The Rhythms in Mantra Pushpam

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ABSTRACT
The Mantra Pushpam, literally means the flowers of a sacred chant, which is recited at the very end of all the praying rituals in the temples, in the Hindu religion. This work questions why it is chanted at the end. What is the essence of it. Here we try to extract few features of these chants mathematically and statistically through the well-known techniques of non – linear time series analysis. We then convert the audio waves into digits and perform both linear and nonlinear analysis of those vectors or array of numbers, normalized, which while chanting can be taken as a time series. We make an assumption that the chanting has some rhythms whose features can be studied and come to a conclusion mathematically, which till now has not been done on any of the Hindu sacred chants. Hence this is a novel approach to such a study.

Keywords:Mantra Pushpam, Yajur Veda, Taittariya Aranyaka, time series, average mutual information, correlation, intensity, audio waves, Lyapunov spectrum, recurrence plot

INTRODUCTION

The Mantra Pushpam is the sacred chants which means the flower of hymns which are rendered at the end of any pooja performed to God in Hindu religion [1-5]. It was a curious question about why this is chanted at the end. When the Hindus offer pooja to the Gods, they start with keeping the water in the copper cup and chant that the waters of the Indian peninsular, that is all the rivers from Ganga, Jamuna, Godavari, Saraswathi, Narmada, Sindhu, Kaveri and assume that it's taken in the cup and continue the remaining pooja. Its also chanted that water is the essence of the entire world, living beings, essentially everything on earth or the universe is water. Then the remaining offerings to the established god in the pooja is performed like the clothes, flowers, Kumkum, sacred rice, etc. Finally, the end of the pooja is by bowing the head to the god which in last is the statement and a sentiment of complete surrender to the all mighty. Just before this the Vedic chants, the mantra Pushpam is chanted irrespective of which god is invoked. But what is mantra Pushpam. It is taken from Taittariya Aranyaka [6 – 10] and by the word meaning of the mantra Pushpam we understand that essentially whatever is there on earth are water and if anyone knows this then he becomes the one in it. Or it's a set of statements which are telling that the person who knows water becomes water. We might be wrong in bluntly telling this, but the literal meaning seems so. If we think in deeper sense, water symbolizes the continuous media as all the rivers which are mentioned in the chants are flowing, especially the rivers of the north Indian peninsular are all perennial. In addition to this concept, the Mantra Pushpam also says that "he who knows that becomes that". So, the understanding to be taken as in our opinion that the entirety of our existence is in knowing that we are not just the body because every other thing which seems external is also in connection with us. If we assume that we are just the body, then the sensory perceptions are because of the sensory organs attached to the external world. In other words, the perceptions are formed in the mind of the individual due to the attachment of the perceptron with the external, inductively every external is connected to the other external and the entire external within the bounds of our perceptions are formed due to these connections. Thus, generalizing this concept, we can tell that the whole universe is in a continuous connection. We also have the conservative laws stating that the energy can only be transformed from one form to another. Everything happening in the Universe is a continuous transformation from one energy form to another, whether it is chemically, physically or biologically. Without much deviation, we are trying to bring out that the

energy forms are all connected in this medium which is perceived by us. Also, All the forms whether is known to that or not are continuous media. What is it that exists in this continuous media? A temporary perception till we are existing. But the existence itself is questionable. Hence a deeper understanding and a deeper sense is required to understand the concept.

Are there any ways to decipher this. We being a part of mathematics department thought that using the new tools of nonlinear time series analysis on the rendering of these hymns might throw some light on the above question. We thought that all the way till the end these hymns are chanted in the same way in temples or in the houses while praying to God. The Mantra Pushpam are the nine similar hymns and the rhythms are same throughout the rendering.

In this research, we collected several renderings of the Mantra Pushpam and found the power spectrum and the intensity of the rendering. This gave us the idea about the rendering of the mantra Pushpam, that however it is chanted they have same intensity because by correlating the intensities of the rendering we observed that the correlation coefficient is above 0.7. In the second section we discuss about the data and then the methodology followed by the results. The inference drawn from these results mark the conclusion of this paper.

The data

The following details will give us an insight of how the data is taken and made ready for process.

1. Audio Recording and Segmentation

Original Format: The Mantra Pushpam recording was initially stored as a .wav file, a common format for uncompressed audio.

Division into Sub-Wave Files: The .wav file was divided into nine smaller wave files, each corresponding to one of the nine verses within the Mantra Pushpam. This segmentation likely aimed to facilitate easier handling and processing of the audio data.

2. Conversion to Digital Data

Software Used: OCTAVE software was employed to convert the nine wave files from their audio format into numerical representations. This step generated arrays of numbers that captured the audio information in a format suitable for computational analysis.

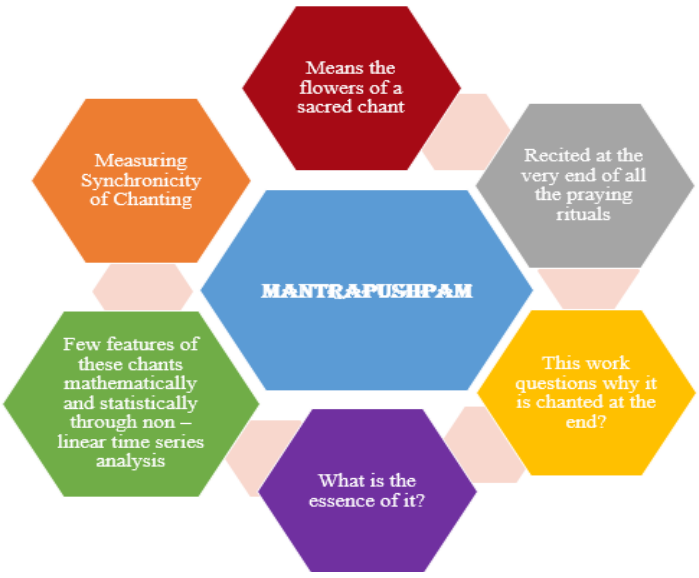
3. Frequency and Normalization

Sampling Frequency: The original wave files and their subsequent digital representations had a sampling frequency of 44100 hertz (Hz). This means that the audio was sampled 44,100 times per second, capturing a high level of detail in the sound wave.

Normalization: The arrays of numerical data were normalized by dividing each value in the array by the maximum value within that array. This process ensures that all values fall within a consistent range (typically between 0 and 1), making the data more uniform and comparable for further processing.

4. Data Preparation for Processing

Uniform Data: The normalized arrays now represent the audio data in a standardized format, ready for subsequent analysis or manipulation using various computational techniques. This uniform representation enables consistent and meaningful processing of the audio content.



METHODOLOGY

The data obtained in the above stage is made to undergo the following methodology as given by Kantz and Scheiber [11].

1. Types of Analysis

Linear Analysis: This commonly refers to techniques that examine the data through a lens of simple, well-defined relationships. Examples could include calculating frequencies, amplitudes, or correlations between elements within the arrays.

Nonlinear Analysis: This explores more complex, potentially hidden relationships within the data that might not be apparent through linear methods. Techniques like fractal dimension analysis, recurrence plots, or phase space reconstruction may be employed to unravel these intricate patterns.

2. Software Choice

TISEAN: Choosing TISEAN software suggests a focus on analyzing the data from the perspective of nonlinear dynamics and chaos theory. Developed by Kantz, Schreiber, and Hegger, this software offers a collection of tools specifically designed for studying complex time series.

3. Data Processing with TISEAN

Possible Applications within TISEAN, the nine arrays could be subjected to various nonlinear analysis techniques such as:

Surrogate data generation: Creating artificial data sets with similar statistical properties but lacking the specific nonlinear dynamics of the original data. This helps distinguish genuine patterns from random fluctuations. But however, the data in nine parts behave as surrogates and hence the surrogacy was not needed

Recurrence plots: Visualizing repeated patterns within the data, potentially revealing hidden attractors or chaotic behaviour.

Phase space reconstruction: Reconstructing a multi-dimensional state space from the one-dimensional time series, allowing for visualizing and analysing the dynamics of the system.

Lyapunov exponents: Quantifying the rate of divergence of nearby trajectories in the state space, indicating the system's sensitivity to initial conditions and potential chaotic behavior.

4. Overall Purpose

Motivation for Analysis: Performing both linear and nonlinear analysis suggests a desire to thoroughly understand the characteristics of the Mantra Pushpam audio data. Using TISEAN specifically implies a focus on uncovering any hidden dynamical patterns or chaotic elements within the audio, potentially revealing deeper insights into the structure and meaning of the mantra [12 – 15].

RESULTS AND DISCUSSIONS

The arrays of nine verses are:

1. Yopam Pushpam Veda -------- aayathanavaam bhavathi – f1
2. Agnirva apaam ayathanam ----- aayathanavaam bhavathi – f2
3. Vayurva apaam ayathanam ---------- aayathanavaam bhavathi – f3
4. Asovyiappanama ayathanam --------- aayathanavaam bhavathi – f4
5. Chandramava ---------- aayathanavaam bhavathi – f5
6. Nakshatraniva ---------- aayathanavaam bhavathi – f6
7. Parjanyova ---------- aayathanavaam bhavathi – f7
8. Samvathsarova ---------- aayathanavaam bhavathi – f8
9. Rajadhirajaya Prasahya ---------- parasva maheshwara – f9

1. Measuring Synchronicity of Chanting

Initial Question: We aimed to assess the level of synchronicity between the chanting of different verses in the Mantra Pushpam recording.

Method Used: Correlation analysis was chosen as a tool [16-19] to quantify the similarity between the "renderings," which likely refers to the processed data representations of each verse.

2. Interpretation of Correlation Results

Table Interpretation: The table (Table 1) presumably showed correlation coefficients between different verse renderings. Finding no correlation between any two verses was expected since they differ in content and chanting style.

Nonlinearity Conclusion: The lack of correlation between verses suggests that the underlying data exhibits nonlinear characteristics. This makes sense as each verse has its unique pattern, unlike a perfectly synchronized recording where data points would overlap significantly.

3. Time Series Characteristics

Flatness and Trendlessness: The paragraph mentions that the individual time series for each verse (presumably the arrays of processed data points) appeared flat and trendless. This means their mean and

variance remained constant throughout, indicating no significant changes or patterns over time within each verse.
Diagonal Entries in Correlation Table: The diagonal entries of the correlation table likely refer to the correlation of each verse with itself. Finding a value of 1 for these entries confirms that each verse exhibits perfect correlation with itself, as expected.

Autocorrelation Analysis
Focus on Left and Right Channels: The analysis shifted to exploring the autocorrelation within each verse, specifically focusing on the correlation between the left and right audio channels.
Expected Autocorrelation: Despite individual data points differing between channels, the overall trends were anticipated to be similar due to the chanting being identical on both sides.
High Autocorrelation Values: As expected, the autocorrelation for diagonal entries (comparing left and right channels within the same verse) approached 1. This confirms that the chanting patterns, though not identical point-by-point, maintained high similarity across both audio channels.
The exploration of the Mantra Pushpam audio data unveils fascinating facets of the chanting, raising intriguing questions about synchronicity, intensity, and underlying dynamics. Building upon the initial observations, analysis steps and delve deeper into potential further avenues of investigation we provide a comprehensive and insightful journey into the sonic landscapes of this sacred chant.

1. Unravelling the Power Spectrum
Our initial analysis focused on quantifying the frequency content of each verse rendering through power spectrum calculations. This technique essentially decomposes the complex time series data of each chant into its constituent frequencies and their respective amplitudes. By finding the absolute square root of the sum of Fourier coefficients, we essentially extract the magnitude or "energy" associated with each frequency component.
Figure 1, then, provides a visual representation of these power spectra, offering a glimpse into the frequency distribution of each verse. Observing peaks and valleys in the plots allows us to identify dominant and subdued frequencies, potentially revealing characteristic sonic features of each verse. For instance, a prominent peak at a specific frequency might indicate the presence of a recurring melodic element in that particular verse.

2. Illuminating Intensity through Squared Power Spectrum
Taking the square of the power spectrum further amplifies the energy contribution of each frequency component. Figure 2 showcases these "squared power spectra," essentially highlighting the intensity or loudness of each frequency band within the chant renderings. This transformation essentially emphasizes the overall energy distribution across the frequency spectrum, providing a different perspective on the sonic characteristics of each verse.

3. Unveiling Synchronicity through Intensity Correlation
Recognizing the potential significance of energy alignment across verses, we proceeded to calculate the correlation between the intensity profiles (squared power spectra) of each verse pairing. The resulting Table 2 presents a fascinating picture of synchronization on a subtle level.
An average correlation coefficient of 0.7 across different verse pairs indicates a surprisingly high degree of similarity in the overall energy distribution across the frequency spectrum. This suggests that despite potentially distinct melodic or rhythmic patterns, the verses share a remarkably consistent level of intensity across different frequency bands.
This finding is indeed intriguing and prompts further investigation. What specific frequency components contribute to this high correlation? Are there certain equency ranges where the similarity is most pronounced, potentially hinting at shared harmonic elements or chanting techniques? Exploring these questions through spectral comparisons and targeted filtering techniques could offer deeper insights into the underlying synchronicity mechanisms.

4. Beyond Correlation: Unveiling Hidden Dimensions
While correlation analysis sheds light on intensity similarities, exploring other nonlinear measures can add further layers of understanding to the dynamics of the chants. Here correlation dimension, correlation sum, and entropy levels opens the doors to exciting possibilities [20 – 24].
Correlation Dimension: This statistic characterizes the complexity of the underlying dynamical system generating the chant data. A low dimension suggests a predictable, periodic pattern, while a higher dimension indicates a more complex, potentially chaotic system. Calculating the correlation dimension for each verse and comparing them could reveal subtle differences in the chant dynamics, shedding light on variations in chanting style or emotional intensity.
Correlation Sum: This measure quantifies the average distance between points in the state space reconstructed from the time series data. A rapidly increasing correlation sum with increasing time lag

suggests a chaotic system with highly sensitive dependence on initial conditions. Analyzing the correlation sum for each verse could offer insights into the degree of determinism or randomness within the chanting patterns.

Entropy Levels: Entropy measures the amount of uncertainty or randomness in a system. Calculating the entropy of each verse's intensity profile could reveal variations in the predictability or repetitiveness of the chanting across different frequencies. This might highlight verses with more improvisational elements or greater freedom in melodic expression.

Exploring these additional measures requires advanced nonlinear analysis techniques. However, the potential insights they offer into the subtle dynamics and complexity of the Mantra Pushpam renderings make them worthwhile endeavors.

5. A Tapestry of Insights

From Linearity to Chaos:Our analysis so far paints a fascinating picture of Mantra Pushpam, revealing subtle synchronicity in energy distribution despite differences in individual verse patterns. It highlights the potential richness hidden within seemingly simple audio data, beckoning further exploration through advanced nonlinear techniques.

CONCLUSION

The results show that the nine recitals are in tune with each other and not much variation is observed between them. All the tests done on the recitals beginning with finding the correlation, correlation amongst their power spectral density, average mutual information, correlation sum, correlation dimension and the entropy. Lyapunov spectrum and recurrence plots all signify that all recitals are in tune with each other. This means to us that the recitations must be in sync in order to please the god or the minds of the worshipper. Scientifically, the chanting must be soothing to the minds of all the worshippers of the almighty, in order to relieve them from their pains and expectations. Also, even if a worshipper has no expectations the chanting in this way would give mental peace and enlighten their minds.

The significance of the pooja in Hindu tradition is observed here. The recital of Vedic chant – “Mantra Pushpam” is examined using the statistical toolbox TISEAN. The recital shows no deviation from the initial chanting to the end from all these tests performed. This shows that there might be a specific reason for them to be recited in the similar manner in temples and the reasons could be the one mentioned above.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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Table 1. The table for correlation among the recitals.

fft corr	**f1**	**f2**	**f3**	**f4**	**f5**	**f6**	**f7**	**f8**	**f9**
f1	1	0.724158	0.70385	0.664699	0.639574	0.654159	0.660546	0.646962	0.640127
f2	0.724158	1	0.731241	0.680881	0.648787	0.654857	0.671954	0.654765	0.641672
f3	0.70385	0.731241	1	0.723624	0.702561	0.705378	0.705031	0.697779	0.688275
f4	0.664699	0.680881	0.723624	1	0.736062	0.739543	0.735077	0.720637	0.71735
f5	0.639574	0.648787	0.702561	0.736062	1	0.741359	0.737067	0.732397	0.723779
f6	0.654159	0.654857	0.705378	0.739543	0.741359	1	0.736942	0.72641	0.72911
f7	0.660546	0.671954	0.705031	0.735077	0.737067	0.736942	1	0.74434	0.733572
f8	0.646962	0.654765	0.697779	0.720637	0.732397	0.72641	0.74434	1	0.732891
f9	0.640127	0.641672	0.688275	0.71735	0.723779	0.72911	0.733572	0.732891	1

Table 2. The table showing the fast Fourier transform correlation amongst the nine recitals

Corr	**f1**	**f2**	**f3**	**f4**	**f5**	**f6**	**f7**	**f8**	**f9**
f1	1	0.00381	-0.00248	0.000798	-0.00048	0.004385	-0.00259	-0.00044	-0.00184
f2	0.00381	1	-0.0035	0.01029	-	-0.0036	0.00146	0.00172	-

				9	0.00121		5	7	0.00122
f3	-0.00248	-0.0035	1	-0.00026	-0.0007	0.001439	0.003437	-0.00091	0.00529
f4	0.000798	0.010299	-0.00026	1	-0.00255	0.003855	-0.00099	-0.00067	-0.00232
f5	-0.00048	-0.00121	-0.0007	-0.00255	1	-0.00108	-0.00127	0.002713	-0.00227
f6	0.004385	-0.0036	0.001439	0.003855	-0.00108	1	-0.00418	0.002657	0.004216
f7	-0.00259	0.001465	0.003437	-0.00099	-0.00127	-0.00418	1	0.010593	0.001132
f8	-0.00044	0.001727	-0.00091	-0.00067	0.002713	0.002657	0.010593	1	-0.00589
f9	-0.00184	-0.00122	0.00529	-0.00232	-0.00227	0.004216	0.001132	-0.00589	1

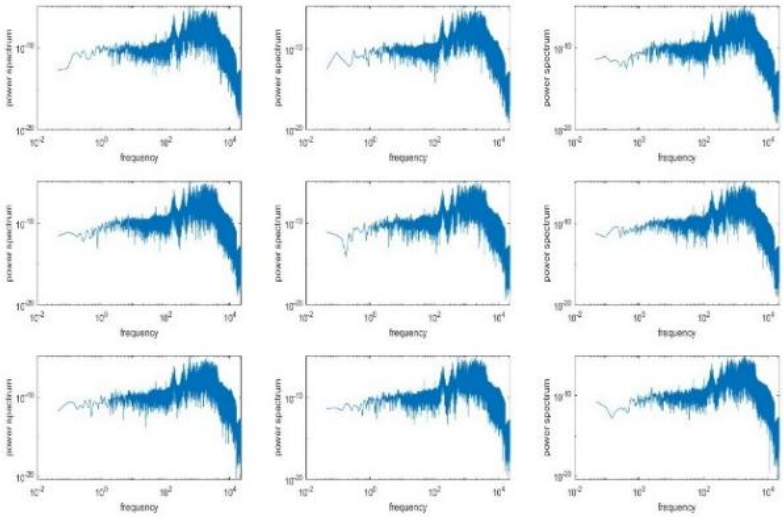

Figure 1. The power spectral of all nine renderings looking very similar to each other.

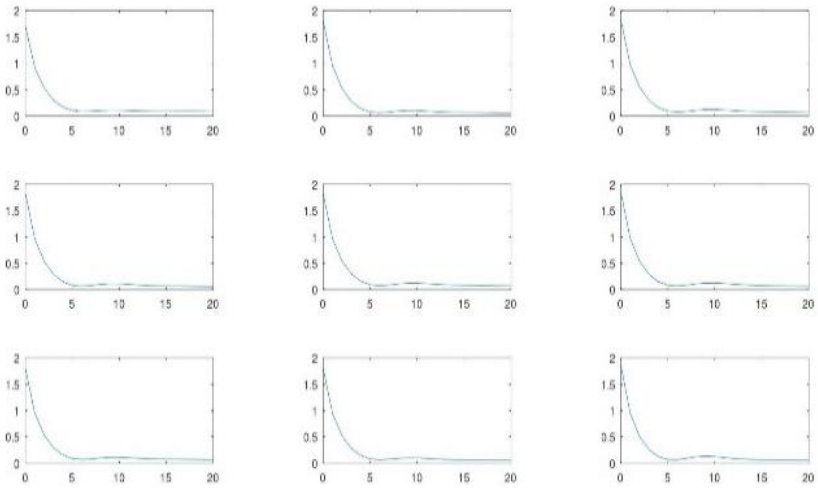

Figure 2. The mutual information function trend looks similar for all the nine recitals.

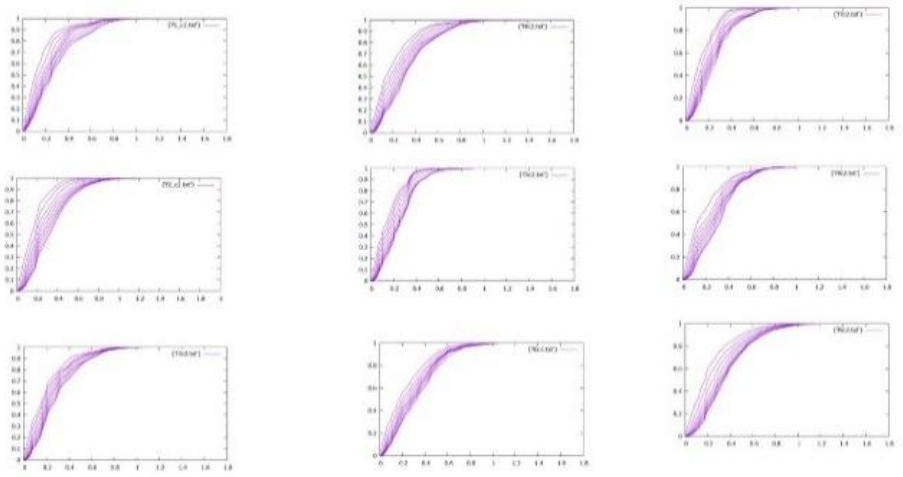

Figure 3. The correlation sum for all nine recitals and there plots similar to each other for 1 to 10 embedding dimensions.

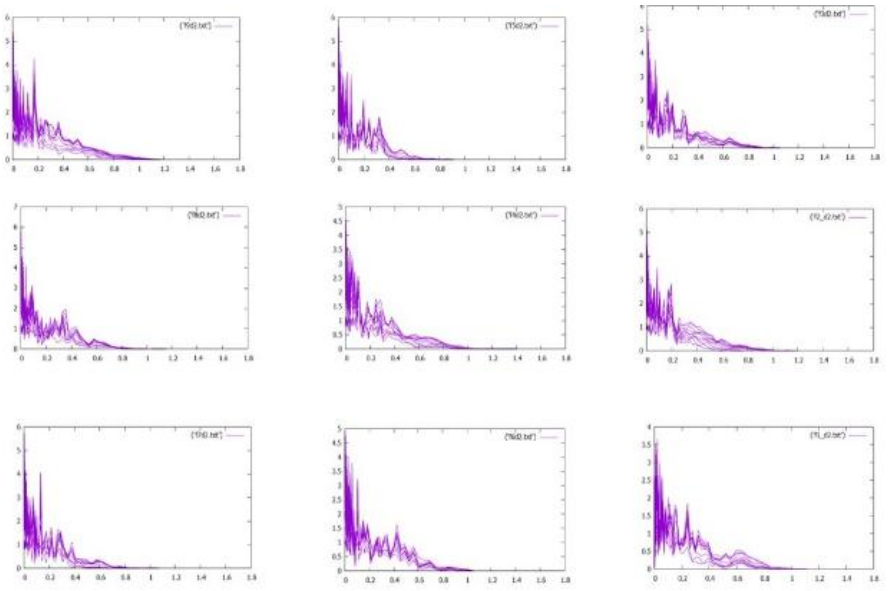

Figure 4. The correlation dimension plot looks for each to converge at 0. to 0.3.

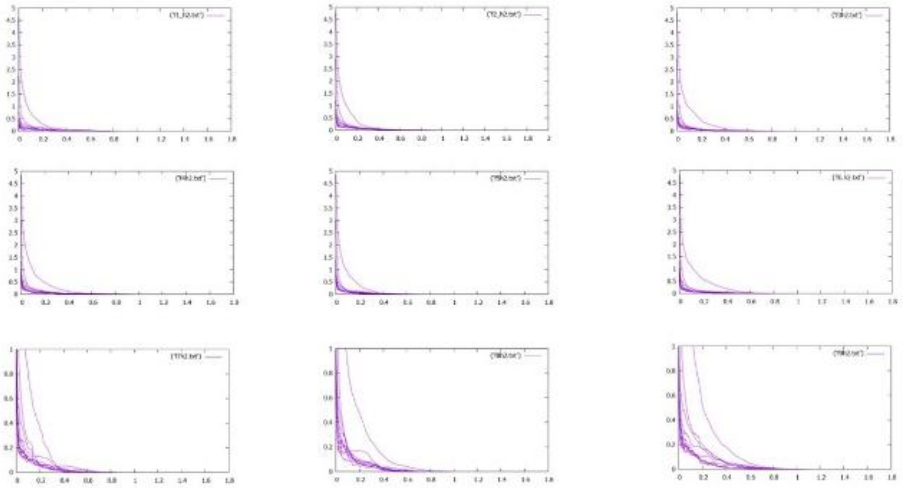

Figure 5. The entropy plot for 10 embedding dimensions for all nine recitals

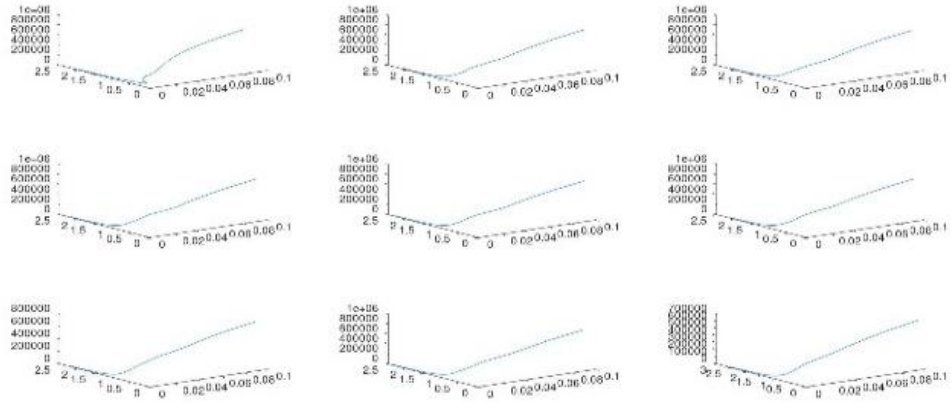

Figure 6. Lyapunov spectrum for all nine recitals

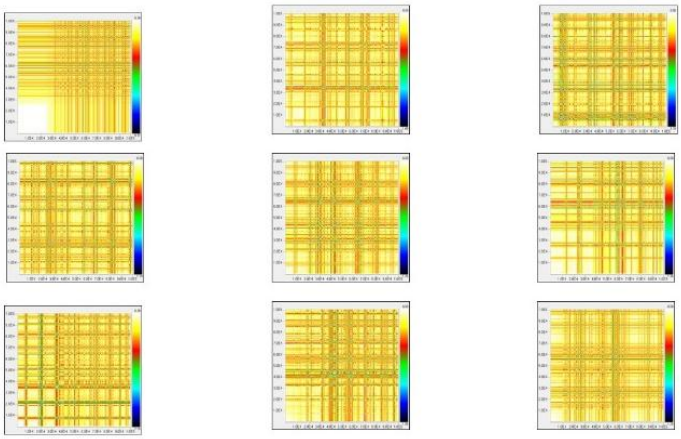

Figure 7. The recurrence plot for nine recitals.