NOTRAIL: GRAPH CONSTRUCTION TO FORM A TRAIL ON THE MALANG STATE UNIVERSITY MARS SONG

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Abstract. Music could be a sound that's made in such a way as to make a cadence, tone, and harmony. In music, there's a melodic documentation or what is commonly known as a note. Notes are melodic images that portray a tone outwardly. A melody can be spoken to within the shape of a chart development as a path builder, by deciding the vertices and edges of the comparing notes. The representation of the vertices is the documentation itself, whereas the weights of the edges are gotten from the time esteem of each documentation. The development of the chart development that speaks to the melody can be decided by the form of path obtained by taking after the weighted and coordinated chart that has been made. The chart shown is named notrail, which suggests that it isn't a chart and a path. This investigation was conducted to see how to decide the development chart as a path that speaks to the Defaces UM melody documentation, and to discover how to peruse or sing and know the development of the documentation spoken to by the chart development as a path creator. The chart models are made with a few builds to determine how the model is formed and the level of trouble in perusing and knowing its developments. From the demonstrated shape, there are 3 constructs, to be specific notrail based on by and large documentation, notrail based on tune verses, and notrail based on bars (virama lines). The findings of this research, which utilized three notrail methods to construct the Mars UM song reveal a well-balanced composition. This is evident form the abundance of recurring note patterns and subtle pitch variations, which also have a potential impact on delivering the meaningful of the song to the listeners. Additionally, the carefully considered breath-taking intervals in the Mars UM song can be regarded as ideal, as they involve more frequent use of one second intervals. Notably, it refrains form employing breath-taking intervals that are too rapid, such as half a second, or prolonged, like two second.

Keywords: Notrail, Graph, Mars UM

INTRODUCTION

Music may be a composition of high and low tones that run with the beat of time (Mudjilah, 2010). Musical notation may be a composing framework in music, comprising two types of documentation: numeric notation and piece documentation. In Indonesia, the documentation that is regularly utilized is numeric because numeric documentation is exceptionally simple in terms of its use. In numeric documentation, a tone is signified by numbers; specifically, 1 (Do), 2 (Re), 3 (Mi), 4 (Fa), 5 (Sol), 6 (La), and 7 (Si) are the numbers that demonstrate the high and low levels of a note.

In melodic notation, a common issue that regularly emerges is the design of shaping melodic components, such as scale, chord, and notation designs. A melody partner or vocalist in common, when singing a melody with numerical or block notations, must inquire about new notations so as not to induce boredom and end up with modern challenges and advancements.

METHOD

The use of mathematics, particularly the concept of graphs, is exceptionally valuable for lifestyles such as finding routes, electronic components, utility issues, and maps. A melody can be made within the frame of a weighted and directed graph by deciding the vertices of the notes of a song and the edges of the two related notations. A weighted graph may be a graph where each edge is assigned a value or weight, whereas a directed graph (digraph) comprises a set of elements called vertices and a set of components called arcs, where each arc joins two vertices in the indicated direction(Anderson et al., 2001). Within the melodic notation modeling process, we require a weighted and directed graph model to obtain a trial. A graph may be a graph comprising of points, called vertices, joined by lines, called edges, each edge joins precisely two vertices (Anderson et al., 2001).

In past studies, illustrations for melodic notation have been broadly utilized; however, utilizing melody intervals and the concept of the path by Reni Wijaya(Wijaya, 2018). In their work, Mao et al. (Mao et al., 2016) connected the concept of the graph to suggest the quality of music types, and Zhao et al.(Zhao et al., 2016) suggested a music sort by applying a bipartition graph. The tree graph application is additionally connected to composing music notation in numerical notation rearranged by Manalu (Manalu, 2011), which also applies the combinatorial concept to music hypothesis (Adhipradhana, 2018), and indeed taufik hidayat also employs a graph application to decide finger positions that are simple to play guitar (Hidayat, 2013).

This research position, alongside the previous studies that have outlined, serves as complement and a new variation to visualize music into more captivating form of notation. By utilizing weighted and directed graph modeling, we obtain a trial that can represent a notation in one melody. The trail frame may be a notation in a melody, where the trail can also be sung and capacities the same as block or numeric notation.

Mars UM may be a melody displayed by the State University of Malang as a soul and image or symbol of the State University of Malang. This investigation was conducted to determine how to decide the development graph as a trail that represents the Mars UM melody notation, and to discover how to peruse or sing and know the movement of the notation represented by the graph development as a trailmaker. The foundation for the choice of the Mars UM melody is that the author is a graduate class at the State University of Malang, as well as a battling soul and sense of pride within the State University of Malang campus.

FINDINGS AND DISCUSSION

1 Basic of Music Notation

In music notation, there are a few rules that will be utilized in graph construction modelling (Notrail), specifically the notation of the Mars UM melody itself.

The following is the music score for the Mars UM melody and the time-value table.

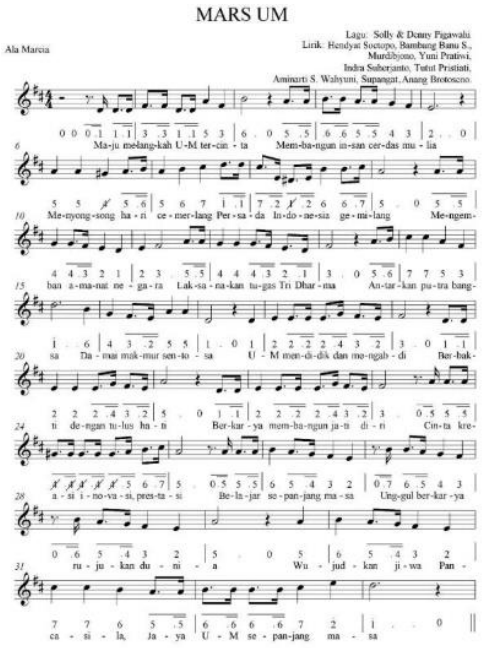

Figure 1. Mars UM Song Score (Solly & Pigawahi, n.d.)

Table 1. Time Value (Lina Ng, 1991)

Name	Image Not	Knock
Semibreve	𝅝	4
Minim	𝅗𝅥 𝄼	2
Crotchet	♩	1
Quaver	♪♫	½
SemiQuaver	𝅘𝅥𝅯♫	¼

Judging from the music scores of Mars UM, there are several symbols of the basic notation of music, namely the key signature (𝄞), key signature is the beginning of a symbol that must be present in a music score, in Mars UM the key signature used is treble cleff (Schmidt-Jones & Jones, 2000) or commonly known as G cleff. The second symbol is sharp (♯) or what we usually call the kress symbol, the sharp symbol means that the notation with a sharp sign will increase by half the value of the notation it occupies. On the Mars UM song score, there are 2 kress symbols at the beginning, which means that the signature key is the D or 1 (Do) key on D. There is also a time signature symbol, in the scores of the Mars UM song the time signature used is simple quadruple (𝄴) which means there are 4 crotchets in 1 bar (Lina Ng, 1991). In the Mars UM song, there is a notation with a dot behind the note (Dotted Notes), which means that the note has half the price of the notes it follows (Mudjilah, 2010).

2 Graph Construction (Notrail)

Based on the research subject, namely Mars UM song scores, the writer made 3 graph constructions to represent Mars UM song sheet music. This graph construction is

called Notrail, which suggests that the note is within the frame of the trail. Notrail is taken form the name "notation and trail" and then combined into "notrail". The graph development in the address is the creation of a graph demonstration that can be utilized as a substitute for the Mars UM melody scores, which have the same work and concept. The three graph developments that will be made utilize the definitions of a weighted graph, directed graph, and trail. A trail could be a walk with all edges, but not essentially all vertices, distinct (Anderson et al., 2001).

Notrail Based on Overall Notation

The construction of the graph to get a trail is obtained in a number of steps as follows:

Step 1: We will look for vertices ($\boldsymbol{v}$) and edges ($\boldsymbol{e}$) to form a graph construction. Based on the scores of the Mars UM song, the vertices ($\boldsymbol{v}$) and edges ($\boldsymbol{e}$) namely vertices ($\boldsymbol{v}$) is

$$v = \{1, \mathcal{1}, 2, 3, 4, \mathcal{4}, 5, 6, 7, \dot{1}, a, b, c\},$$

where $1, \mathcal{1}, 2, 3, 4, \mathcal{4}, 5, 6, 7, \dot{1}$ is the basic scale and a, b, c is a substitute symbol for 0 or a break sign *(Rest)*. The weight assigned to each break sign symbol (rest) are consecutively 2 second, ½ second, and 1 second. The edges (e) obtained from the adjacent notes of the UM Mars song scores are

$$E(v) = \{(a,b),(b,1),(1,1),(1,1)\ (1,3),(3,3),(3,1),(1,1),(1,5),(5,3),(3,6),$$
$$(6,5),(5,5),(5,6),(6,6),(6,5),(5,5),(5,4),(4,3),(3,2),(2,c),(c,5),(5,5),(5,\mathcal{4}),$$
$$(\mathcal{4},5),(5,6),(6,5),(5,6),(6,7),(7,\dot{1}),(\dot{1},\dot{1}),(\dot{1},7),(7,2),(2,\mathcal{1}),(\mathcal{1},2),(2,6),(6,6),$$
$$(6,7),(7,5),(5,c),(c,5),(5,5),(5,4),(4,4),(4,3),(3,2),(2,1),(1,2),(2,3),(3,5),(5,5),$$
$$(5,4),(4,4),(4,4),(4,3),(3,2),(2,1),(1,3),(3,c),(c,5),(5,6),(6,7),(7,7),(7,5),(5,3),$$
$$(3,\dot{1}),(\dot{1},6),(6,4),(4,3),(3,2),(2,5),(5,5),(5,1),(1,c),(c,1),(1,2),(2,2),(2,2),$$
$$(2,2),(2,4),(4,3),(3,2),(2,3),(3,c),(c,1),(1,1),(1,2),(2,2),(2,2),(2,4),(4,3),(3,2),$$
$$(2,5),(5,c),(c,1),(1,1),(1,2),(2,2),(2,2),(2,2),(2,4),(4,3),(3,2),(2,3),(3,b),(b,5),$$
$$(5,5),(5,5),(5,\mathcal{4}),(\mathcal{4},\mathcal{4}),(\mathcal{4},\mathcal{4}),(\mathcal{4},\mathcal{4}),(\mathcal{4},\mathcal{4}),(\mathcal{4},5),(5,6),(6,7),(7,5),(5,b),$$
$$(b,5),(5,5),(5,5),(5,6),(6,5),(5,4),(4,3),(3,2),(2,b),(b,7),(7,6),(6,5),(5,4),(4,3),$$
$$(3,b),(b,6),(6,5),(5,4),(4,3),(3,2),(2,5),(5,c),(c,5),(5,6),(6,5),(5,4),(4,3),(3,2),$$
$$(2,7),(7,7),(7,6),(6,5),(5,5),(5.6),(6,6),(6,6),(6,6),(6,7),(7,2),(2,\dot{1}),(\dot{1},a)\}$$

Step 2: Determine the side weights, the side weights are obtained from the time value of the adjecent notes, from step 1 you get 159 edges, where

$$E(v) = \{e_1, e_2, e_3, e_4, e_5, \dots\dots, e_{159}\}$$

Thus, the weight of each edge can be obtained as follows.

Table 2 Weights edges based on time values

Edges	Weight	Edges	Weight	Edges	Weight	Edges	Weight	Edges	Weight
e_1	2	e_{33}	¾	e_{65}	1	e_{97}	¼	e_{129}	½
e_2	½	e_{34}	¼	e_{66}	1	e_{98}	1	e_{130}	¾
e_3	½	e_{35}	¾	e_{67}	3	e_{99}	¾	e_{131}	¼
e_4	¾	e_{36}	¼	e_{68}	1	e_{100}	¼	e_{132}	1
e_5	¼	e_{37}	1	e_{69}	1	e_{101}	¾	e_{133}	1
e_6	¾	e_{38}	¾	e_{70}	¾	e_{102}	¼	e_{134}	½
e_7	¼	e_{39}	¼	e_{71}	¼	e_{103}	¾	e_{135}	½
e_8	¾	e_{40}	2	e_{72}	1	e_{104}	¼	e_{136}	¾
e_9	¼	e_{41}	1	e_{73}	1	e_{105}	2	e_{137}	¼
e_{10}	1	e_{42}	¾	e_{74}	2	e_{106}	½	e_{138}	1

e_{11}	1	e_{43}	¼	e_{75}	1	e_{107}	½	e_{139}	1
e_{12}	3	e_{44}	1	e_{76}	1	e_{108}	¾	e_{140}	2
e_{13}	¾	e_{45}	¾	e_{77}	1	e_{109}	¼	e_{141}	1
e_{14}	¼	e_{46}	¼	e_{78}	¾	e_{110}	¾	e_{142}	1
e_{15}	¾	e_{47}	1	e_{79}	¼	e_{111}	¼	e_{143}	1
e_{16}	¼	e_{48}	1	e_{80}	¾	e_{112}	¾	e_{144}	¾
e_{17}	¾	e_{49}	1	e_{81}	¼	e_{113}	¼	e_{145}	¼
e_{18}	¼	e_{50}	2	e_{82}	¾	e_{114}	¾	e_{146}	1
e_{19}	1	e_{51}	¾	e_{83}	¼	e_{115}	¼	e_{147}	1
e_{20}	1	e_{52}	¼	e_{84}	2	e_{116}	¾	e_{148}	1
e_{21}	3	e_{53}	1	e_{85}	1	e_{117}	¼	e_{149}	1
e_{22}	1	e_{54}	1	e_{86}	¾	e_{118}	2	e_{150}	1
e_{23}	1	e_{55}	¾	e_{87}	¼	e_{119}	½	e_{151}	¾
e_{24}	1	e_{56}	¼	e_{88}	1	e_{120}	½	e_{152}	¼
e_{25}	1	e_{57}	¾	e_{89}	1	e_{121}	¾	e_{153}	¾
e_{26}	¾	e_{58}	¼	e_{90}	¾	e_{122}	¼	e_{154}	¼
e_{27}	¼	e_{59}	2	e_{91}	¼	e_{123}	1	e_{155}	¾
e_{28}	1	e_{60}	1	e_{92}	¾	e_{124}	¾	e_{156}	¼
e_{29}	1	e_{61}	¾	e_{93}	¼	e_{125}	¼	e_{157}	1
e_{30}	1	e_{62}	¼	e_{94}	2	e_{126}	1	e_{158}	1
e_{31}	¾	e_{63}	1	e_{95}	1	e_{127}	1	e_{159}	2
e_{32}	¼	e_{64}	1	e_{96}	¾	e_{128}	½		
Total	130								

Step 3 : From Steps 1 and 2, a graph that represents Mars UM's music scores can be constructed. The following is a graph construction that represents Mars UM's melody scores.

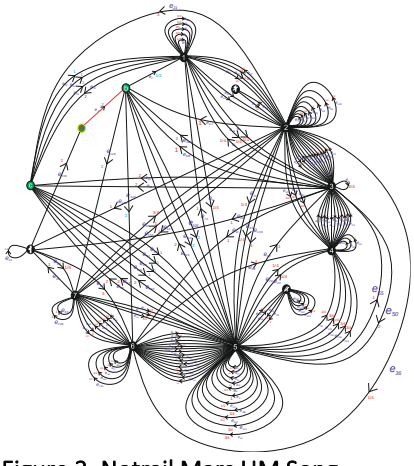

Figure 2. Notrail Mars UM Song

From the graph construction of the Mars UM melody over, the following trial can be obtained:

$$a, e_1, b, e_2, 1, e_3, 1, e_4, 1, e_5, 3, e_6, 3, e_7, 1, e_8, 1, e_9, 5, e_{10}, 3, e_{11}, 6, e_{12}, 5, e_{13}, 5, e_{14}, 6, e_{15},$$
$$6, e_{16}, 5, e_{17}, 5, e_{18}, 4, e_{19}, 3, e_{20}, 2, e_{21}, c, e_{22}, 5, e_{23}, 5, e_{24}, A, e_{25}, 5, e_{26}, 6, e_{27}, 5, e_{28}, 6,$$

$e_{29}, 7, e_{30}, \dot{1}, e_{31}, \dot{1}, e_{32}, 7, e_{33}, 2, e_{34}, \not{1}, e_{35}, 2, e_{36}, 6, e_{37}, 6, e_{38}, 7, e_{39}, 5, e_{40}, c, e_{41}, 5, e_{42}, 5, e_{43}, 4, e_{44}, 4, e_{45}, 3, e_{46}, 2, e_{47}, 1, e_{48}, 2, e_{49}, 3, e_{50}, 5, e_{51}, 5, e_{52}, 4, e_{53}, 4, e_{54}, 4, e_{55}, 3, e_{56}, 2, e_{57}, 1, e_{58}, 3, e_{59}, c, e_{60}, 5, e_{61}, 6, e_{62}, 7, e_{63}, 7, e_{64}, 5, e_{65}, 3, e_{66}, \dot{1}, e_{67}, 6, e_{68}, 4, e_{69}, 3, e_{70}, 2, e_{71}, 5, e_{72}, 5, e_{73}, 1, e_{74}, c, e_{75}, 1, e_{76}, 2, e_{77}, 2, e_{78}, 2, e_{79}, 2, e_{80}, 4, e_{81}, 3, e_{82}, 2, e_{83}, 3, e_{84}, c, e_{85}, 1, e_{86}, 1, e_{87}, 2, e_{88}, 2, e_{89}, 2, e_{90}, 4, e_{91}, 3, e_{92}, 2, e_{93}, 5, e_{94}, c, e_{95}, 1, e_{96}, 1, e_{97}, 2, e_{98}, 2, e_{99}, 2, e_{100}, 2, e_{101}, 4, e_{102}, 3, e_{103}, 2, e_{104}, 3, e_{105}, b, e_{106}, 5, e_{107}, 5, e_{108}, 5, e_{109}, \not{4}, e_{110}, \not{4}, e_{111}, \not{4}, e_{112}, \not{4}, e_{113}, \not{4}, e_{114}, 5, e_{115}, 6, e_{116}, 7, e_{117}, 5, e_{118}, b, e_{119}, 5, e_{120}, 5, e_{121}, 5, e_{122}, 6, e_{123}, 5, e_{124}, 4, e_{125}, 3, e_{126}, 2, e_{127}, b, e_{128}, 7, e_{129}, 6, e_{130}, 5, e_{131}, 4, e_{132}, 3, e_{133}, b, e_{134}, 6, e_{135}, 5, e_{136}, 4, e_{137}, 3, e_{138}, 2, e_{139}, 5, e_{140}, c, e_{141}, 5, e_{142}, 6, e_{143}, 5, e_{144}, 4, e_{145}, 3, e_{146}, 2, e_{147}, 7, e_{148}, 7, e_{149}, 6, e_{150}, 5, e_{151}, 5, e_{152}, 6, e_{153}, 6, e_{154}, 6, e_{155}, 6, e_{156}, 7, e_{157}, 2, e_{158}, 1, e_{159}, a$

Graph construction represents the Mars UM melody as a substitute for the Mars UM melody score. The chart can be examined a bit like the initial Mars UM tune scores by taking after the trial that is obtained. From the graph over, the movement can be viewed from the beginning note to the end note or from the starting vertices to the end vertices, and the result is that the graph construction can be examined or sung as a music score of the initial Mars UM melody. Notrail graph based on the overall notataion in figure 2, the Mars UM song exhibits a well-structured note progression. Thi is evident form the recurring patterns in the same notes, for instance, note 5 (sol) has the highest number of repetitions in the Mars UM song, occurring 11 times. Additionally, the changes in the level of notes are not significantly pronounced, resulting in a smooth transition while singing. As showed, the change from note 3 (mi) to 4 (fa) occurs 11 times, and the transition from note 5 (sol) to 6 (la) has the highest number of note changes occurring 16 times.

The use of intervals in the Mars UM song is also well-balanced. This argument is supported by the higher frequency of repetitions in the letter 'c', which has a breath-taking interval of 1 second, considered quite ideal as it is neither too prolonged like letter 'a' with a two second interval, nor too brief like letter 'b' with only a half second interval. The 'c; interval repetition occurs 14 times, whereas 'a' is repeates 8 times, and 'b' is repeated 2 times.

Notrail Based on Song Lyrics

To make it easier to see the movement of the tone in the Mars UM song, the writer made a graph construction based on the song lyrics, meaning that the graph would consist of several song lyrics according to the pause or comma on the Mars UM song scores. Based on the UM Mars song scores, the construction results were obtained as many as 12 models. To read, sing, and know the movement from the beginning to the end of the notes, follow the leading edges of the graph, the first vertices of the graph or the starting notes and the starting edges or beats of the starting notes are marked in red and end in yellow vertices or notes, green vertices are rest and blue weight means rest weight. Out of the 12 models, one of them is as described below:

Lyrics 1:

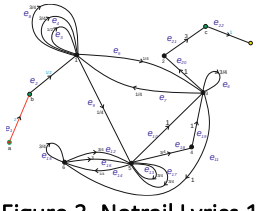

Figure 3. Notrail Lyrics 1

From lyrics 1 the trail is obtained:

$$a, e_1, b, e_2, 1, e_3, 1, e_4, 1, e_5, 3, e_6, 3, e_7, 1, e_8, 1, e_9, 5, e_{10}, 3, e_{11}, 6, e_{12}, 5, e_{13}, 5, e_{14}, 6, e_{15}, 6, e_{16}, 5, e_{17}, 5, e_{18}, 4, e_{19}, 3, e_{20}, 2, e_{21}, c, e_{22}, 5$$

It appears to be quite intricate to read due to recurring patterns in certain notes such as note 1 (do) and 5 (sol), as figure 3 shows the notrail graph for the first lyrics of the Mars UM song. Despite its apparent complexity, these patterns are intriguing and, in reality, quite straightforward. From the graph, the singer can also observe the number of insignificant and significant pitch canges, which can be beneficial for the song's creator in considering the necessary breath-taking intervals to ensure that the song remains enjoyable for both the singer and the music listeners.

Notrail Based on Bars (Virama Line)

Graph construction based on bar is also made so that the movement of the notes can be seen more clearly and can be compared with the construction based on the lyrics. In the graph construction based on the bar, the results of the construction are 33 graph constructions according to the number of bars on the Mars UM song scores. Of the 33 models, one of them are as follows:

Bar 24:

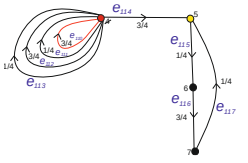

Figure 4. Notrail Bar 24

From bar 24 the trail is obtained:

$$\mathcal{A}, e_{110}, \mathcal{A}, e_{111}, \mathcal{A}, e_{112}, \mathcal{A}, e_{113}, \mathcal{A}, e_{114}, 5, e_{115}, 6, e_{116}, 7, e_{117}, 5$$

CONCLUSION

In this study, we show that melodic notation can be constructed or modeled using graphs, weighted, and directed graph modeling that shapes a trail, where the trail represents a Mars UM song notation. The trail shape could be a notation in a melody, where the trail can be sung and functions the same as a block or numeric notation in common. From the demonstrated shape, there are three constructs: specific notrails based on overall notation, notrails based on melody lyrics, and notrails based on bars (virama lines). The three constructions can represent the Mars UM song and its movements can be seen, read, and sung like all other scores in common.

Th findings of this study, which constructed the Mars UM song using three notrail methods, demonstrate a well-balanced composition. This is evident from the abundance of repeated note patterns and the subtle changes in pitch, which also have potential impact on delivering the meaning of the song to the listeners. Additionally, the carefully considered breath-taking intervals in the Mars UM song can be regarded as ideal, as they involve more frequent use of one second, and setting not both overly rapid (e.g. ½ second) and excessively prolonged (e.g. 2 second) pauses.

The author trusts that there will assist in the investigation and assortment of diverse songs, and it is hoped that there will be those who proceed and apply this strategy to songs advertised to the State University of Malang. Furthermore, for the wider community, it is expected that this research can be used as reference for future research, particularly in the collaboration of music and mathematics, as applied in this research using concept of graphs, such as studying music trends broadly, both within Indonesia and internatonally.

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