

# You Are What You Sing: Folksong Tone Pattern Feature Correlation to Geographical Distance with Gabor Filter and OLS Linear Regression

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**Abstract**—Cultural diffusion occurs. This is evidenced by the existence of cultural heritage artifacts. There are many types of artifacts, tangible or intangible. Folksongs are one of the intangible cultural artifacts. Songs have tone, tone patterns are a unique feature of a song. Regional province songs are the identity of each region, because songs are images of the culture of an area. This study uses folk songs from each province in Indonesia which are extracted features by applying Gabor filters and then differences in output and geographical distance are put into linear regression. The results show that the tone pattern feature have a correlation relationship with the distance between regions throughout Indonesia. When observing the scope per large island, there is also correlation between the number of tone patterns with the distance of province. However, this has less confidence result for Sumatra island.

**Index Terms**—cultural diffusion, folk song features, Gabor filter, geographical distance, tones

## I. INTRODUCTION

Cultural diffusion happens. This process is naturally occurred and has proven to give major advances to human [1]. These advances are catalyzed more by the advancement of technology in communication. Despite of advances in digital communication, Liu's study [2] on intercultural communication point out the fact that there are many cultural differences between east side and the west side of the world. This implies that geographical distance is a factor in spreading culture. Furthermore, there are studies comparing artifacts to geographical distance such as rituals [3], language [4], archaeological data [5] or even human DNA.

In [5], Kovacevic investigates relation between different bead types and the geographical distance of the site it's found history events by using bead. In [3], Amati differentiate between different rituals and geographical distance. In [4], Kathy did an analysis of language by its history and how they migrate. These studies show that artifacts are used to refer cultural

diffusion. If language is an example of why cultural diffusion happens, this also means that songs created by certain language are also an artifact. This argument supported by Sterne study on audio as cultural artifact. However, Sterne's study doesn't have empirical evidence.

There are some studies using songs for classifying certain group, such as genre [6], composer [7], instrument [8], or general city environment sound [9]. They have same method in common which is visualize audio signal and extracting features from the visualized audio. Some of these studies uses gabor filter as their method of extracting features. Bammer [10] explicitly said that gabor filter's result has certain signal features, such as tones or pitch.

This study goal is to explore whether music has potential to be used as artifact in studying cultural diffusion by evaluating the relationship between music features and geographical distance.

This study has contribution in:

1. Identifying the possibility to use music in studying cultural diffusion.
2. Exploring music features that are useful in relating music and geographical distance.

## II. DATA DESCRIPTION

This study use folksongs from 34 regions in Indonesia. The music is taken from YouTube. The data is validated by MUSIKA group book and searched on YouTube. Data criteria are:

1. From the most popular Indonesian Folk Song channel called "Lagu Daerah Indonesia" which literally translated to Indonesian Folksongs.
2. Song chosen by the most viewed from each province.

Data is taken from YouTube, by referencing book from MUSIKA group which is used as standard music curriculum for schools throughout Indonesian school. These are the data statistics.

TABLE I. DISTRIBUTION OF DATA TAKEN

<b>Data count</b>	34 folksongs
<b>Mean</b>	234.089 sec
<b>Std dev</b>	41.463 sec

These data are converted from YouTube as file wav file format via saveclipbro.com. The stereo wav file the converted to mono, with specification of sample rate of 44100khz and bit rate of 705kbps.

Geographical distance is calculated by using longitude latitude data from Google Maps, which use the middle point of an area for each province. Longitude and latitude between 2 provinces then calculated using Haversine formula for providing distance in km.

### III. METHODOLOGY

This study use Short-Time Fourier Transform (STFT) and Gabor filter as music extraction as in [11] but with some changes. The extraction consists of five steps:

1. Audio signal representation using Short-Time Fourier Transform (STFT).
2. Applying binarization to the image.
3. Applying gaussian filter to the image.
4. Put the image into 19 different gabor filter and sum all the output signal
5. Ordinary Least Square linear regression

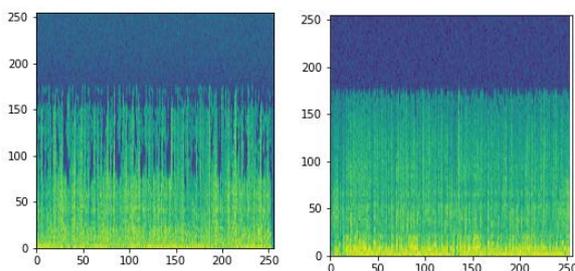


Fig. 1. The difference between 2 different songs from different province

To get the proper song features, 19 orientation is used to resemble how fast or slow the pattern of notes gets high or low.

Second, the spectrogram binarized to emphasize the representation and the tones features, whether the tone is or is not there.

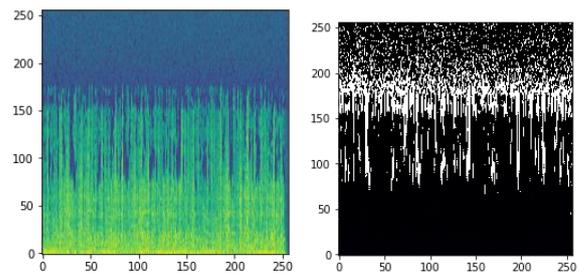


Fig. 2. Binarized image emphasizing tones feature

A gaussian filter then applied to the modified spectrogram to further reduce noises [12].

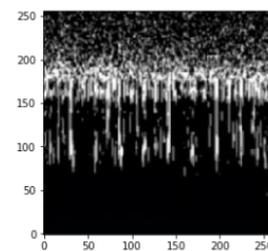


Fig. 3. Spectrogram after gaussian filter application

Gabor filter then applied to get the folksongs tones pattern. Parameters for the gabor filter are chosen by trying to make each data more unique and different [13]:

TABLE II. PARAMETERS FOR THE GABOR FILTER

<b>Spatial Harmony</b>	0.05
<b><math>\lambda</math> (Lambda)</b>	20 pixels
<b><math>\theta</math> (Theta)</b>	0 to 180 deg, 10-degree increment
<b>Offset</b>	0.5

These are the output from the gabor filter. Each of the orientations for the different 10 increment of  $\theta$  theta/orientation, this will bring up result of how fast tones changes whether the tones going up or down. Each of the gabor filter output are summed up to one dimension to collect how much information on each orientation has.

Data from 19 orientation and geographical distance then put into OLS linear regression to test the significance of this feature and what tone fluctuation pattern relation to geographical distance.

### IV. RESULTS AND DISCUSSION

Observation on whole Indonesia on 34 folksongs with total of 1536 distance data, has r square of 0.12 and p-value of 1.81e-20. This means the tone feature has significance to distance while having very wide distribution of data. Upon further look, there are 6 specific tone patterns has significance to distance on Table 3.

TABLE III. SPECIFIC ORIENTATION OF SIGNIFICANCE TO GEOGRAPHICAL DISTANCE

Filter Orientation	p-Value
10	0.01
50	0.02
60	0.00
70	0.00
90	0.00
100	0.00
150	0.02

Another observation is having the geographical distance by not the province but which island the province is located. With the same data but different geographical distance shows r square value of 0.11 with p-value of  $1.17e-18$ . This shows significance too which conclude to province identity, has similar trait with island identity. With further look, has:

TABLE IV. SPECIFIC ORIENTATION OF SIGNIFICANCE TO GEOGRAPHICAL DISTANCE

Filter Orientation	p-Value
0	0.00
10	0.00
40	0.05
50	0.02
60	0.01
70	0.00
90	0.03
110	0.00
150	0.04
180	0.04

More features have significance for island distance data. This made assumption of observation inside island should have high significance with distance. Another OLS with only scope of 4 big islands shows result:

TABLE V. RESULT OF OBSERVATION PER ISLAND

Island	r-Square	p-Value
Jawa	1	4.30E-259
Kalimantan	1	1.95E-180
Sulawesi	1	1.70E-235
Sumatera	0.54	4.10E-05

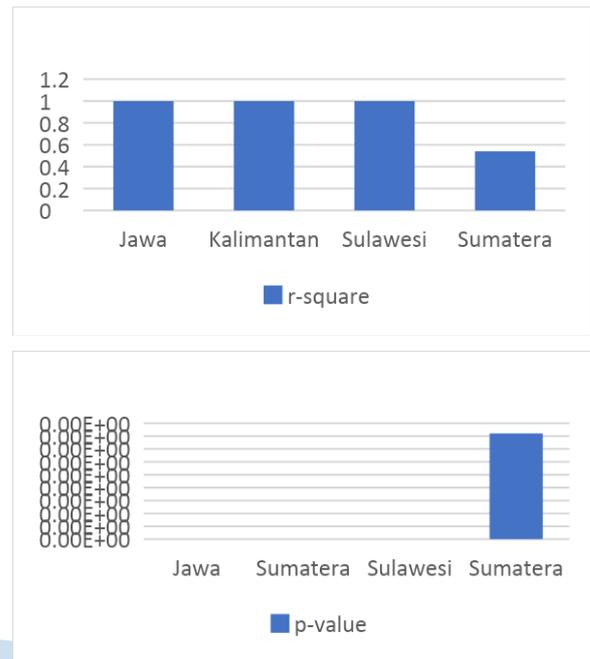


Fig. 4. Result of observation per island

## V. CONCLUSION

Folksongs, has tones. There are patterns on tones fluctuation or flatness. With result positive relation between tones fluctuation and distance, but only on the scope of one island. Observations between islands with larger scopes gives negative result. Sea might be a factor of cultural diffusion.

Some of the tone patterns are emphasized by the filter throughout the song, so there is no analysis on specific timing or frequency band. There is anomaly found on Sumatera Island observation might have something to do with culture spread pattern on the island. There might not be enough data for comparison each province 1 data. There is limitation on how to get the data, and YouTube as fastest channel to get music.

The proposed procedure of the study are more data, add another feature. With enough feature, there is enough information to dig deep and explore the relation of songs to linguistic, cultural, historical, musical aspect.

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