Exploitation of Memetics for Melodic Sequences Generation

Hokky Situngkir
[hs@compsoc.bandungfe.net]
Dept. Computational Sociolpgy
Bandung Fe Institute

Abstract
Music, or in narrower sense, melodic contours of the aesthetically arranged pitches and the respective durations attracts our cognition since the beginning and now shaping the way we think in the complex life of culture. From evolutionary school of thoughts we could learn our perspective of seeing the musical diversity of folk songs in Indonesian archipelago by hypothesizing the aligning memes throughout the data sets. By regarding the memeplexes constructed from the the Zipf-Mandelbrot Law in melodic sequences and some mathematical characteristics of songs *e.g.:* gyration and spiraling effect, we construct evolutionary steps *i.e.:* genetic algorithm as tools for generating melodic sequences as an alternating computational methods to model the cognitive processes creating songs. While we build a melodic-contour generator, we present the enrichment on seeing the roles of limitless landscape of creativity and innovation guided by particular inspirations in the creation of work of art in general.

Keywords: song generation, memetics, creativity, cognition.

"Music creates order out of chaos:
for rhythm imposes unanimity upon the divergent,
melody imposes continuity upon the disjointed,
and harmony imposes compatibility upon the incongruous"
Yehudi Menuhin

1. *Prelude*

Musical generation is a challenge for analyzing how human mind enjoys melodic sequences and harmony. Growing music computationally far or less can bring us to the conjecture on how the audible aesthetics has brought us into our realm for music. As a study directed to enhance our understanding to culture in general, endeavor to finding out what hypothetically becomes the elementary information in music (or roughly speaking, the melodic sequences) is a key point in observing music in the nature of memetics. Some hypotheses have been proposed, though [12], and while they have brought us to some conjectures revealing the complexity within music, they have also pointing some musical characteristics (*i.e.:* meme) that could be acquired for some experimental works on melodic generation. This is the interest of the paper, collaborating our understanding of memeplexes comprising melodic sequences, the interface between melody and computation, and our ability to enjoy beautiful music.

However, a lot of pioneering , yet different with those we present in the paper, have been initiated. The interface of computation to MIDI has brought the possibility to incorporating cellular automata to the creative processes on generating melodic sequences [3], while others present the acquisition of one dimensional cellular automata for specific musical purposes, *e.g.:* the generation and evolution of rhythmic patterns [2]. While some other authors see music as growing substance with a kind of generative grammars [8] on creating pleasing melodies by using the fractal L-System to be interpreted as music [16].

It is interesting to find out that the self-similarity of fractal geometry is confirmed in musical artifacts [1, 10]. However, this musical characteristic also play important role in our presentation. A musical property that directly or indirectly is related to the fact that melodious notational sequences could be views in special arrays of fractal Brownian motion, a kind of "music walk" [16], an interesting discovery showing us the anti-persistent behavior of musical for the tendency not to have monotonous melody in music compositions. These findings however, even further disclosing an intrinsic property of music by analyzing the fractal aspects of music both rhythmic motions and melody independently. The calculation thus brings the multifractal analysis for music [13].

While fractal geometry is widely used observing (and generating) music computationally, we also should pay attention to the recognition of music as evolutionary. The science of networks for musical representation in some cases have also been used for the analysis and representation musical composition as well as generating melodies by acquiring our understanding in the model of Genetic Algorithm [4].

Our presentation would be arranged in line to the works discussed above. The paper is structured as follows. First things first, we discuss about the hypothetical of musical aspects that proposed to be regarded as the elementary unit of song (*i.e.:* meme) along with some related reviewing arguments. The next thing to be depicted is the generative process of the song by employing the memes presented previously. The paper is ended by outlining some discussions and examples of song generations in order to have particular concluding remarks for further works.

2. Memes in Songs

"I'd like to think that when I sing a song,
I can let you know all about the heartbreak, struggle,
lies and kicks in the ass I've gotten over the years for being black and everything else,
without actually saying a word about it."
Ray Charles

Songs are complex artifact in human culture. It is a reflection from the appreciation of human cognition to the audible cultural realm. This is why observation to music or songs, especially the seeking for the elementary unit comprising beautiful song is never easy. There are so many things in life that is musical and pursuing the meme of the music is felt to be so much attached to this fact (*cf.* [7]. However, computational processing and its interface with music (*e.g.:* Musical Instrument Digital Interface) has brought a lot of possibility boosting our creativity in music in the past few decades [7]. Songs, when they are reduced in the interplay between pitches and the respective durations, thus can be characterized by some elementary calculated variables.

The fact that the rank of pitches and durations would nicely follow the Zipf-Mandelbrot fitting equations as to,

$$f(r) = \frac{a}{(1+br)^c} \tag{1}$$

where there is a relation between the rank (r) and the frequency of usage ($f(r)$) in songs [8]: a thing that previously has been confirmed so well in textual data. The findings for the gyration coefficient as representation of the melodic contour in the phase diagram depicting the transitional pattern of a note to another note, $\theta_d(\tau)$ vs $\theta_d(\tau+1)$ that formed a "trend line" depicting the "axis of rotation" in song dynamics, calculated as,

$$R_g = \sqrt{\frac{\sum_{i=1}^{n}\left[\left(n_{i+1} - y_{i+1}\right)\cos\alpha\right]^2}{(n-1)}} \tag{2}$$

where $\alpha = \tan^{-1} m$ and m is the slope of the trend line of linear equation, $y = mx + c$ [5]. This radial representation of musical pitches and durations could also be improved in order to get the "spiraling effect" of a song – a variable named after the finding of the logarithmic spirals

$$\rho = a\exp(b\phi) \tag{3}$$

in the radial specific visualization of the sorted melodic representation (pitches and durations) following

$$\cot\alpha = \frac{dr}{rd\phi} \tag{4}$$

where $[r, \varphi]$ denotes the radial coordinates in the model [5 , 11].

As the smallest unit of (cultural) information, memes in songs should stand for elementary concepts covering the "interaction" among pitches as well as the respective duration. The fitness of a song cannot be seen from the chosen pitches in a song, but they way the pitches contribute along with others forming the song that is enjoyable. These are interesting facts about memes in music that has brought the quantitative elementary unit in a song that is postulated to be the memes in songs. Empirically, the work on Indonesian traditional songs have interestingly shown how those mathematical characteristics used to differing songs from one folk songs to another related to the diverse ethnicities [12]. This is shown in figure 1, as the visual representation of Indonesian phylomemetic tree of traditional songs.

Figure 1
The phylomemetic tree of Indonesian traditional songs.

3. Generating Songs from Memes

"To study music, we must learn the rules. To create music, we must break them."
Nadia Boulanger

Our understanding for the variables acting as the elementary unit forming enjoyable songs, we could reverse the process of scrutinizing the existing songs into generative process. Here, our generator works as a machine that generates melodious sequences from a pre-defined one(s). The algorithmic steps are simply depicted in figure 2, from the calculation of the mathematical coefficients of each song to the generative process employing evolutionary process, *i.e.:* genetic algorithm.

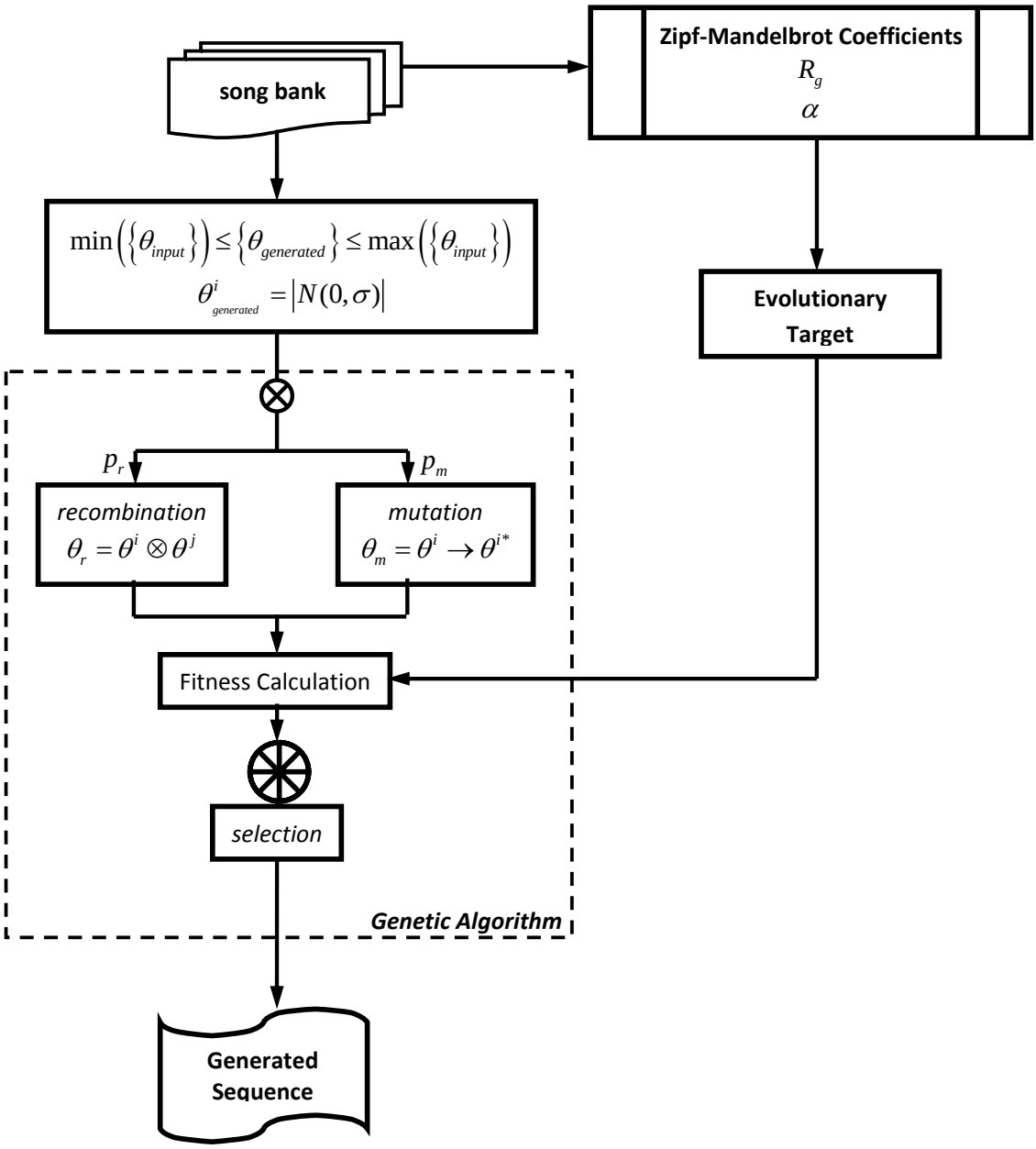

Figure 2
Algorithmic steps of the applied song generation.

The input of the system could be a single song (or some melodic parts of the data). Calculation of the coefficients is conducted in order to have the evolutionary aim of the whole generating processes. While one input song to be re-generated, we could use the yield of calculation directly, but when two or more songs are going to be regenerated altogether, the average value is a possibility,

$$m^i_{fitness} = \frac{\sum_{j>1} \omega^i M}{N} \qquad (5)$$

where m^i stands for the meme, be it $i \in I \triangleq \{$ Zipf-Mandelbrot coefficients ($a, b,$ and/or c), R_g , α $\}$. Thenafter, the random seeding of initiating population can be done with boundaries of the highest and lowest pitches of the reference songs to be regenerated. By adapting the genetic algorithm process, we apply the recombination probability (p_r) based upon the iteratively calculated fitness value f_k of the respective binary form of pitches and respective durations (θ) along with the mutation rate (p_m).

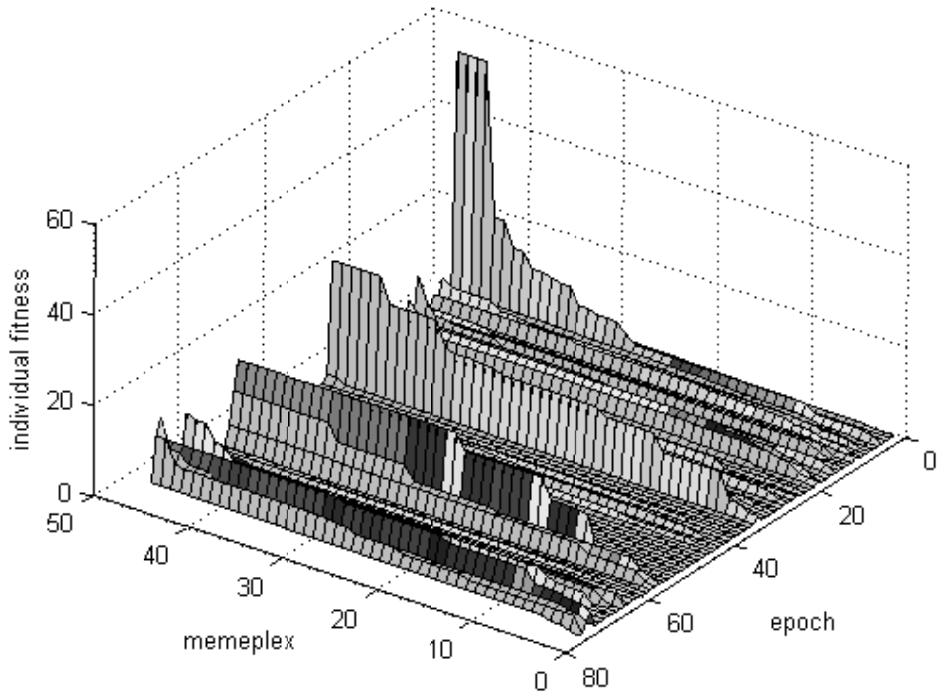

Figure 3
The fitness landscape for each epoch in regeneration of Javanese song “suwe ora jamu”

As we have noted previously, the binary representation of both pitches and durations (θ) cannot stand for their own sake, thus the calculation of the fitness value should be done collectively. Thus, upon the available population, in every iteration of the genetic algorithm, we do random sampling returning melodic sequences that are treated as song for the fitness regarding to the evolutionary aims wanted to be achieved. We can do Z times of sampling process, thus a fitness value of a single representation in the population can be written as,

$$f_k = \frac{1}{Z}\sum_{z}^{Z}[\, f_k \,]_z \qquad (6)$$

where $[\, f_k \,]_z$ denotes the collective fitness from the z-th sampling procedure for specific k-th binary representation of pitches and durations. The more sampling process we do in every fitness calculation, the more detailed the respective fitness value of each representation relative to selected sampled population. Thus after some epochs of generations, the generated melodic sequences are in our hand. It is worth noting that in our algorithm, the length of generated melodic sequences, say s, would always be smaller than the length of the recombining, mutating, and selected populations in each epoch ($|s| < |\theta|$).

For every evolutionary epoch, there are a constant, ε, denotes the number of "elite" of most fit populations that are excluded from any recombination and mutation, but instead, have direct offspring of the same memeplexes configurations. Those are special populations that will always be chosen for each time selection process is held [9]. The elites are, however, replaced by other memeplexes when in overall, a more fit ones comes up.

Our data of folk songs as shown in figure 1 thus can be treated as the songs bank from which we can regenerate jingles by using the our generative algorithm. An exemplification result of our computer simulation is shown in figure 3 for the regeneration of Javanese song "*suwe ora jamu"*. Our generative steps showed a creativity landscape of songs re-grown from a single folk song. This heuristic landscape of fitness is shown in figure 3 presenting the fitness value of each generated memeplexes. From the figure, we could see that in some epoch particular memeplexes with high fitness are emerged. However, our selection for the generated song shall not based upon the fitness value of individual memeplex from any epoch, but from the average fitness value overall the epoch as shown in figure 4.

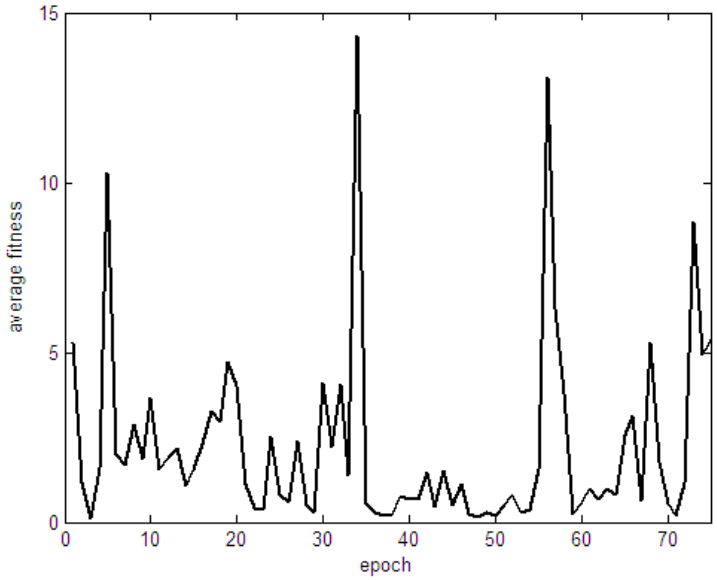

Figure 4
The average of fitness value in each epoch of our regeneration of Javanese song "*suwe ora jamu*"

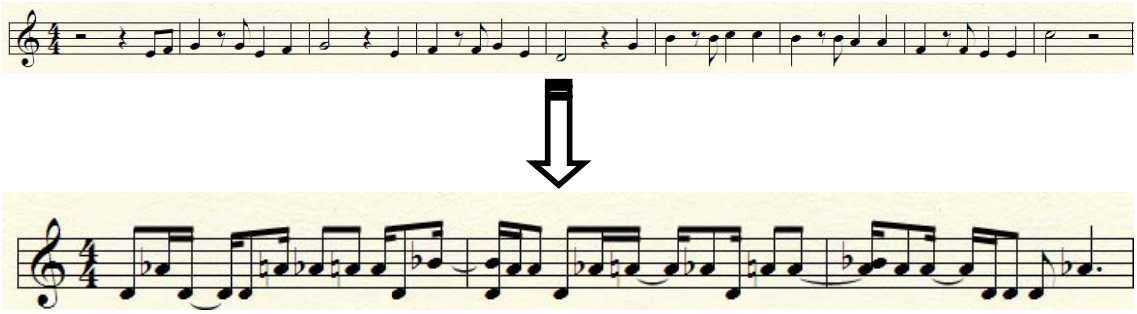

Figure 5
15 notes generated (*below*) from Javanese "*Suwe Ora Jamu*" (*above*)

4. Discussions

"Hear my song. People won't you listen now? Sing along!
You don't know what you're missing now.
Any little song that you know
Everything that's small has to grow.
…and it has to grow!"
Led Zeppelin

The computational generating process yield the note matrix that can be evaluated in the standard Musical Instrument Digital Interface as shown in figure 5. From the figure we can see how a single Javanese song "*Suwe Ora Jamu"* is regenerated in our evolutionary algorithm by the ruling fitness of the Zipf-Mandelbrot coefficients, gyration effect, and the spiraling effect of the song which are the hypothetical memes since the beginning.

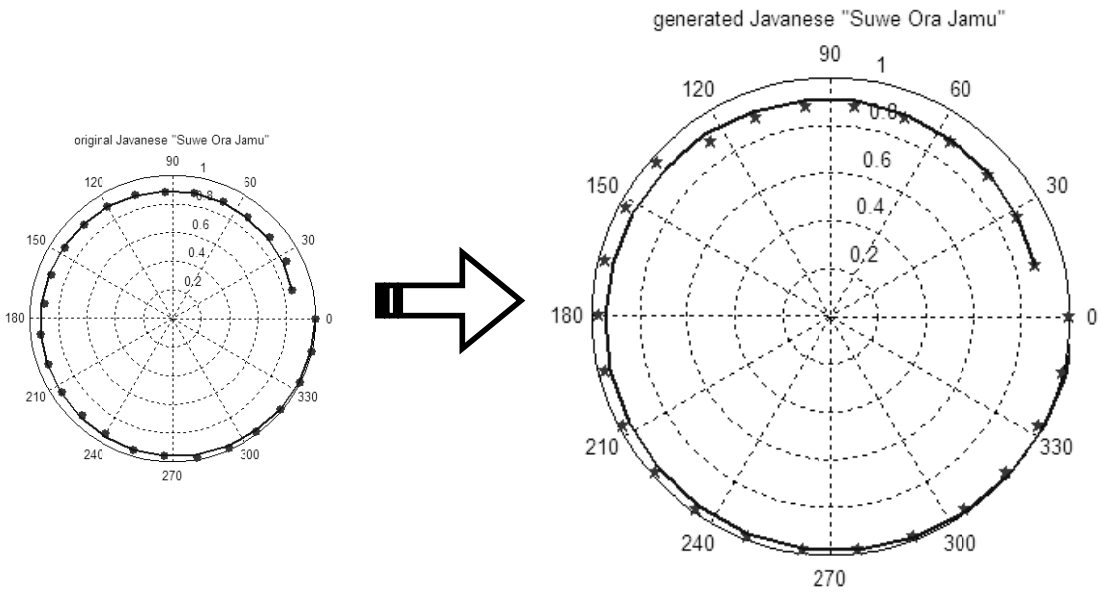

Figure 6
Alpha Spiraling Effect of the original song and the generated one

In advance, the spiraling effect of the source song and the generated one is shown as comparison in figure 6. It is obvious that the generated one and the source fit the similar spiraling effect, a thing that is also exhibited when we see the fitting of Zipf-Mandelbrot equation for both the source and the generated song in figure 7.

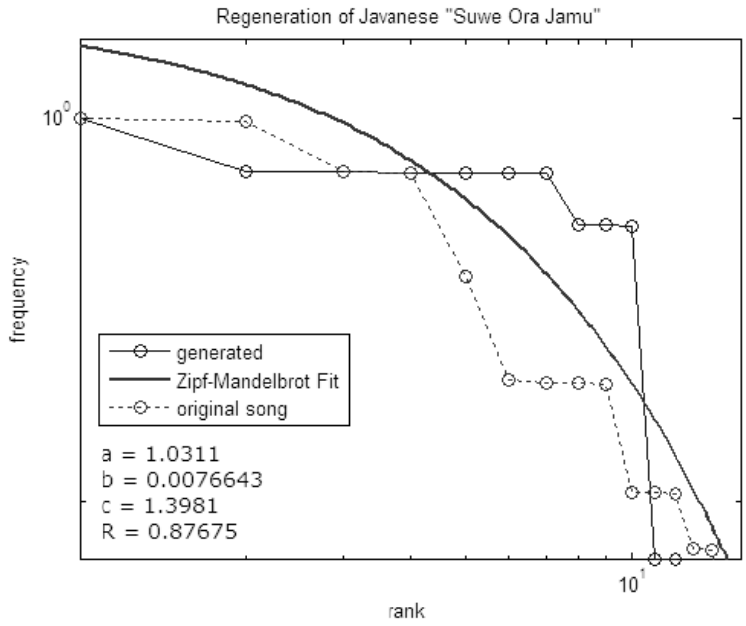

Figure 7
The fitting of the Zipf-Mandelbrot of the generated and the source song of Javanese "*Suwe Ora Jamu*"

5. *Finale*

"A good composer does not imitate; he steals."
Igor Stravinsky

The fitness landscape of the whole evolutionary processes in our algorithm is actually can be viewed as creativity landscape [13]. It reflects the possibility of pitches' (with respective durations) acquisitions in the generative process. Nonetheless, the landscape is thus bounded by the evolutionary aims calculated from the mathematical characteristics of song(s) we used as reference. In fact, that is positively the creative process work. The referred songs can be seen as the 'inspiration' of the generative (or we may denote it as the writing process) of songs. The referential songs could be retrieved This allegory thus becomes our way of working and inquiry in the further work ahead. Let the limitless of creativity works that is governed by the sources of inspiration, references, or previous works of art inducing the whole creation of the new works of art.

The 'inspiring' one can be two or more songs, and even a slightest short melodic contour. The creation of arts could be roughly seen as the result of state of aesthetic mixture between the infinite horizon of human cognitive process and the inspiring works attracting (or sometimes repelling) the conjectures of creativity.

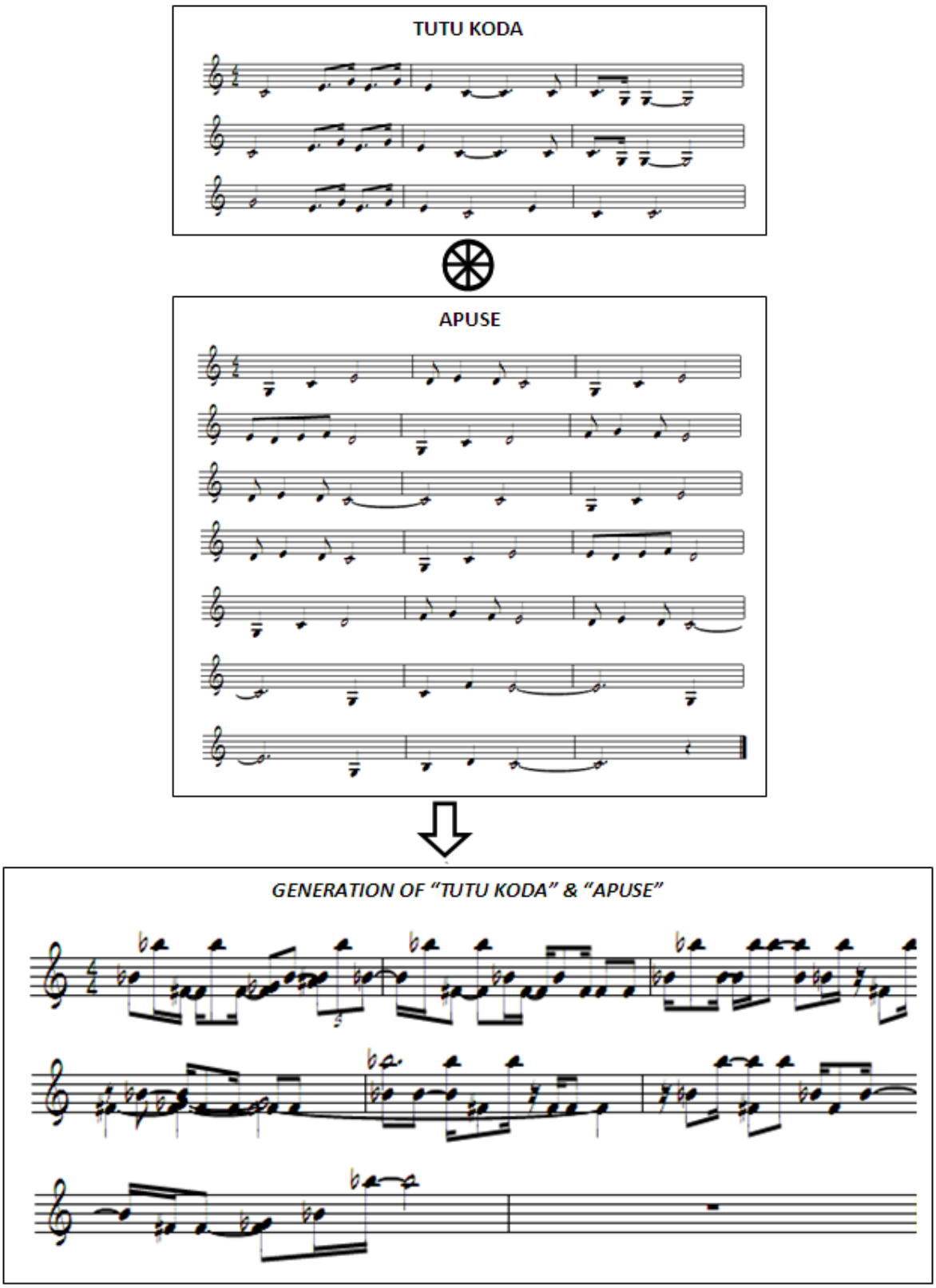

Figure 8
Regeneration of Papuan Traditional Songs by averaging the memeplexes between "*Tutu Koda"* and "*Apuse*".

An exemplification we present here is the mixing memeplexes of two Papuan songs: '*tutu koda*' and *'apuse'*. Both are neighbors in the cluster of songs from eastern-side of Indonesian archipelago in the phylomemetic tree drawn on figure 1 . The two songs and the generated one are shown in figure 8.

We have seen how we can exploit our understanding on the hypothetical elementary unit of information in songs in generative art of songs. This process also could also give an alternative explanation by practical demonstration about how the creativity as well as the inspirations plays the role in the progress of creating works of art. In big picture and larger context, this has shown how the borderless creativity and innovative thinking ahead, especially in the way we can appreciate, create, or even just enjoy melodic contours or music in general. The great future is ahead of us.

Acknowledgement
I thank Deni Khanafiah for discussions related to elite population and the adjustments of the mutating probability, SRI for financial support and people in BFI for support in which period the paper is written.

Works Cited

[1] Bigerelle, M. & Iost, A. (1999). "Fractal Dimension and Classification of Music". Chaos, Solitons & Fractals 11: 2179-2192.

[2] Brown, A. R. (2005). "Exploring Rhythmic Automata". *Applications on Evolutionary Computing: Lecture Notes on Computer Science*. Springer. pp. 551-6.

[3] Burraston, D., Edmonds, E., Livingstone, D. & Miranda, E. R. (2004). "Cellular Automata in MIDI based Computer Music". *Proceedings of the International Computer Music Conference*.

[4] Campolongo, G. & Vena, S. (2006). "Science of Networks and Music: A New Approach on Musical Analysis and Creation". *Applications of Evolutionary Computing: Lecture Notes on Computer Science*. Springer. pp. 642-51.

[5] Gündüuz, G. & Gündüz, U. (2005). "The Mathematical Analysis of the Structure of Some Songs". *Physica A* 357: 565-92.

[6] Jan, S. (2000). "Replicating Sonorities: Towards a Memetics of Music". *Journal of Memetics - Evolutionary Models of Information Transmission* 4. URL: http://cfpm.org/jom-emit/2000/vol4/jan_s.html

[7] Lartillot, O., Eerola, T., & Toiviainen, P. (2008). "A Matlab Toolbox for Music Information Retrieval". *Data Analysis, Machine Learning and Applications*. Springer. pp. 261-8.

[8] McCormack, J. (1996). "Grammar-based Musical Composition". *Complexity International* 3.

[9] Mitchell, M. (1998). *An Introduction to Genetic Algorithms*. MIT Press.

[10] Situngkir, H. (2007). "An Alternative Postulate to see Melody as 'Language'". *BFI Working Paper Series* WPK2007. Bandung Fe Institute. URL: http://www.bandungfe.net/?go=xpf&&crp=4661f04c

[11] Situngkir, H. (2007). "Menuju Studi Kompleksitas Musik Indonesia". *BFI Working Paper Series* WPT2007. Bandung Fe Institute. URL: http://www.bandungfe.net/?go=xpf&&crp=46d3de52

[12] Situngkir, H. (2008). "Conjectures to the Memes of Indonesian Songs". *BFI Working Paper Series* WP-VI-2008. Bandung Fe Institute. URL: http://www.bandungfe.net/?go=xpg&&crp=487645bd

[13] Situngkir, H. (2009). “Evolutionary Economics Celebrates Innovation and Creativity-Based Economy”. *The Icfai University Journal of Knowledge Management* 7(2):7-17.

[14] Su, Z-Y., & Wu, T. (2006). "Multifractal Analyses of Music Sequences". *Physica D* 221: 188-194.

[15] Su, Z-Y, & Wu, T. (2007). "Music Walk, Fractal Geometry in Music". *Physica A* 380: 418-428.

[16] Worth, P. & Stepney, S. (2005). "Growing Music: Musical Interpretations of L-Systems". *Applications on Evolutionary Computing: Lecture Notes on Computer Science*. Springer. pp. 545-50.