Psyche: University of Tsukuba, Computer Music Project

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Abstract
The computer music project Psyche started in 1983 at University of Tsukuba, AI lab. The project has been pursuing to let a computer render musically expressive performance especially on an acoustic instrument. Systems of Psyche are categorized into two. One consists of static programs to analyze and synthesize expressive performance. The other dynamic real-time programs to control a computer so as to accompany a human player.

1 Introduction
The computer music project Psyche started in 1983 at University of Tsukuba, AI lab. Psyche's core research subject is to obtain musically expressive performance of classical music pieces by a computer. In order to pursue the objective, we have built and been building some infrastructures as well as individual computer music systems.

Although the computer music has not a short history and some Japanese groups had been engrossed in the subject in 1983, the computer music as a research area has not been pervasive and recognizable in Japan in those days. We presented our prototype music description compiler language Europa (Extensible Universal Representation Of Phrasing and Articulation), which was used for representing information explicitly appeared on a score, at a symposium. The presentation inspired to formulate an informal computer music research group then now grown to an approved SIG (special interest group) of IPSJ (Information Processing Society of Japan).

Professor Igarashi, an amateur tenor and an accordionist as well as a theorist in computer science [1], of the Institute of Electronics and Information Sciences of University of Tsukuba has been leading the project. About ten students (six undergraduate and four graduate) come to the project and are assigned systems to work on individual basis every year. They take over their systems from their seniors, on which they work for three years at the most (one year as an undergraduate and two in master program). Some of them make presentations on their systems at domestic conferences and demonstrate them at a Tsukuba musical festival every year.

2 Systems of Psyche
In order to obtain musically expressive performance by a computer, many systems have been designed and built in Psyche in the following three directions.

1. To provide data for describing music score written in Europa beforehand to run any system. Systems with the score information are easy to extend when manipulation of performance becomes complicated.

2. To manipulate MIDI (strictly speaking, a special file format which is in accordance with MIDI), that has fewer performance parameters than data from other devices. So as to concentrate our research to the understanding and generation of musical expression within programming power (students), research subjects which are more immediate to synthesize and analyze music rendition are given priority. Consequently, some research issues of a few steps away from generating performance are not present objective, however important and interesting they may be. The research of automatic analysis of music structure, for example, has lower priority in Psyche, while users of Psyche systems analyze music structure for themselves to obtain performance.

3. To introduce music structure.
This turned to be the most effective direction in solving various fundamental problems in music rendition. Several difficulties in automatic ensemble are solved elegantly by taking music structure into consideration.
2.1 Equipment

The acoustic grand piano with MIDI I/O and synthesizers are our oldest instruments for experiments. Other instruments with MIDI I/O are accordions, a silent drum system, a guitar, and a clarinet. The output of systems for synthesizing music rendition is played on the grand piano. The piano and other instruments are played by human players accompanied by Psyche's ensemble systems. Orchestrated data for piano concertos on the market are partly used for an accompaniment system also.

Ensemble systems to control MIDI instruments have been built on DOS. Although informal, the inevitable time latency is pointed out by a developer of Windows 95, so that we have not yet decided to depend on Windows 95 to run the ensemble systems completely where the real time control is vital. The least time latency caused by an operating system is the biggest concern in selecting an OS on which an accompaniment system runs. Static programs, such as synthesizing music rendition or visualizing musical performance, are written on Unix currently.

2.2 Current systems

Systems of Psyche are categorized into two. One consists of static programs to analyze and synthesize expressive performance. The other dynamic real-time programs to control a computer so as to accompany a human player. The main systems are as follows.

2.2.1 Performance analysis and synthesis

- Performance synthesis with rules.
  Musical rendition is obtained by unfolding performance of music structure (usually a motif)[8]. The performance expansion is derived by applying context-free performance rules based on music structure. Context-free rules are simple and describe relationships between occurrences of music structure and appearance of significant harmony progression. Currently, a portion of the actual performance by a professional pianist is used as a seed performance for the expansion. As for Mazurka Op. 7-2 by Chopin, providing one third of the whole performance as seed turned to be enough for synthesizing artistic music rendition.

- Performance visualization for analysis and synthesis.
  There are several types of visualization systems in Psyche. All of them have proved that the characteristics are recognized when performance is presented visually based on music structure [2][8]. Figure 1 shows performance data of measures nine through twenty four of Chopin's Mazurka Op. 7-2 by two professional pianists. The visualization system gets MIDI data and the data on music structure, such as the information of motif or sentence. The performance starts from the leftmost fan shape, whose radius represents the length of a beat, and moves clockwise. A half circle represents a motif. Then the phase of the circle is inverted and the performance proceeds counterclockwise. We can observe several performance characteristics on this piece.

  Common ground in their performance.
  - Both of them play longer at the beginning and the end of a sentence which consists of four motifs.
  - The performance of the third motif resembles that of the first. We can recognize on the score that the two motifs are similar as music structure.

  Differences in their performance.
  - The length of the third beat in many of the motifs are played differently. A player plays it longer than adjoining beats, while the other plays it shorter.

- Expression analysis on agogics and dynamics.
  In order to generate the seed performance used in the system of performance synthesis with rules, performance characteristics are analyzed and made into rules. MIDI data is used for the analysis. Example observations on several performance samples by professional pianists are as follows.

  - Although not recognized by listening, higher notes in Alberti bass played by the left hand are played louder and longer than other notes, contrary to the player's intention.
  - A note in the accompaniment part is played softer than other notes when some keys are pressed simultaneously.
  - Usually a note in the melody part is played first when some keys are pressed simultaneously.

Human pianists are usually unconscious of these observations on performance. The quantification of performance rules which
are described qualitatively is enabled by collecting more data. Attribute grammar is a candidate for a quantification method to get performance data from qualitatively expressed performance rules [3].

2.2.2 Accompaniment systems

- Ensemble for an acoustic grand piano.
  A human player playing the primo part is accompanied automatically by the computer controlled secondo part. Before the actual ensemble, performance by human player is released to find out the best tempo elasticity. During ensemble, the system detects the tempo of human performance then anticipates the player’s tempo in the next measure or motif [6].

  The information concerning music structure is given to the system as well as the information of the score which enables for the accompaniment part to refer the way a human pianist plays the corresponding melody.

  The difficulties of the system is caused by the mechanical specification of the grand piano that it must receive MIDI data 500ms prior to the actual key movement. Consequently the calculation for the accompaniment has to be done at least 500ms earlier than the actual key movement which is a severe restriction in designing the system.

- An orchestra accompaniment to an acoustic grand piano.
  The orchestra accompaniment system provides the automatic tempo control facility, so that a pianist can practice or enjoy piano concerto without bothering anybody else.

- Ensemble with triggers.
  A computer controlled drum set with MIDI I/O accompanies an acoustic piano played by a human, or, conversely, the acoustic piano automatically follows the percussion played by a human. This system was the only exception which didn’t use score information provided in advance but only used triggers from the MIDI I/O device. Applying "An Der Schönen, Blauen Donau Op. 314" by Johann Strauss II to the system has shown the necessity of giving score information, data of music structure, and rehearsal data to the system for better performance.

3 Future plans

There are three subjects which are on going and will continue in the future with many system plans in Psyche. Three themes are as follows.

1. The design and implementation of music description languages — Daphne and Leda.

  Music structure plays a very important role both in performance analysis and in synthesis. Thus we have started the design and the implementation of a language for representing music structure —Daphne (Deductive Analysis of Phrasing and Expression). In order to obtain musically expressive performance data, the information on music structure, relationships between occurrences of music structure, etc. are necessary, which are written in Daphne. Performance plans based on music structure is written in Leda (Logical Expression of Dynamics and Agogics). Using the information of music structure written in Daphne, systems look for performance plans at knowledge base of context-free performance method written in Leda.

2. System integration by object-oriented approach.

  Besides taking advantage of object-oriented approach in the design and the implement-
tation of Psyche systems, object-oriented concept is adopted as the consistent design methodology. There are three reasons to use object-oriented approach.

- To hold easiness of expansivity of systems and languages.
  It is often pointed out that music research has never reached to an end.
  A mechanism to append the attribute which is revealed later is necessary,
  since a particular attribute for music structure may be found to be desirable
  for expressive musical performance, for example. Inheritance mechanism is a
  method to expand or specify the later requirement to the system.

- To integrate knowledge base into existing systems written in object-oriented programming language.
  Utilizing object-oriented approach for AI, Psyche systems can be seen in a
  single object-oriented manner as a whole.
  In order to represent knowledge base in an object-oriented way, we must take
  the latest research of the concurrent object-oriented issues into consideration.

- To expand some systems as cooperative programming systems.
  For the purpose of evolving the current ensemble systems into cooperative
  programming systems, agents which run concurrently will be introduced. For
  this expansion, the concurrent object-oriented approach will be of good use.

3. The mathematical representation and formulation of musical performance especially for accompaniment systems.

Accompaniment systems are regarded as real-time control systems whose states (positions, volume, etc.) are changing continuously but controlled by discrete actions, such as “note on” and “note off”, by a program or a human performer. When the systems are specified formally, verification of correctness in program action and musical expression is mathematically and rigorously analyzed. For this purpose, we are formulating the systems in the verification formalism SOFA [7] based on the analytical semantics [4].

An example of system plans is an integrated musical performance editor. Psyche’s systems are built mainly by expanding the existing ones. The editor has been designed and built based on performance visualization systems described above.

References


