Annals of Pure and Applied Mathematics
Vol. 8, No. 2, 2014, 9-18
ISSN: 2279-087X (P), 2279-0888(online)
Published on 17 December 2014
www.researchmathsci.org

Annals of
Pure and Applied Mathematics

Ranking of Emotion Factors for the effect of Western Classical Symphonies using Triangular Fuzzy Associative Memories

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Received 17 August 2014; accepted 21 November 2014

Abstract. This article deals with triangular fuzzy associative memories (TFAMs). TFAMs method is used to analyze unsupervised data of musical emotions caused by Western Classical Symphonies. Further the ranking preference to the consequences of the problem is experimented to show the effectiveness of the proposed methodology.

Keywords: Musical Emotions, Synaptic Connection, Triangular Fuzzy Number Linguistic terms, FAM

AMS Mathematics Subject Classification (2010): 94D05

1. Introduction

The nature of music is to convey the innermost feelings of human. People's primary motivation for listening to music is its emotional effect. Most theories of music and emotion have focused on the representational features of music that enable listeners to perceive emotions. Listeners have repeatedly reported that they experience emotional feelings while listening to music in experiments, survey studies, diary studies and qualitative interviews. Research on human psychology had long considered the notion of an emotion to be a matter of degree. For Western classical symphonies, the causal relationship between musical features and their impact on the emotion of the listeners are described in terms of linguistic variables. The modified Fuzzy Associative Memories (FAM) is the main tool which has been applied to analyze the problem of assigning and ranking emotions to the musical symphonies having different musical features in this paper. This is because the factors that attribute to the problem can be classified into antecedent and consequent sets and the relationship between them needs to be analyzed. In this paper we propose that Triangular fuzzy numbers are associated with FAMs for dealing with the linguistic variable terms of the problem.

2. Method of triangular fuzzy associative memories

The new Triangular Fuzzy Associative Memories (TrFAMs) are more applicable when the relationship between the antecedent and consequent of the problem are described in terms of linguistic terms. In this section some basic concepts and working method of TrFAM are briefly explained.

2.1. Fuzzy Associative Memories (FAMs)

A fuzzy set is a map $\mu : X \to [0,1]$ where *X* is any set called domain and [0,1] the range. That is to every element $x \in X$, μ assigns membership value in the interval [0,1]. Fuzzy theorists often picture membership functions as two- dimensional graphs with the domain *X* represented as a one-dimensional axis. Its graphical representation is given in Figure1.

The geometry of fuzzy sets involves both domain $X = (x_1, x_2, ..., x_n)$ and the range [0,1] of mappings $\mu : X \to [0,1]$. A fuzzy subset equals the unit hyper cube $I^n = [0,1]^n$. The fuzzy set is a point in the cube I^n . Vertices of the cube I^n define a non-fuzzy set. Now within the unit hypercube $I^n = [0,1]^n$ we are interested in distance between points, which led to measures of size and fuzziness of a fuzzy set and more fundamentally to a measure. Thus within cube theory directly extends to the continuous case when the space *X* is a subset of R^n . The next step is to consider mappings between fuzzy cubes.

A fuzzy set defines a point in a cube. A fuzzy system defines a mapping between cubes. A fuzzy system *S* maps fuzzy sets to fuzzy sets. Thus a fuzzy system *S* is a transformation $S : I^n \to I^p$ (Figure 2). The *n*-dimensional unit hypercube I^n houses all the fuzzy subsets of the domain space or input universe of discourse, $X = (x_1, x_2, ..., x_n)$. I^p houses all the fuzzy subsets of the range space or output universe of discourse, $Y = (y_1, y_2, ..., y_n)$. *X* and *Y* can also denote subsets of R^n and R^p. Then the fuzzy power sets $F(2^X)$ and $F(2^Y)$ replace I^n and I^p.

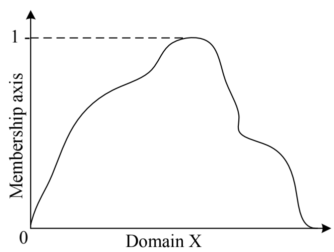


Figure 1:

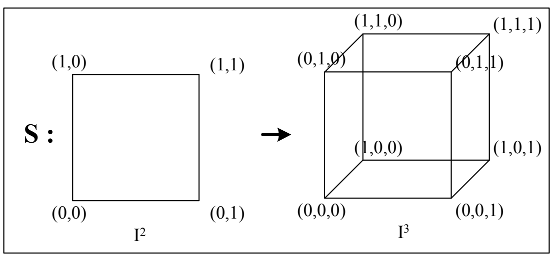


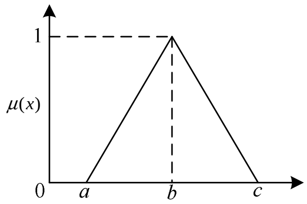
Figure 2:

In general a fuzzy system *S* maps families of fuzzy sets to families of fuzzy sets thus $S : I^{n_1} \times ... \times I^{n_r} \to I^{p_1} \times ... \times I^{p_s}$. Here too we can extend the definition of a fuzzy system to allow arbitrary products or arbitrary mathematical spaces to serve as the domain or range spaces of the fuzzy sets. We shall focus on fuzzy systems $S : I^n \to I^p$ that map balls of fuzzy sets in I^n to balls of fuzzy set in I^p . These continuous fuzzy systems behave as associative memories. The map close inputs to close outputs. We shall refer to them as Fuzzy Associative Maps or FAMs.

2.2. Triangular fuzzy number

It is represented with three points as follows: A = (a_1, a_2, a_3). Its membership function and graphical representation defined as follows,

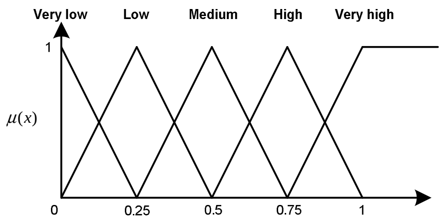
$$\mu_{\tilde{A}}(x)=\begin{cases} 0 & ; \quad x<a \\ (x-a)/(b-a) & ; \quad a\le x\le b \\ (c-x)/(c-b) & ; \quad b\le x\le c \\ 0 & ; \quad x>c \end{cases}$$



2.3. Triangular fuzzy number for linguistic variable

The responses for the subjective questionnaire are given in terms of linguistic term words. The values for the linguistic variables defined in terms of triangular fuzzy numbers are,

Very low ⟶ (0, 0, 0.25)
Low ⟶ (0,0.25,0.5)
Medium ⟶ (0.25,0.5,0.75)
High ⟶ (0.5,0.75,1)
Very high ⟶ (0.75,1,1)



2.4. Synaptic connection matrix for TrFAMs

Let ${}_{Tr}A_1$, ${}_{Tr}A_2$, ${}_{Tr}A_3$,..., ${}_{Tr}A_n$ and ${}_{Tr}C_1$, ${}_{Tr}C_2$, ${}_{Tr}C_3$,..., ${}_{Tr}C_p$ be the antecedent F_x and consequent F_y nodes of the TrFAMs respectively. The relation between these nodes in different level (linguistic variable) of experiences is given in terms of number of responses in each level. The membership values for the different level experience matrices are calculated with normalization then defined as follows: $N_{ELG-Level(1)}=\left(b_{ij}^{(1)}\right)$, $N_{ELG-Level(2)}=\left(b_{ij}^{(2)}\right)$,…, $N_{ELG-Level(k)}=\left(b_{ij}^{(k)}\right)$ where $i=1,2,...,n$ and $j=1,2,...,p$ which represent the opinions on *k*-different linguistic levels of experience of a group about causal relationship between the neurons field F_x with *n*-neuron and the neuron field F_y with *p*-neurons. Then these matrices are combined as one synaptic connection matrix M = (a_{ij}) where $a_{ij}=\max level\left(\max\left(b_{ij}^{(1)},b_{ij}^{(2)},b_{ij}^{(3)},...,b_{ij}^{(k)}\right)\right)$ and $\max level=\max(linguistic\ variable(1,2,3,...,k))$ $\forall$ $i=1,2,...,n$ and $j=1,2,...,p$. Then M is converted into a dynamical system $Tr(M)$ by giving triangular fuzzy numbers for the corresponding linguistic variables in M.

2.5. Equilibrium state of dynamical system

If the equilibrium state of a dynamical system is a unique state vector in both F_x and F_y sets, then it is called a fixed point. Consider a TRFAM with ${}_{Tr}A_1$, ${}_{Tr}A_2$, ${}_{Tr}A_3$,..., ${}_{Tr}A_n$ and ${}_{Tr}C_1$, ${}_{Tr}C_2$, ${}_{Tr}C_3$,..., ${}_{Tr}C_p$ as nodes of the two sets. For example let us start the dynamical system by switching on ${}_{Tr}A_1$. Let us assume that the TrFAM settles down with ${}_{Tr}A_i$ and ${}_{Tr}A_j$ *ON* in F_x and ${}_{Tr}C_l$ and ${}_{Tr}C_m$ *ON* in F_y respectively i.e., in the state vector remains as fixed point in F_x and F_y.

2.6. Limit cycle

If the TrFAM settles down with a state vector repeating in the form $A_1 \rightarrow A_2 \rightarrow A_3 \rightarrow \ldots \rightarrow A_i \rightarrow A_1$ and $B_1 \rightarrow B_2 \rightarrow B_3 \rightarrow \ldots \rightarrow B_j \rightarrow B_1$ then this equilibrium is called a limit cycle.

2.7. Method of determining the hidden pattern of triangular fuzzy associative memories (TrFAMs)

Step 1: Let $Tr(M)$ be the associated adjacency matrix formed by the causal relationship between the nodes ${}_{Tr}A_i$ and ${}_{Tr}C_j$ $\forall\ i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, p$ using the above procedure.

Step 2: Let us find the hidden pattern when ${}_{Tr}A_1$ is switched *ON*. This is done by fixing the state vector $A_1 = (1, 0, 0, \ldots, 0)$ (instead of ${}_{Tr}A_1 = (1, 0, 0, \ldots, 0)$). When an input is given as the vector A_1, the data should pass through the relation matrix $Tr(M)$ by multiplying A_1 with the triangular matrix $Tr(M)$.

Step 3: Let $A_1Tr(M) = (a_1, a_2, \ldots, a_n)$ be a triangular vector. Now we have to find the average of triangular fuzzy numbers in each entry of $A_1Tr(M)$ and we call it as $A_1Tr(M)_{avg}$. It gives the triangular weights of the consequent attributes.

Step 4: Then we threshold $A_1Tr(M)_{avg}$ by finding $A_1Tr(M)_{max}$. That is by replacing a_i by *1* if a_i is the maximum weight in $A_1Tr(M)_{avg}$, otherwise a_i by *0*. This operation is denoted by ($\hookrightarrow$) and call the thresholded vector as B_1.

Step 5: Find $B_1Tr(M)^T$ by multiplying B_1 with $Tr(M)^T$. Let $B_1Tr(M)^T = (b_1, b_2, \ldots, b_p)$ be a triangular vector and find $B_1Tr(M)^T_{avg}$ for B_1 as in ***step 3***. $B1Tr(M)^T_{avg}$ gives the triangular weights of the antecedent attributes.

Step 6: The threshold operation is done for $B_1Tr(M)^T_{avg}$ by finding $B_1Tr(M)^T_{max}$ as in ***step 4***. The thresholded vector is now called as A_2.

Step 7: Find $A_2Tr(M) = (a_1, a_2, \ldots, a_n)$ and perform the ***steps 3*** and ***4*** for A_2. By finding B_2 after thresholding, perform the ***steps 5*** and ***6*** to find A_3 from $B_2Tr(M)^T$.

Step 8: If the $A_iTr(M)_{max} = A_jTr(M)_{max}$ at certain stage for ($i \neq j$) and $B_lTr(M)^T_{max} = B_mTr(M)^T_{max}$ at certain stage for ($l \neq m$), then the dynamical system end otherwise repeat the above procedure.

Step 9: This procedure is repeated till we get a limit cycle or a fixed point in both *A* and *B* vectors. In general, this procedure can be repeated for any vector ${}_{Tr}A_i$; $i = 1, 2, \ldots, n$.

2.8. Ranking of TrFAMs using weight

The triangular weights of the fixed points are taken to evaluate the ranking process. Here we have considered two different category modes of symphonies. So, first three attributes in the domain space are taken to prepare ranking for major mode and another three for minor mode. The last attribute is not considered because the mode is changing from major to minor.

3. Adaptation of TrFAMs to the problem

We have considered the thirteen music excerpts having different features from the Western Classical Symphonies of L.V. Beethoven, Symphonie-6, Pastorale and George

Friedrich Handel as the nodes ${}_{Tr}A_1$, ${}_{Tr}A_2$, ${}_{Tr}A_3$,..., ${}_{Tr}A_7$ and nine major musical emotion factors described by Zentner et al., as the nodes ${}_{Tr}C_1$, ${}_{Tr}C_2$, ${}_{Tr}C_3$,..., ${}_{Tr}C_9$. We have interviewed 35 students from the age group ranging between 21 and 25 and recorded their opinions while listening to those musical excerpts. We choose the following attributes as the nodes in the domain space of TrFAM.

Combi	T.No.	Excerpt	Time Segment	Scale	Rhythm	Tempo	Instrument	Dynamics	Harmony	Comp
${}_{Tr}A_1$	1	Track 2	02.50 – 04.17	M	3/4	Andante	String, Violin, Cellos, Flute	mf – f	Full	LVB
${}_{Tr}A_2$	2	Track 3	00.00 – 01.38	M	6/8	Allegro	String, Oboe solo Clarinet solo, Trombone solo	mf – ff	Unison to Harmony	LVB
	7	Track 8	00.00 – 01.49	M	6/8	Vivace	Piano Quintet	f	Full	LVB
${}_{Tr}A_3$	8	Track 1(a)	00.59 – 03.10	M	2/4	Vivace	Strings Wood Wind	f	Full	GFH
${}_{Tr}A_4$	5	Track 7(a)	00.50 – 02.59	m	2/4	Andante	Piano solo , String Quintet Cello solo Violin solo	mf	Full	LVB
${}_{Tr}A_5$	9	Track 1(b)	03.13 – 04.25	m	3/4	Largo	Oboe solo, Strings Wood Wind	mp	Punctuated	GFH
	11	Track 5	00.52 – 02.07	m	3/4	Moderato	Strings	mf	Full	GFH
	12	Track 11	00.59 – 01.59	m	3/4	Moderato	Wood Wind Strings	f	Full	GFH
	13	Track 13	06.34 – 07.33	m	3/4	Largo	String Quintet	mf	-	GFH
	14	Track 16	00.00 – 00.59	m	3/4	Andante	Wood Wind Strings	mf	-	GFH
${}_{Tr}A_6$	4	Track 6	04.48 – 06.25	m	4/4	Allegro	Piano Strings Quintet	mf	Total	LVB
	10	Track 2	02.29 – 04.39	m	4/4	Moderato	Strings, Bassoon Wood Wind	mf	Full	GFH
${}_{Tr}A_7$	6	Track 7(b)	03.00 – 05.30	M-m	2/4	Andante	Piano Quintet Viola solo	mf	Full	LVB

The following are the attributes as the nodes in the range space of TrFAM.

R	Emotion	Sub-attributes
${}_{Tr}C_1$	**Wonder**	**H**appy, **A**llured, **Am**azed, **M**oved, **D**azzled
${}_{Tr}C_2$	**Transcendence**	**I**nspired, **T**ranscendence, **S**pirituality, **T**hrills
${}_{Tr}C_3$	**Tenderness**	**L**ove, **T**ender, **A**ffectionate, **S**ensual, **S**oftened-up
${}_{Tr}C_4$	**Nostalgia**	**S**entimental, **D**reamy, **N**ostalgic, **M**elancholic
${}_{Tr}C_5$	**Peacefulness**	**C**alm, **Se**rene, **R**elaxed, **S**oothed, **M**editative
${}_{Tr}C_6$	**Power**	**E**nergetic, **T**riumphant, **F**iery, **S**trong, **H**eroic
${}_{Tr}C_7$	**Joyful activation**	**S**timulated, **J**oyful, **An**imated, **D**ancing, **A**mused
${}_{Tr}C_8$	**Tension**	**A**gitated, **N**ervous, **T**ense, **I**mpatient, **Ir**ritated
${}_{Tr}C_9$	**Sadness**	**S**orrowful, **D**epressed

The fuzzy relation in five different levels of experiences of the group between these attributes of the problem is given by the following matrices.

$$N^{(1)}_{ELG-VL} = \begin{pmatrix} 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0.5 & 0.5 & 0.5 & 0.5 & 1 & 0.5 & 0 & 0.5 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.33 & 0.33 & 0.33 & 0 & 0.33 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0.5 & 0.5 & 0 \end{pmatrix} \quad N^{(2)}_{ELG-L} = \begin{pmatrix} 0.31 & 0.38 & 0.46 & 0.23 & 1 & 0.23 & 0.15 & 0.23 & 0.31 \\ 0.2 & 0.4 & 1 & 0.4 & 1 & 0.6 & 0.8 & 0.2 & 0 \\ 1 & 0 & 0 & 0.67 & 0.67 & 0.67 & 0.67 & 0.33 & 0 \\ 0.13 & 0.25 & 0.13 & 0.38 & 0.63 & 0 & 0.38 & 0.25 & 1 \\ 0.88 & 0.75 & 0.88 & 0.88 & 1 & 0.75 & 1 & 0.5 & 0.88 \\ 0.33 & 0.33 & 0.33 & 0.67 & 1 & 0.33 & 0.33 & 0.67 & 0.67 \\ 0 & 0.5 & 1 & 1 & 0.25 & 0.5 & 0.25 & 0.5 & 0.75 \end{pmatrix}$$

$$N^{(3)}_{ELG-M} = \begin{pmatrix} 0.58 & 0.17 & 1 & 1 & 0.92 & 0.25 & 0.67 & 0.17 & 0.5 \\ 0.41 & 0.24 & 1 & 0.53 & 0.35 & 1 & 0.94 & 0.12 & 0.06 \\ 0.45 & 0.18 & 0.36 & 0.55 & 0.36 & 0.45 & 1 & 0.09 & 0 \\ 0.09 & 0.09 & 1 & 0.73 & 0.64 & 0.09 & 0 & 0.18 & 0.73 \\ 0.54 & 0.21 & 0.5 & 1 & 0.5 & 0.36 & 0.57 & 0.25 & 0.46 \\ 0.55 & 0.27 & 0.55 & 0.91 & 0.82 & 0.55 & 1 & 0.18 & 0.55 \\ 0.1 & 0.2 & 0.6 & 1 & 0.7 & 0.2 & 0.3 & 0.1 & 0.6 \end{pmatrix} \quad N^{(4)}_{ELG-H} = \begin{pmatrix} 0.18 & 0.55 & 0.45 & 0.45 & 1 & 0.18 & 0.64 & 0.18 & 1 \\ 0.62 & 0.24 & 0.29 & 0.29 & 0.33 & 0.29 & 1 & 0.29 & 0.1 \\ 0.3 & 0.6 & 0.2 & 0.2 & 0.6 & 0.7 & 1 & 0 & 0.1 \\ 0.25 & 0 & 0.13 & 0.75 & 1 & 0 & 0.13 & 0.13 & 1 \\ 0.59 & 0.47 & 0.76 & 0.65 & 0.82 & 1 & 0.71 & 0.35 & 0.71 \\ 0.64 & 0.27 & 0.91 & 1 & 0.55 & 0.82 & 0.55 & 0.64 & 0.55 \\ 0.38 & 0 & 0.5 & 1 & 0.25 & 0 & 0.25 & 0.38 & 0.88 \end{pmatrix}$$

$$N^{(5)}_{ELG-VH} = \begin{pmatrix} 0.25 & 0.25 & 0.25 & 1 & 1 & 0.25 & 0.75 & 0.5 & 0.25 \\ 0.11 & 0 & 0.11 & 0 & 0.11 & 0.11 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0.5 & 1 & 0.5 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0.67 & 0.33 & 0 & 0 & 1 \\ 0.5 & 0.33 & 0.5 & 0.67 & 0.33 & 0.33 & 0.17 & 0.17 & 1 \\ 0.33 & 0 & 0.83 & 1 & 0 & 0.33 & 0.33 & 0.5 & 1 \\ 0 & 0 & 0.25 & 1 & 0 & 0.5 & 0 & 0.5 & 0.25 \end{pmatrix}$$

Now we give the synaptic connection matrix of TrFAM in terms of linguistic variables using the above method in 2.4.

$$M = \begin{pmatrix} M & H & M & VH & VH & VH & VH & VH & H \\ H & VL & M & M & L & M & VH & VL & H \\ VH & H & M & L & L & VH & H & VL & H \\ H & L & M & VH & H & VH & L & L & H \\ L & L & L & M & L & H & L & VL & VH \\ VL & L & H & VH & L & H & M & VL & VH \\ H & L & L & VH & VL & VH & VL & VH & H \end{pmatrix}$$

Now we give the synaptic connection matrix of TrFAM in terms of triangular fuzzy numbers for the corresponding linguistic variables in above matrix.

$$Tr(M) = \begin{pmatrix} (0.25,0.5,0.75) & (0.5,0.75,1) & (0.25,0.5,0.75) & (0.75,1,1) & (0.75,1,1) & (0.75,1,1) & (0.75,1,1) & (0.75,1,1) & (0.5,0.75,1) \\ (0.5,0.75,1) & (0,0,0.25) & (0.25,0.5,0.75) & (0.25,0.5,0.75) & (0,0.25,0.5) & (0.25,0.5,0.75) & (0.75,1,1) & (0,0,0.25) & (0.5,0.75,1) \\ (0.75,1,1) & (0.5,0.75,1) & (0.25,0.5,0.75) & (0,0.25,0.5) & (0,0.25,0.5) & (0.75,1,1) & (0.5,0.75,1) & (0,0,0.25) & (0.5,0.75,1) \\ (0.5,0.75,1) & (0,0.25,0.5) & (0.25,0.5,0.75) & (0.75,1,1) & (0.5,0.75,1) & (0.75,1,1) & (0,0.25,0.5) & (0,0.25,0.5) & (0.75,1,1) \\ (0,0.25,0.5) & (0,0.25,0.5) & (0,0.25,0.5) & (0.25,0.5,0.75) & (0,0.25,0.5) & (0.5,0.75,1) & (0,0.25,0.5) & (0,0,0.25) & (0.75,1,1) \\ (0,0,0.25) & (0,0.25,0.5) & (0.5,0.75,1) & (0.75,1,1) & (0,0.25,0.5) & (0.5,0.75,1) & (0.25,0.5,0.75) & (0,0,0.25) & (0.75,1,1) \\ (0.5,0.75,1) & (0,0.25,0.5) & (0,0.25,0.5) & (0.75,1,1) & (0,0,0.25) & (0.75,1,1) & (0,0,0.25) & (0.75,1,1) & (0.5,0.75,1) \end{pmatrix}$$

Attribute $_{Tr}A_1$ is ON, i.e., $A_1 = (1\ 0\ 0\ 0\ 0\ 0\ 0)$

$A_1 = (1\ 0\ 0\ 0\ 0\ 0\ 0)$

$A_1Tr(M)$ = ((0.25,0.5,0.75) , (0.5,0.75,1) , (0.25,0.5,0.75) , (0.75,1,1) , (0.75,1,1) , (0.75,1,1) , (0.75,1,1) , (0.75,1,1) , (0.5,0.75,1))

$A_1Tr(M)_{avg}$ = (0.5 , 0.75 , 0.5 , 0.91667 , 0.91667 , 0.91667 , 0.91667 , 0.91667 , 0.75)

$A_1Tr(M)_{max} \hookrightarrow$ (0 , 0 , 0 , 1 , 1 , 1 , 1 , 1 , 0) = B_1

$B_1Tr(M)^T$ = ((3.75,5,5) , (1.25,2.25,3.25) , (1.25,2.25,3.25) , (2,3.25,4) , (0.75,1.75,3) , (1.5,2.5,3.5) , (2.25,3,3.5))

$B_1Tr(M)^T_{avg}$ = (4.58333 , 2.25 , 2.25 , 3.08333 , 1.8333 , 2.5 , 2.91667)

$B_1Tr(M)^T_{max} \hookrightarrow$ (1 , 0 , 0 , 0 , 0 , 0 , 0) = A_2 (= A_1)

$A_2Tr(M)$ = ((0.25,0.5,0.75) , (0.5,0.75,1) , (0.25,0.5,0.75) , (0.75,1,1) , (0.75,1,1) , (0.75,1,1) , (0.75,1,1) , (0.75,1,1) , (0.5,0.75,1))
$A_2Tr(M)_{avg}$ = (0.5 , 0.75 , 0.5 , 0.91667 , 0.91667 , 0.91667 , 0.91667 , 0.91667 , 0.75)
$A_2Tr(M)_{max} \hookrightarrow$ (0 , 0 , 0 , 1 , 1 , 1 , 1 , 1 , 0) = B_2 (= B_1)

Similarly we do this procedure for all the other attributes $_{Tr}A_2$, $_{Tr}A_3$,..., $_{Tr}A_7$ in *ON* state. The following table gives the different limit points of their corresponding input vectors in *ON* state.

Table 1: Limit points for different input vectors

Input	Limit points
(1 0 0 0 0 0 0)	(1 0 0 0 0 0 0) , (0 0 0 1 1 1 1 1 0)
(0 1 0 0 0 0 0)	(1 1 0 0 0 0 0) , (0 0 0 0 0 0 1 0 0)
(0 0 1 0 0 0 0)	(0 0 1 0 0 0 0) , (1 0 0 0 0 1 0 0 0)
(0 0 0 1 0 0 0)	(0 0 0 1 0 0 0) , (0 0 0 1 0 1 0 0 1)
(0 0 0 0 1 0 0)	(0 0 0 1 1 1 0) , (0 0 0 0 0 0 0 0 1)
(0 0 0 0 0 1 0)	(0 0 0 1 0 1 0) , (0 0 0 1 0 0 0 0 1)
(0 0 0 0 0 0 1)	(1 0 0 0 0 0 1) , (0 0 0 1 0 1 0 1 0)

The limit points are given as the combination of antecedent and consequent attributes for each attribute in *ON* state in the above table.

Triangular Weights of the musical features and emotion factors are shown in the following tables for evaluating the effect of Major scale and minor scale musical symphonies on the emotion factors.

Table 2: Triangular weights of Musical features

Tri. Wgts	Musical Features Triangular Weight						
ON states	M-3/4	M-6/8	M-2/4	m-2/4	m-3/4	m-4/4	M-m-2/4
Major scale excerpts in ON state	***4.58333***	2.25	2.25	3.08333	1.83333	2.5	2.91667
	0.91667	***0.91667***	0.75	0.25	0.25	0.5	0.08333
	1.41667	1.25	***1.83333***	1.66667	1	0.83333	1.66667
Total wgt.	**6.91667**	**4.41667**	**4.83333**	**5**	**3.08333**	**3.83333**	**4.66667**
Ranking (M)	1	5	3	2	7	6	4
Minor scale excerpts in ON state	2.58333	1.75	1.91667	***2.75***	2.16667	2.58333	2.58333
	0.75	0.75	0.75	***0.91667***	***0.91667***	***0.91667***	0.75
	1.66667	1.25	1	***1.83333***	1.41667	***1.83333***	1.66667
Total wgt.	**5**	**3.75**	**3.66667**	**5.5**	**4.50001**	**5.33333**	**5**
Ranking (m)	3	5	6	1	4	2	3

Table 3: Triangular weights of Emotion factors

Tri. Wgts	Triangular weight of Emotion Factors								
ON states	Wonder	Transcen	Tender	Nostal	Peaceful	Power	Joy active	Tension	Sadness
Major scale excerpts in ON state	0.5	0.75	0.5	***0.91667***	***0.91667***	***0.91667***	***0.91667***	***0.91667***	0.75
	1.25	0.8333	1	1.41667	1.16667	1.41667	***1.83333***	1	1.5
	0.91667	0.75	0.5	0.25	0.25	***0.91667***	0.75	0.08333	0.75
Total wgt.	**2.66667**	**2.3333**	**2**	**2.58334**	**2.33334**	**3.25001**	**3.5**	**2**	**3**
Ranking (M)	4	7	8	5	6	2	1	8	3
Minor scale excerpts in ON state	0.75	0.25	0.5	***0.91667***	0.75	***0.91667***	0.25	0.25	***0.91667***
	1.08333	0.75	1.5	2.3333	1.25	2.41667	1	0.41667	***2.75***
	0.83333	0.5	1.25	***1.83333***	1	1.66667	0.75	0.3333	***1.83333***
Total wgt.	**2.66666**	**1.5**	**3.25**	**5.0833**	**3**	**5.00001**	**2**	**0.99997**	**5.5**
Ranking (m)	6	8	4	2	5	3	7	9	1

4. Conclusion

We infer from the tables above that the Triangular FAM brings out the factors of musical features which affect the emotion factors in the analysis. The result derived here are the combined levels of experience of a group.

From the table 1, we observe that when the Major scale excerpts having 3/4, 6/8 and 2/4 rhythms attributes in *ON* state, we have the emotion factors {Nostalgia, Peacefulness, Power, Joyful activation, Tension}, {Joyful activation} and {Wonder, Power} attributes respectively are in *ON* state for the attributes {(M,3/4)}, {(M,3/4),(M,6/8)} and {(M,2/4)} induced by $_{Tr}A_1$, $_{Tr}A_2$ and $_{Tr}A_3$ respectively. When the minor scale excerpts having 2/4, 3/4 and 4/4 rhythms attributes in *ON* state, we have the emotion factors {Nostalgia, Power, Sadness}, {Sadness} and {Nostalgia, Sadness} attributes respectively in *ON* state for the attributes {(m,2/4)}, {(m,2/4),(m,3/4),(m,4/4)} and {(m,2/4),(m,4/4)} induced by $_{Tr}A_4$, $_{Tr}A_5$ and $_{Tr}A_6$ respectively. When the excerpt sequence changing from Major to minor scale with 2/4 rhythm attribute in *ON* state, we have the emotion factors {Nostalgia, Power, Tension} in *ON* state for the attributes {(M,3/4),(M-m,2/4)} induced by $_{Tr}A_7$.

From the tables 2 and 3, we observe that the emotion factor Joyful activation is mostly induced by Major scale excerpts. Also Sadness is induced mostly by minor scale excerpts. The ranking of the emotion factors for the Major scale excerpts is given as Joyful activation (3.5), Power (3.25001), Sadness (3), Wonder (2.66667), Nostalgia (2.58334), Peacefulness (2.33334), Transcendence (2.3333) and {Tenderness, Tension} (2) by triangular weight of the attributes. The ranking of the emotion factors for the minor scale excerpts is given as Sadness (5.5), Nostalgia (5.0833), Power (5.00001), Tenderness (3.25), Peacefulness (3), Wonder (2.6666), Joyful activation (2), Transcendence (1.5) and Tension (0.99997) by triangular weight of the attributes.

Acknowledgements

This research work is supported by UGC scheme MANF. Award Letter No.: F1-17.1/2011-12/MANF-CHR-TAM-7467/(SA-III/Website).

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