시계열을 이용한 음악의 해석

Analysis of the Music based on Time series

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ABSTRACT

This paper describes an analysis of the music as a time series and the fuzzy logic-based modeling of it. All music is made up of a finite number of musical notations known as the musical symbols, such as clefs, staff, time signature, notes, rests, etc.. The musical score uses musical symbols to present various characteristics, such as rhythm, melody, chord, etc., for interpreting the music. In this paper, it is possible to transform the beat and pitch in the musical into time series from the viewpoint of recognizing beat and pitch of sounding tone at ecah time. On the basis of the identified features of the musical score, a musical score is represented as a time series and then is constructed to fuzzy logic-based model for predicting them. Examples are presented to illustrate the validity of the proposed method.

요약

이 논문에서는 음악을 시계열 자료로 해석하고 시계열 자료의 퍼지 로직에 기반한 모델링에 대해 설명한다. 음악은 음악적 기호들인 보표, 악센트, 오선, 박자표, 음표, 쉼표 등등과 같은 유한개의 음악적 표기법들로 구성된다. 악보는 음악 해석에 필요한 리듬, 멜로디, 화음등과 같은 다양한 특성을 표현하기 위해 음악적 기호들을 사용한다. 본 논문에서는 각각의 시간에서 소리나는 음들의 비트와 높낮이로 인식한다는 관점에서 음악에서의 비트와 음의 높낮이를 시계열 자료로 표현하는 것이 가능하다. 악보의 규정된 특징들을 바탕으로, 악보를 시계열 자료로 표현하고 시계열을 예측하기 위해 퍼지 로직에 기반한 모델로 구성한다. 제한한 방법의 타당성으로 보이기 위해 몇 가지 예를 제시한다.

Keywords : time series, music, beat, pitch

1. INTRODUCTION

Music consists of many musical symbols, such as clefs, notes, rests, time signatures, staff, etc., including values of beat, pitch, accent, etc.. And it has many music notations, which is analyzable information such as chord, harmony, rhythm, melody, and so on. In music, melody results from the sequent varying of pitches. Melody must be considered with rhythm. Rhythm, the basic temporal element of music, concerns with duration in regard to sounding of notes. They are two necessary elements to analyze music. When we listen to the music in general, we recognize the varying of beats and pitches of tones during a musical performance. Therefore, it is possible to express musical sounds, generated by the variety of beats and pitches of tones, as the time series[2,3]. However, they represented a musical score as a time series by using the techniques of pattern analysis. And, the predicted data in them bring about the variety of the beat and pitch in sounding of one tone. It is impossible to change the beat and pitch of a sounding tone.

In this paper, we interpret a musical score as two time series corresponding to beats and pitches, respectively, and then present the fuzzy modeling of musical score. The modeling process is made of two cooperating layers. The fitting and forecasting quality of the model is analyzed by applying it to a concrete example, "A rock-island" which is one of the most popular Korean songs[2,3].

2. Fuzzy Modeling

In this section, we present the ways transforming the beat and pitch in music into time series and construct the fuzzy model of it for predicting the time series.

As shown in figure 1, the modeling process is made of two layers.

Fuzzy modeling

↑

Transformation Beats and Pitches into Two Time Series

↑

Beats and Pitches in the Music

Figure 1. The Modeling process

A method transforming beats and pitches in a musical score into two time series data sets is summarized in the following:

Step 1: Assign a sequential number t (t=1, ·, N) to notes and rests in a musical score.

Step 2: Using table 1, transform a set of muscial notation symbols into a set of beats.

Table 2. Notation Symbols vs. Beats

Notation Symbols	Value	Beats
𝅘𝅥𝅯 , 𝄿	a 32nd note / rest	1
𝅘𝅥𝅰 , 𝄾	a 16th note / rest	2
𝅘𝅥𝅮 , 𝄽	a 8th note / rest	4
𝅘𝅥 , 𝄼	a quarter note /rest	8
𝅗𝅥 , 𝄻	a half note / rest	16
𝅝 , 𝄺	a whole note / rest	32

Step 3: Transform the place of musical notation symbols on the staff into a time series data set. Assign its bottom place on the staff to 1.That is, the lowest pitch is 1. The others are determined by the following equation (1):

Each value of their place on the staff = 1 + difference between the place and bottom place on the staff (1)

In step 2, we use a temporal information to represent a musical factor, defined a rhythm. In step 3, we use pitches to represent another factor, melody. After completing above three steps, we will obtain two different time series on rhythm and melody. Commonly, when sounding music sound at present are related to past ones. In other words, a musical score has characteristic of auto-regressive model(AR model).

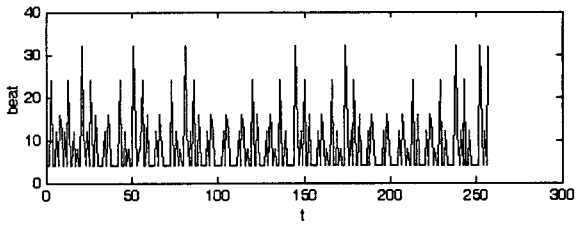
In the following, the fuzzy models of them are constructed by using some of entire data. The others data use for comparing with the predicting results. The Fuzzy models are constructed as follow:

Rule 1(n) -
IF beat(t) is A_1 and ... and beat(t+p) is A_i
THEN beat(t+p+1) is A_{new}.
Rule 2(m) -
IF pitch(t) is B_1 and · and pitch(t+q) is B_j
THEN pitch(t+q+1) is B_{new}.

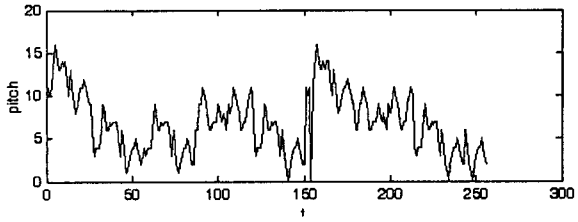
where A_k and B_k (k=1,...,n) are fuzzy sets corresponding to time series obtained from step 2 and 3, respectively. The p and q denote orders of the AR model.

3. EXAMPLES

In order to show the validity of proposed method, we consider a musical score, called "A rock-island" which is one of the most popular Korean songs. It has 257 musical notation symbols, such as notes and rests, which represent information of rhythm and melody. We use the first 200 ones to transform the musical notation symbols into time series data, and then appropriate thses data to construct the fuzzy models. The next 57 data are used for evaluating the forecasting performance of the fitted fuzzy model.



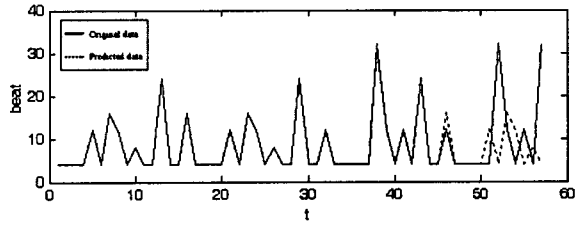
(a) time series 1 (t vs. beat)



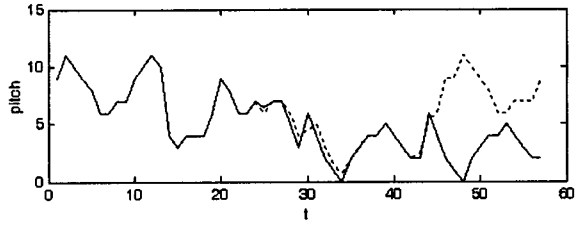
(b) time series 2 (t vs. pitch)

Figure 2. Two time series

Fig.2 show two time series data obtained from beat and pitch, concerned with rhythm and melody, respectively.



(a) t vs. beat



(a) t vs. pitch

Figure 3. The comparison of the original data and the predicted data

In fig.3, it shows the comparison of the original data and the predicted data, expressed as a solid line and a dotted line, respectively.

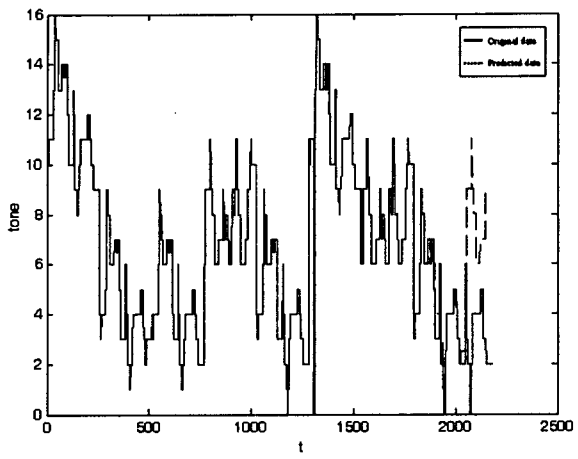


그림 4. Sounding of tones

As show in fig. 5, it shows varying tones on entire playing duration and the performances. In fig.5, the music is entirely played during 2184 time. The number of the observed data is 1688 data. The others, 496 data, are predicted data by using fuzzy model.

4. CONCLUSION

In this paper, we have presented the method for fuzzy modeling of a musical score on the basis of the interpretation of it as a time series. We showed the validity of the proposed method by the evaluation of the fitting and forecasting performance of the fuzzy model, all of which has been obtained by application to the Korean song, called "A rock-island".

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