Isao Hidaka, Masataka Goto, and Yoichi Muraoka: An Automatic Jazz Accompaniment System Reacting to Solo,
Proceedings of the 1995 International Computer Music Conference, pp.167-170, September 1995.

An Automatic Jazz Accompaniment System Reacting to Solo

Isao Hidaka Masataka Goto Yoichi Muraoka
School of Science and Engineering , Waseda University
3-4-1 Ohkubo Shinjuku-ku, Tokyo 169, JAPAN.
+81-3-3209-5198/{hidaka,goto,muraoka}@muraoka.info.waseda.ac.jp

ABSTRACT: This paper presents an automatic accompaniment system for jazz that understands solist's intention of improvising and outputs expressive accompaniment of a bass guitar and drums reacting to solo. Previous systems extracted just one parameter as solist's intention and output accompaniment by switching registered patterns. Our system can understand solist's intention in more detail by extracting five parameters as his intention from solo. In addition, to make accompaniment rich in variation, this system directly alters accompaniment data such as loudness, pitch and the number of notes, according to those parameters. In our experiment, it outputs appropriate accompaniment following the solist's intention.

1 Introduction

This research aims to simulate human music listening process in a jazz ensemble, and cooperation among players. Although there are various kinds of jazz, we consider only four-beat jazz standards with a constant tempo. We deal with trio play that consists of a human pianist (or a guitarist), a bassist and a drummer by a computer. In this study we assume that the most significant player is a pianist, and the other two are accompanists – i.e., the pianist improvises a solo with a certain intention, which plays very important role in this ensemble. If the accompanists do not understand it, the ensemble sounds poor totally. It is therefore desirable that the accompanists play following the solist's intention.

A previous system called *JASPER* [Wake et al., 1994] extracted just one parameter called *tension parameter* as solist's intention and output the accompaniment by switching pre-registered patterns according to this parameter. It was not enough to express his intention with only this parameter, however. In another system, Tsutomu Kanamori [Kanamori et al., 1993] implemented a listening model in a jazz session. They proposed detecting four kinds of *sensuous information* from the performance as a message that represented a psychological state of a player. In other related work, Robert Rowe implemented an interactive music system called *Cypher* [Rowe, 1992]. This system classified MIDI input into six features such as loudness, duration, and density, to understand a human's play. However, it didn't extract player's intention.

Our system can understand solist's intention in more detail by extracting multiple parameters as his intention from the various aspects of the solo. In addition, to make the accompaniment rich in variation, this system alters the accompaniment data such as loudness, pitch, and the number of notes, according to these parameters. This system takes MIDI data as input, plays based on stored data such as keynote, chord progression, theme and plain accompaniment data, and outputs MIDI data as the accompaniment.

Our system extracts five parameters called *intention parameters* as solist's intention from solo performance. In our current implementation, the intention parameters are *excitement*, *tension*, *emphasis on chord*, *chord substitution*, and *theme reprise*. Since it is hard to extract these parameters from individual notes directly, the system first detects eight musical primitives from the notes. These are *louder note*, *chord tone*, *higher note*, and so on. Each intention parameter is induced by summing up the particular musical primitives. Our system then alters the stored accompaniment data according to the intention parameters. The intention parameters control two modules that directly alter the accompaniment data. One module called *MIDI filter* adjusts loudness and pitch. The other called *MIDI phase shifter* adds notes by shifting timing of notes.

This system has been implemented on a personal computer and works in real time. It was tested by a pianist and a guitarist. Experimental results show that it was able to extract intention parameters from individual notes of solo, and output appropriate accompaniment of a bass guitar and drums that followed the solist's intention of improvising.

2 Features of our system

2.1 Multiple solist's intention

Extracting various solist's intention enables the system to understand the solo and to react to it appropriately. We therefore extract solist's intentions that are important for jazz play as five *intention parameters* from various aspects of solo (Figure 1). The five intention parameters are as follow:

- **excitement**
  The parameter *excitement* expresses a solist's intention to make the ensemble inspiring. This intention is significant in jazz as well as in other music genres. This parameter is similar to *JASPER*'s parameter. The accompanists excite their play reacting to this intention.
- **tension**
  The parameter *tension* expresses a solist's intention to make the ensemble a little different from a standard by playing some notes such as tension notes and higher notes. Since tension notes are non-chord notes, they cause a variety of chord feelings. For example, when our system detects many tension notes, this intention is extracted.
- **emphasis on chord**
  The parameter *emphasis on chord* expresses a solist's intention to emphasize a standard's chord progression by playing a phrase that includes some chord notes specified in a song. For example, our system extracts this parameter when the solist plays a phrase such as arpeggios of the chord notes.
- **chord substitution**
  The parameter *chord substitution* expresses a solist's intention to emphasize standard's chord progression with slightly different from a song by playing a phrase that includes some substituted chord notes. Because a substituted chord has the same function as the original chord has, the solist can play a phrase with some substituted chord notes with keeping a feeling of the original chord.
- **theme reprise**
  The parameter *theme reprise* expresses a solist's intention to plays a standard's theme or a faking theme that can be recognized as the standard. When the system detects this intention, it outputs plain accompaniment data without any alteration.

2.2 Dynamic alteration of accompaniment

To make a total ensemble better, it is necessary for the accompanists to play reacting to the solist. We dynamically alters accompaniment data such as loudness, pitch and the number of notes, according to the intention parameters mentioned above. Even if the solist suddenly changes his play, the system can make accompaniment more appropriate to solo than outputting by switching pre-registered patterns.

Figure 1 shows five intention parameters, musical primitives that induce intention parameters, and alteration of accompaniment reacting to intention parameters. In the next section, we describe how the system works in more detail.

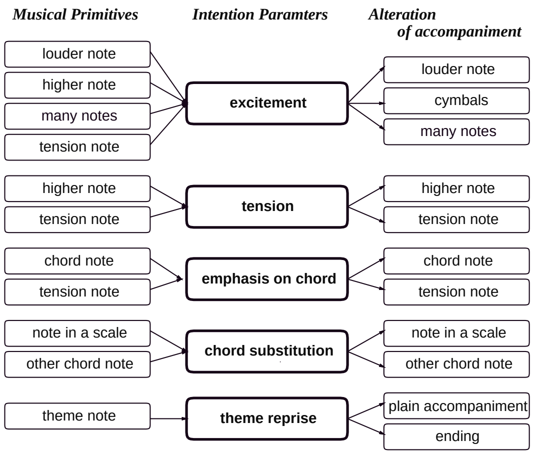

Figure 1: Solist's intention

3 System description

Figure 2 shows an overview of our system. The system consists of three main stages, *Detection of musical primitives*, *Extraction of intention parameters*, *Alteration of accompaniment*. For the preparation of a real-time performance, chord and key are analized in the *Analysis of chord and key* stage, in advance. In the *Detection of musical primitives*, eight musical primitives are obtained from the solo's individual notes using the results of analysis of chord progression and key. In the *Extraction of intention parameters*, five intention parameters are induced by summing up the corresponding musical primitives. In the *Alteration of accompaniment*, accompaniment data are directly altered according to the intention parameters by using two modification modules.

3.1 Analysis of chord and key

The system analyzes the chord and key on the basis of music theory [Taniguchi, 1991] in order to understand chord function, tension notes in the stored chord progression, available note scale and so on. The system utilizes these results to detect the musical primitives from solo performance and to alter accompaniment data.

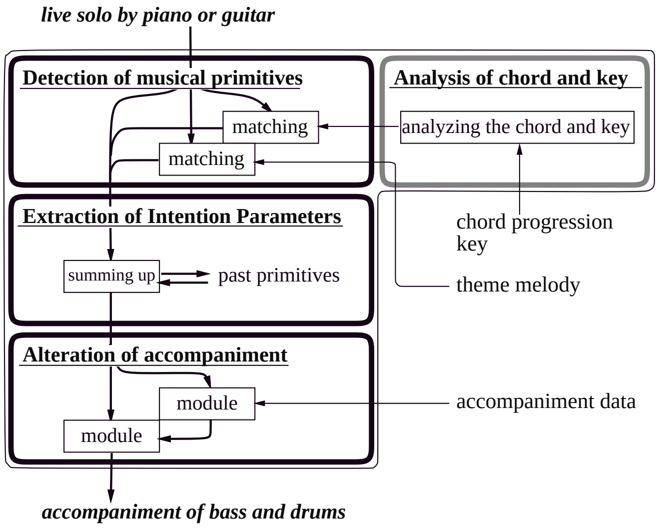

Figure 2: Overview of our system

3.2 Detection of musical primitives

For the preparation of extracting the intention parameters, the system detects eight musical primitives from every note to understand some of musical features of the notes. The musical primitives *tension note*, *chord note*, *scale note*, and *other chord note* are detected by using the results of analysis of the chord and key. Another primitive *theme note* is detected by matching the input note with the theme melody. This stage does nothing for the other primitives *louder note, higher note*, and *many notes*, since they are simple primitives, and can be obtained directly.

3.3 Extraction of intention parameters

In this stage, five intention parameters are extracted from musical primitives. Each intention parameter is induced by summing up the particular musical primitives shown in Figure 1.

To follow a solist correctly when he suddenly changes his intention, this system extracts these parameters on every beat, and to extract a slight but continuous intention, this system sums up the musical primitives in a certain period.

	Intention parameters				
musical primitives	excite	tension	emphasis on chord	chord substitution	theme reprise
louder note	100	---	---	---	---
higher note	80	70	---	---	---
many notes	5	---	---	---	---
tension note	3	2	0	---	---
chord note	---	---	0	---	---
note in a scale	---	---	---	0	---
other chord note	---	---	---	0	---
theme note	---	---	---	---	$*$

Table 1: Threshold values for extracting intention parameters

Our system weights some musical primitives according to their importance in the intention parameters under consideration. In summing up the primitives, our system ignores the primitives whose values are less than their threshold value. These threshold values are listed in Table 1. In this table, the value at the louder note is MIDI velocity, and the values at the higher note are MIDI note number. The mark $*$ indicates that the parameter *theme reprise* is detected on the basis of how the input notes are matched with the stored theme without threshold.

3.4 Alteration of accompaniment

In this stage, our system dynamically alters the accompaniment data according to values of intention parameters and the period for which the intention parameters extracted. To follow only the solist's apparent intentions, the system alters accompaniment data when an intention parameter's value is greater than it's threshold value.

The intention parameters control two modules that alter accompaniment data directly. One module called *MIDI filter* adjusts loudness and pitch. The other called *MIDI phase shifter* puts additional notes by shifting timing of the original notes. In this case, the intention parameters control how long and how many times it shifts data. For example, when the intention parameter *excitement* is extracted, the system makes the accompaniment note louder and higher with MIDI filter and it adds some notes with MIDI phase shifter. In the case of altering the bass part, the pitch of notes is calculated on the basic of the results if the analysis of the chord and key. In the case of altering the drums part, notes of other percussion instruments are added, or the part of a percussion instrument in the stored accompaniment is replaced by another instrument.

4 Experimental results

This system has been implemented on a personal computer (*NEC PC-9821 Ap2*) and works in real time. It was tested by a pianist who had studied music in the university, and a guitarist who had experience of playing in an amateur jazz band. They played with a MIDI synthesizer (*KORG 01/W*) or a guitar that can output MIDI streams. The accompaniment sounds are output by the synthesiser. We handled a standard called ‘‘take the A train.’’ We requested them to play the theme in the first half and then improvise.

Figure 3 shows how our system extracted five intention parameters, and how it altered accompaniment data according to these parameters. Both players evaluated that the system output the accompaniment at an amateur level, and that it could nearly extract their intentions. The system sometimes extracted several intentions when the solist played with only one intention. The reason for the mistakes is that a certain note caused the multiple musical primitives to be obtained.

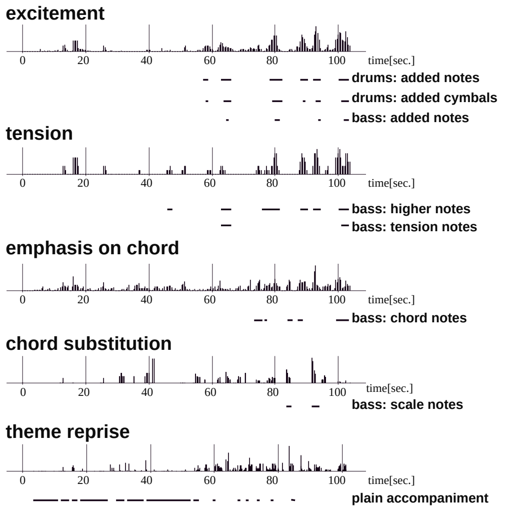

Figure 3: Intention parameters and accompaniment

One of the solists pointed out that the system reacted too sensitive. This was chiefly because we fixed the threshold values that affected the extraction of intention parameters. We think that the system will react more appropriate to solo by dynamically modifying these values or by changing them so that they fit the solist.

5 Conclusion

In this paper, we proposed the way of extracting five parameters that express solist’s intention and accompanying him appropriately by altering the accompaniment data according to them. To extract parameters as intention, the system summed up several musical primitives, and to alter the accompaniment data directly, we implemented two modules that handled raw MIDI data. Experimental results showed that our system was able to extract the intention parameters and output appropriate accompaniment reacting to them.

We implemented a fixed accompanist because we statically defined all the threshold values concerning with extraction of intentions. We plan to improve the algorithm for modifying those values automatically during the performance. Future work will include the implementation of changing the accompaniment actively, and understanding solist’s feelings.

References

[Wake et al., 1994] Sanae Wake, Hiroaki Katou, Naoki Saiwaki, Seiji Inokuchi: Cooperative Musical Partner System Using Tension Parameter: JASPER (Jam Session Partner) *Trans. of Information of Processing Society of Japan*, Vol. 35 No. 7 pp. 1469-1481, 1994 (in Japanese).

[Kanamori et al., 1993] Tsutomu Kanamori, Haruhiro Katayose, Seiji Inokuchi, Hiroshi Hirai, Yasuhisa Niimi: Interpretation of Musicality in Jazz Improvisation using Multi-Agent Model, *Proceedings of IAKTA/LIST International Workshop on Knowledge Technology in the Arts*, pp.107-114, 1993.

[Kanamori et al., 1995] Tsutomu Kanamori, Haruhiro Katayose, Yasuhisa Niimi, Hiroshi Hirai, Seiji Inokuchi: A Study of Music Recognition in a Jazz Session System, *Trans. of Information of Processing Society of Japan*, Vol. 36 No. 1, pp. 139-152, 1995 (in Japanese).

[Rowe, 1992] Robert Rowe: Machine Listening and Composing with Cypher, *Computer Music Journal*, Vol. 16, No. 1, pp. 43-63, 1992.

[Taniguchi, 1991] Hiroshi Taniguchi: The Real Jazz Guitar Volume 1, *Tokyo Ongaku Syoin*, pp. 15, 28-34, 57-70 1991 (in Japanese).