

# ACF analysis on Japanese Buddhist Chant

Tomohiro OHSAWA <sup>a</sup>, Ryota SHIMOKURA <sup>b</sup>, Shin-ichi SATO <sup>c</sup>, Yoshiharu SOETA <sup>b</sup>, Ken ITO <sup>a\*</sup>, Yoichi ANDO <sup>d</sup>

<sup>a</sup>The University of Tokyo, Tokyo, Japan

<sup>b</sup>National Institute of Advanced Industrial Science and Technology (AIST), Osaka Japan

<sup>c</sup> South China University of Technology, Guangzhou, China

<sup>d</sup>Kobe University, Hyogo, Japan

\*corresponding author: itosec@iii.u-tokyo.ac.jp

(Received 30 November 2009; accepted 7 December 2009)

The parameters of autocorrelation functions (ACF) and inter-aural cross-correlation(IACC) functions of Japanese Buddhist Monk's traditional chant in JYODO SHINSYU (Shinsyu Ohtani-ha) style are measured and calculated. According to the course of "NENBUTSU-WASAN", monks change the way of vocal expression in various manner and make Buddhist Hymn's CRESCENDI and ALLARGANDI in quite organized styles. In this paper we would show the variety of this expression showing the systematic changes of parameters in ACF and IACC analysis.

**Key words:** autocorrelation function (ACF), inter-aural cross-correlation function (IACC), chant, expression

## 1. INTRODUCTION

JYODO SHINSYU is REFORMED BUDDHISM school in Japan founded by SHIN-RAN(1172-1262). Just like the case of Martin LUTHER's REFORMATION in Christianity, SHINRAN had translated Buddhist Scriptures, originally written in ancient Indian language and then translated into Chinese, to Japanese systematically. Also, just like the case of LUTHER, SHIN-RAN had written lyrics of many Japanese Buddhist Hymns, and composed them into styled Chants, which are reorganized by his offspring REN-NYO in 15<sup>th</sup> century.

In the WASAN singing, Chinese holy phrases are also sung in repetitive ways. This is called NENBUTSU.

NENBUTSU consists of only six syllables; "NA-M[U]-A-M[I]:-DA-BU-[TSU]" which means in Chinese "I would believe only the salvation of A-MI-DA Buddha". Though the meaning of this is not clearly understood by Japanese people, this phrase is repeated again and again in various singing style, just like the cases of Christian holy phrases "Amen", "Hallelujah" or "Kyrie".

In the repetition of this NENBUTSU, JYODO SHINSYU Buddhist monks sing with "crescendo" and "allargando", if we use the terms of western music. It is widely known to professional musicians that the expression of crescendo is not at all increasing of physical loudness. For trained ear, the technique is quite clearly listened. But in the conventional analysis of Buddhist chant, such aspects are not shared.

## 2. MEASUREMENT, RESULT AND DISCUSSION

### 2.1 Structure of the rite of NENBUTSU-WASAN

Below is the structure of NENBUTSU-WASAN chant in a JYODO SHINSYU rite in Shinsyu Ohtani-ha style in SANJYU manner.



Fig. 1. The schematic structure of NENBUTSU-WASAN

In this SANJYU manner the chant of NENBUTSU-WASAN are sung with crescendo and allargando in three stages. NENBUTSU's phrase is repeated again and again, through three stages of crescendo and allargando. And WASAN, Japanese hymns are sung in between the NENBUTSU also for three times. The structure of this chant-rite is like a sandwich. The first turn is called SYOJYU and the voice stays low, solemn and deep. The second turn is called NIJYU where pitches are a little higher

and loudness also increases. The third, and also the final turn is called SANJYU and sung in higher pitch register of monks' with much power and loudness.

## 2.2 Set-up for the measurement

We have used two different microphones for the measurement of the monks chant in a JYODO SHINSYU style temple, in authentic, traditional positions of singing and listening. We used a monaural microphone just in front of the monk who sits in the center of alter-front in JYOSHINJI temple, Nagoya, Japan and from the data of this "direct recording," ACF parameters of the chant are calculated. We also use a pair of microphones installed into a dummy head at various listening positions and we calculate the IACC parameters from data got through this detection (Fig.2).



Fig. 2 View of the measurement in Jyoshinji Temple.

## 2.3 Results

Spectral analysis of the chant clearly shows the changes in pitch and timbre to some extent. However, the various changes in the vocal expression in NENBUTSU and WASAN are not clear. Fig. 3 is the shifts of listening levels in NENBUTSU (first, second and third turn) and WASAN (first turn). It clearly shows the increase of physical loudness during the NENBUTSU-WASAN chant but would not explain the qualitative or even dramatic change of the vocal expression.

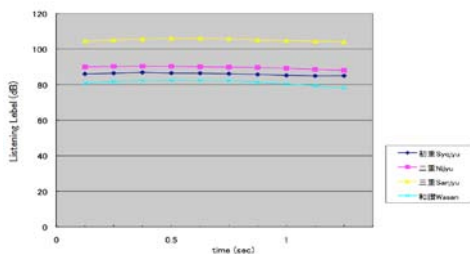


Fig. 3 Listening levels

However, with the ACF analysis, calculated from the data from the monaural microphone, definite changes are observed in effective duration time ( $\tau_e$ ) and the peak level ( $\phi_1$ ) [1].

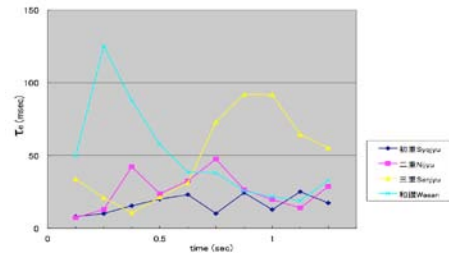


Fig. 4-a  $\tau_e$  in NENBUTSU-WASAN

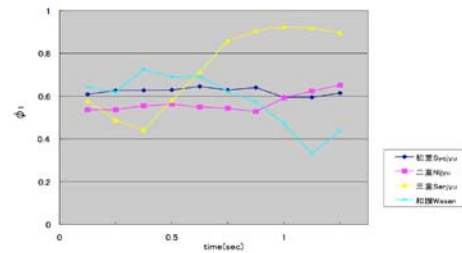


Fig. 4-b  $\phi_1$  in NENBUTSU WASAN

Dynamic changes of ACF parameters are observed especially in SANJYU, the most dramatic part in NENBUTSU, and in WASAN. Although WASAN is sung quietly, it contains wide ranges of change in such ACF parameters. As vocal utterance causes to change ACF parameters, it is thought that these changes are caused by techniques of chanting in traditional NENBUTSU-WASAN singing.

IACC in NENBUTSU-WASAN also shows interesting changes of the chant. Followings are the values of IACC (Fig. 5-a) and the  $W_{IACC}$ , width of the peaks of the inter-aural cross-correlation function (Fig. 5-b) respectively.

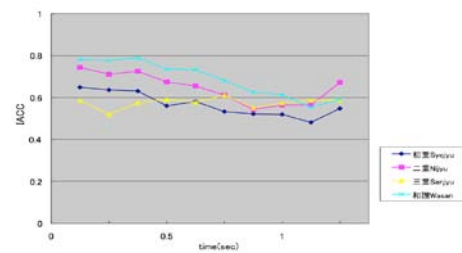


Fig. 5-a IACC in NENBUTSU-WASAN

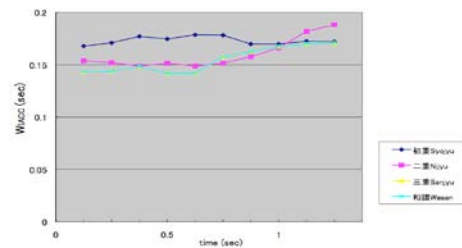


Fig. 5-b Changes in  $W_{IACC}$ , NENBUTSU WASAN

Where the ACF parameters could be thought as (rather) “pure” vocal indexes, the IACC parameters here, could be appreciated as more “performing” or even “theatrical” “operatic” indexes to explain the phenomena --- singing and listening --- the NENBUTSU - WASAN.

Here we must remember that the NENBUTSU is sung in Chinese which for ordinal Japanese people listened without verbal meaning and WASAN in Japanese language not only whose meaning but also every possible nuance could be appreciated. Figs. 6-a and 6-b are the wave forms and Correlograms of NENBUTSU (SANJYU, “molto espressivo!” and WASAN.

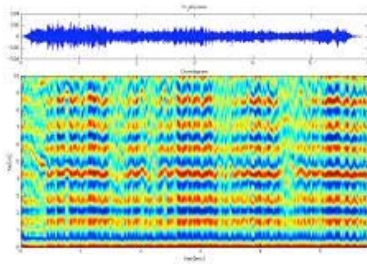


Fig. 6-a Correlogram of NENBUTSU in SANJYU

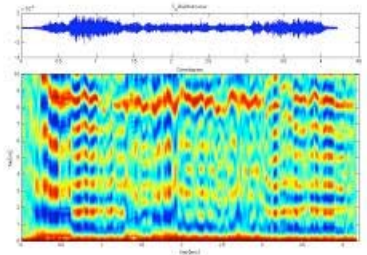


Fig. 6-b Correlogram of WASAN in SYOJYU

As Figs. 6-a, -b clearly show, NENBUTSU, sung in Chinese Syllables without particular meanings in Japanese language, shows “stable” --- mainly in vowels --- characteristics like timbres of instruments, where the WASAN, sung in Japanese with clear meanings and expression --- with vowels and consonants --- have features much more likely to that of ordinal spoken language.

As WASAN is sung quietly in low voice register, the wavelength of the fundamentals at WASAN chant would be often longer than the distance between listeners’ two ears. Thus this caused a sense of surrounding to listeners. Especially in the religious context this sense of surrounding could often be appreciated as DIGNITY or DIVINITY of THE GREATER EXISTENCE --- God, Buddha, and in this case AMIDA --- to be recognized instinctively by the listeners; here, the believers.

Although the ACF and IACF parameters change dynamically, they have some tendency. Fig. 7 is the order of the ACF and IACC parameters, numbered following the

values; we would like to call this “intensities”. As those “intensity” values, and consequently the orders often change, the mark “ \* ” is added for those numbers with much alternation in its “intensity-order”.

	LL	Space=Performing		Time=Vocal	
		IACC	WIACC	$\phi 1$	$\tau e$
SYOJYU	3	2*	1*	2*	3*
NIJYU	2	1*	2*	3*	2*
SANJYU	1	3*	3*	1*	1*

Fig. 7 Table of ACF-IACF parameters’ intensity order

Similar measurements and analysis are done for the singings of WASAN in SYOJYU, NIJYU and SANJYU levels. About the listening levels WASAN also show the same tendency to that of NENBUTSU (Fig. 9). Interesting are the ACF- and IACF parameters as we see in Figs. 9-a, -b and Figs. 10-a –b.

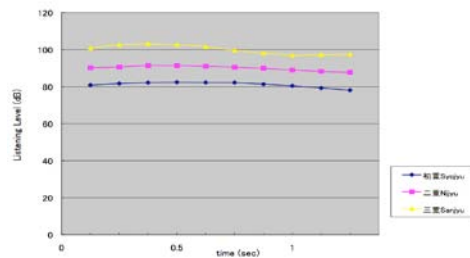


Fig. 8 Listening Levels of WASAN in SYOJYU, NIJYU and SANJYU levels.

The listening levels of WASAN in each turn are less than proceeding NENBUTSU chant. This shows the non-monotonous process of crescendo even in the physical listening levels of the whole NENBUTSU-WASAN.

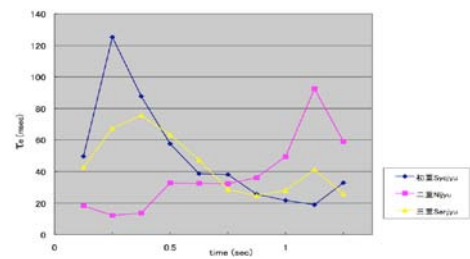


Fig. 9-a ACF effective duration time in WASAN in each levels

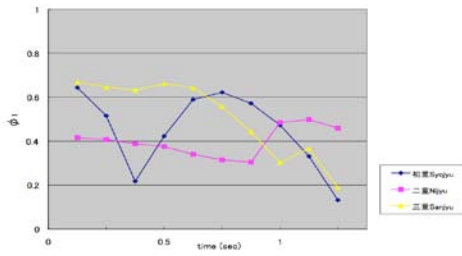


Fig. 9-b The peak levels of ACF in WASAN.

Although they showed dynamical changes, they still have clear and simple characteristics. WASAN singing consists of quite different TWO parts: ones are VERY LONG VOWELS, just like the GREGORIAN CHANT, and the others are rather SHORT VOWELS-AND-CONSONANTS --- syllables --- which transmit verbal meanings of Japanese spoken language in the WASAN text to the believers.

ACF parameters in WASAN chant often change much more than that of NENBUTSU. This has much to do with the Japanese text, syllabic parts with transmission of verbal meanings and long vowel parts. The “crescendo” and “allargando” processes in WASAN chant are much more indirect and seemingly complicated. But the COMPLICATION itself seems to play an important role in the whole NENBUTSU-WASAN rite. The process of crescendo and allargando in NENBUTSU part is much more monotonous than that of WASAN so that for the audience = believers would refresh their impression and feel less tired than mere continuation of same sound character; WASAN states the atmosphere of the temple’s SPACE-TIME effectively.

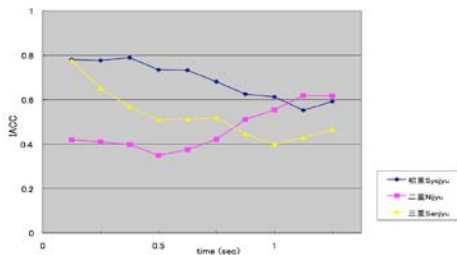


Fig. 10-a IACC in WASAN

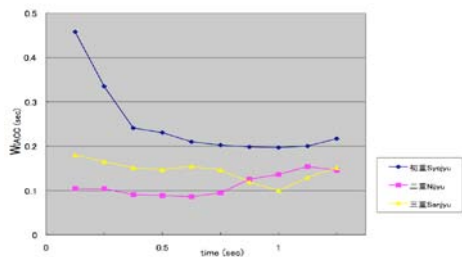


Fig. 10-b Changes in WIACC, WASAN

The IACC parameters in WASAN also change to some extent, but not as much as in ACF parameters. As these index SPACE characteristics and performing = theatrical aspect of the singing, WASAN part is much stable with the point of space localization. It shows good harmonization with the nature of WASAN, to transmit verbal means; the localization of sound source is very important, especially for the listeners to listen to and understand the message WASAN tells.

Just the same manner to the cases of NENBUTSU, we can number the “intensity order” also for the WASAN chant. Fig. 11 shows the whole process of NENBUTSU-WASAN.

	LL	IACC	WIACC	$\phi_1$	$\tau e$
NENBUTSU 1	3	2*	1*	2*	3*
WASAN 1	3	1*	1	2*	1*
NENBUTSU 2	2	1*	2*	3*	2*
WASAN 2	2	2*	3*	3*	2*
NENBUTSU 3	1	3*	3*	1*	1*
WASAN 3	1	3*	2*	1*	3*

Fig. 11. Continuity and Variety in the NENBUTSU-WASAN chant

The characteristics of succeeding WASAN have much common “intensity order” to the predecessor NENBUTSU, and vice versa in NENBUTSU to the predecessor WASAN; three or four parameters are common in the neighboring parts. This shows that in the whole process of NENBUTSU-WASAN, the least change in vocal and performing technique results the most effective realization of the MISSION of the JYODO SHINSYU Buddhism.

### 3. CONCLUDING REMARK

In realistic musical acoustic measurements in architecture, the traditional ways to use it could reveal the true dynamic mechanism of the performance there. In this paper we had shown the example from Japanese Temple. But the method is universal and we would also like to reveal the reality in Christian churches, concert halls and opera houses; because they have traditional know-how to let them vibrate the most. ACF- and IACC analysis are the most effective methods for the study of vocal and musical expression in every possible field.

### REFERENCES

[1] Ando Y., (1985). Concert hall acoustics, Springer Series in Electrophysic, Berlin