns of information, in our particular case musical information, on the basis of past experience is one form of what we call "intelligence"; it can dramatically enhance an organism's chances of survival. Knowing what is coming is always much more profitable than being caught by total surprise.

The way human brain handles this comparison-based process is grounded in the workings of neural mappings that correlate to a specific sonic event. For the sake of simplicity, let's say that there is a sound of an oboe playing A=440 Hz. Now, in most of the musicians' brains there is a neural correlate for A=440 Hz sound. These neural mappings are physical representation in the brain of a "formula" for the reconstruction of person's memory about an A=440 Hz. This "formula" will be put in use when the ear receives an external stimulus of an oboe playing and passes this stimulus to the auditory cortex. Then, in turn, the auditory cortex would use the "formula" to reconstruct the memory of the closest similar experience and its context stored in the long-term memory that matches the one of the external stimulus just being received. Through the process of semantically matching the new and the old mental image of an oboe playing A=440 Hz, the brain

would assign the meaning to the event in question, based on the context in which the new information was received. If that context happens to be tuning an orchestra, rather than starting the first note of an A-minor scale, the brain will call up the semantic correlate for the given context and react appropriately.

Since we know that humans constantly judge by comparison, and our judgment of any item depends upon what we are comparing it to at that moment, let's be wise and use this knowledge in composing music. If there is a pattern that reflexively reoccurs throughout the musical composition it will create its memory in the brain and that will become a "point of reference" to which future transformations of the same pattern may be compared to. If humans are able compare, then in return, they will be also able to evaluate. If this evaluation process keeps going on, that probably means there is a growing interest in what is going on. This still does not mean by any means that a musical composition containing reoccurring patterns of some sort and their transformations will be a guaranteed recipe for the creation of a successful music. It simply means that unless there is a point of reference, which may be just about anything previously digested and recognizable to the ear-minds of the audience, there is a significantly much lesser chance for produced musical piece (a meme) to catch on and make people react with positive feelings. How successfully one is going to play with musical patterns will, in the end, always remain the matter of human musical talent.

4. MUSICAL EMOTIONS

Now, another significant point to make is, to try to understand how the human brain deals with emotions and feelings. Here is just one of many perspectives, but the one that definitely needs a "point of reference" in order to be explained.

The human body, as represented in the brain, provides a fundamental frame of reference for the neural processes that we experience as the mind. We use the physical state of our very organism as the ground reference for the mental constructions which we make about the environment we live in. [3] In short, the background state of our body landscape provides a rather neutral "mood," against which we can judge any changes shaken by emotions. When the brain consciously appraises emotional changes in that equilibrium, we are having an emotional response—a feeling. Thus we may say that feeling depends on the juxtaposition of an image of the body, correlated to an image of something else; such as the auditory mental image of a musical pattern. [3] This differentiation between emotions and feelings is very important because:

... all emotions generate feelings if you are awake and alert, but not all feelings originate on emotions. [3]

Pretty much like being aware of the goose bumps, that your body creates while your mind is listening to an effective piece of music. It is generally agreed that feelings are strongly related to a need (desire) for something. Thus, in order to feel something, two things are necessary:

... a body and some disturbance signal from the body, but also presupposes some mind—endowed with beliefs—attributing this sensation to the lack of needed resource/action, and motivating in such a was the search for something. [2]

So, what could be the need when listening to a piece of music? To generalize again, most of the music listeners expect to get some kind of "positive" feeling generated by the listening process. I guess we can all agree that hardly anyone would listen to a piece of music that would generate the feeling of pain. Conversely, we may assume that intentional activity of listening to music is indeed induced by some need for pleasure. Conscious feeling of pleasure, generated by the process of listening to music, will create in your brain a memorized history of such intellectual experiences. Therefore, later on in life, under the similar listening conditions, your brain may recreate this correlation of "incoming" and "stored" mental images, and you may experience the feeling of goose bumps again. So far my personal research shows that goose bumps are always called up as evocation of the memory about the previous emotional experiences.

5. DESIGNING A SYSTEM

Knowing all this, the question arises: How to approach a design of an AI emotion-based system that would help computer music composers in making their musical pieces more appealing to the audiences? When dealing with designing an emotion-based agent, the main requirement should be the functional need for such a system.

Design must be guided by the following question: What does this particular (type of) agent need emotions for in the concrete environment it inhabits? (for what activities?) [1]

First, let me define the social context in which this system were suppose to function. The application of the proposed system would work only when applied to the certain kinds of music, that is predominantly practiced in the western cultures. This is the music that engages its listeners in making insightful intellectual and emotional responses rather than the music that helps their audience in achieving specific unique states of mind. Most of the later kind of

music may be found within the eastern and African cultures. Therefore, my impression is that within the western socio-cultural context, a system for evaluation of computer music is increasingly needed, as I outlined in the beginning of this paper.

It is crucially important to keep in mind, that when proposing this AI system, I am going to generalize a lot. We need simplicity when trying to understand the complex processes that trigger emotions and feelings when humans listen to music. This AI system, like any other system, seeks to reduce the aspect of the real world it represents, to its essential components. An integral part of doing science, necessarily involves generalization (i.e., disregarding details) and simplification of the complex phenomena under study. [8]

The practical application of our knowledge about the human brain could be put to use in the proposed AI emotion-based adaptive fuzzy system that utilizes deviations from a self-adjusted cognitive algorithm. This algorithm simulates the "formula" for generation of positive feelings. Proposed agent should be capable of analyzing the structure of computer music pieces in terms of musical patterns and their anticipation and predictability by the human brain. Such analysis would be able to suggest, if a composed piece of music has the necessary "ingredients" needed to produce a "meme" that is appealing to the audience.

In order to do this, the agent should first be able identify a musical pattern, as a stream of cognitive data that feeds into a neural or statistical network and out come the fuzzy rules for musical pattern analysis. The system could learn from experience and may use fresh data to tune its stock of knowledge. Pattern mapping and identification within a given musical piece, should be based on search for the possible similarities inside the musical fabric of the piece in question. The most fundamental matching ought to be performed on the rhythmic level, then on the pitch level, and finally on the timbral level. After identifying a pattern of some sort, the system should be able to follow its behavior throughout the musical piece. It would look if too many deviations from the mapped pattern fall together, and conclude that in such case the listener is most likely to lose track of the underlying musical stability, suppressing anticipation of the coming patterns forcefully. Significant deviations from pattern predictability tend to weaken subsequent pattern anticipation and thereby undercut the impact of further musical deviations. Every single mismatch in musical pattern anticipation may be countered by adjustments to the next expectation. For the listener, with too many deviations the music becomes increasingly incoherent, while with too little deviations, music becomes cold and mechanical.

The behaviours of most interest will be neither fully predictable nor completely random, but exhibit dynamic and occasionally emergent behaviour, as in the nature of natural systems. [6]

Thus, the proposed AI emotion-based adaptive fuzzy system could be, in fact, searching for a "point of reference" within the musical composition, and finding out if the computer music piece that is being analyzed, refers in some way from time to time to the initially established patterns, while refreshing audiences' memory. Furthermore, the system should be able to tell us if the manipulations of the patterns throughout the musical piece make the audience to be reasonably prepared for their occurrences. This is important because we know that the human brain perceives by anticipation, formulating perceptual hypotheses and then confirming them. [7] Successful confirmation of the human expectations, coupled with reasonable challenge for making such a confirmation, could be the impetus needed for generation of a positive feeling while listening to music.

Concluding, I hope that the working principles of the human brain that I have dealt with in this paper may help us in designing a template for an AI emotion-based adaptive fuzzy analysis system capable of audience simulation. This would hopefully guide a computer music composer towards more successful compositions and wider audiences.

REFERENCES

- [1] Dolores Canamero. *Issues in the Design of Emotional Agents*. Proceedings of the 1998 American Association for AI, Fall Symposium, Emotional and Intelligent: The Tangled Knot of Cognition, Technical Report FS-98-03, AAAI Press, Menlo Park, 1998.
- [2] Cristiano Castelfranchi. To believe and to feel: The case of "needs". Proceedings of the 1998 American Association for AI, Fall Symposium, Emotional and Intelligent: The Tangled Knot of Cognition, Technical Report FS-98-03, AAAI Press, Menlo Park, 1998.
- [2] Antonio Damasio, R. *Descartes' Error*. New York: A Grosset/Putnam Book, 1994.
- [3] Richard Dawkins. *The Selfish Gene*. Oxford University Press, Oxford, 1976.
- [4] Daniel C. Dennett. *Darwin's Dangerous Idea*. Simon & Schuster, New York, 1995.
- [5] Jonathan Impett. *Modeling the Dynamics of Musical Engagement*. Proceedings of the 1998 American Association for AI, Fall Symposium, Emotional and Intelligent: The Tangled Knot of Cognition, Technical Report FS-98-03, AAAI Press, Menlo Park, 1998.
- [6] Robert Jourdain. *Music, the Brain, and Ecstasy*. William Morrow and Company, Inc., New York, 1997.
- [7] Manfred Spitzer. *The Mind Within the Net: Models of Learning Thinking, and Acting*. A Bredford Book, The MIT Press, Cambridge, MA, 1999.