Chapter 5

Examples, Applications and Discussions of DAPHNE

In this chapter, I will show an analysis example in details. Then three applications of DAPHNE are introduced. Finally I will make some discussions about the evaluation of DAPHNE.

5.1 An analysis example

When a user selects a music piece to perform analysis, a certain set of files related to the piece will be loaded into memory. Including a series of score image files, a score description file, a EUROPA score-coding file, and a UNI performance data file. After all these files are successfully loaded, the main control window is ready to receive the user's input. On the top of the window is the command history area, which preserves all the user's inputs and results. On the bottom is an input control where the user enters commands. See Figure 34 for details.

Figure 34. Main control window of DAPHNE
Let's take Chopin's Mazurka 7-3 as an example. Since there are four sheets of score images, we can tile them on the two screens to get a better outlook. Figure 38 depicts the score image with the results of the following analyses.

5.1.1 Musical structures
First, we try to specify musical structures manually. In Figure 38, from measure 9 to 24, there are 16 measures. Input the following command in the main window, we will get the motifs.

*Input:*  motif9, 11, 13, 15, 17, 19, 21, 23

*Output:*  ok

For verifying the result:

*Input:*  show motif from motif9 to motif23

*Output:*  motif9 (9,10); motif11 (11,12); motif13 (13,14); motif15 (15,16); motif17 (17,18); motif19 (19,20); motif21 (21,22); motif23 (23,24);

Musical structures can also be analyzed automatically. The following is the automatic phrase analysis for measure 9 to 24.

*Input:*  show phrase from 9 to 24

*Output:*  phrase9 (9_1_0, 12_3_0); phrase13 (13_1_0, 16_3_0); phrase17 (16_3_1/2, 20_3_0); phrase21 (21_1_0, 24_3_0);

Figure 35. Phrase analysis in the sub-window
The above analyses can also be performed on the analysis sub-windows. In Figure 35, we can obtain the same command as in the main window through the following steps.

- Set the proper parameters like range and structure;
- Check the inquire option to indicate automatic analysis
- Press OK

The message shown in the Command input area is generated by the system automatically.

5.1.2 Relationships among occurrences of musical structures

Based on the analysis results of musical structures, the relationships among occurrences of musical structures can be further obtained.

**Input:** set similarity level of motif1: motif9, 3
**Output:** ok

The above input specifies that motif1 is similar to motif9, motif9 is the reference motif of motif1, and the similarity level is 3.

The following is an example for automatic analysis.

**Input:** show similarity level from motif9 to motif15
**Output:** motif9: motif9, 0; motif1: motif9, 3; motif13: motif9, 1; motif15: motif9, 3;

DAPHNE can find their relationships automatically. For instance, “motif13: motif9, 1” means motif13’s reference motif is motif9, and the similarity level is 1.

Relationships among structures can also be analyzed in the sub-window depicted in Figure 36.

![Figure 36. Similarity level analysis in the sub-window](image)

Next, let's manipulate the score image.
Select measure 9 to measure 24 as the analysis range by dragging the mouse over the score.

Select an analysis item (For example, “automatic structure analysis”) on the popup menu. Occurrences of the motifs in the selected range are displayed on the score as the first line between the two staves.

Analyze the relationships among the motifs. The numbers under the line show the reference structure and the similarity level. For example, “Seed” means the reference structure is itself, and “M9: 3” for motif 11 means that motif11’s reference structure is motif 9 and the similarity level is 3. See Figure 38 for details.

Same as motif, we can get similar analysis results on phrase and sentence. The second line between the two staves stands for phrases, and the third line stands for sentences.

5.1.3 Structure functions

Structure function can be specified in the sub-window depicted in Figure 37. For instance, in order to set “F” of note 11_3_0 as the initiative of phrase 9, do as follows:

- In Range, input 11_3_0;
- Select initiative in function type Select
- Select set in Command
- Press OK

![Daphne - Structure Function](image)

Figure 37. Structure function analysis in sub-window

Then the following messages will be appended to the history area in the main window.
Input: set initiative at 11_3_0
Output: ok

5.1.4 Harmony, chord progression, and tonality

Before analyzing Harmony, Tonality of whole piece must be specified. In Figure 10, select F and minor, then Tonality can be seen in the preview window. We can confirm it by comparing with the real score. Meanwhile, command is generated in the main window:

Input: set global tonality to F_minor
Output: ok

Next, we analyze chord.

➢ Set the position to note "9_1_0" on the score image.
➢ Open the sub-window depicted in Figure 11 and select "T" in Chord Function.
➢ Preview the result and confirm with the real score.

The generated commands in the main window are:

Input: set chord to 1 at 9_1_0
Output: ok

In the meantime, the letter 'T' can be seen under the note "9_1_0" on the score image.

5.1.5 Musical forms

Same as the other items, musical form can be analyzed both manually and automatically. As Figure 38 shows, Mazurka is a composite three-part form and the brackets indicates the range of each one.
Figure 38. Score images with musical analysis results
5.2 Applications

There are many systems in project PSYCHE, all of which related to performance rendition. They are categorized to automatic accompaniment, performance visualization and performance rendition. The analysis results of DAPHNE can be used by these systems since all of them are based on musical structures.

5.2.1 System of performance synthesis with rules

In order to generate better expressive performance, based on the relationship between musical structures and performances, we have found some rules by analyzing performances. Some of the rules affect performance greatly. For example, in a structure, the procedure of “beginning-initiative-end” follows the “slow-fast-slow” rule. In this system, at first we obtain the information of structures, structure functions and musical forms from DAPHNE. Then, according to the musical forms, we analyze the performance in each structure of different levels and compare the performances between different structures of the same level. Finally, we find and confirm the performance rules that can be used widely [Liu00-a].

Rules are expressed in terms of analyzed items, especially musical structures and the (metric) structure functions.

Examples of rules [Koi00]:

- Performance for the first note of a musical structure starts rather longer, gets accelerated to the initiative, and then slows down in the reactive.
- Comparing with surrounding notes, a note that has smaller note value will be played shorter.
- A series of notes whose note values are the same and relatively small will be played shorter.

5.2.2 Automatic accompaniment system

Automatic accompaniment system is a real-time system. It can automatically generate harmonious accompaniment for musician’s performance by following the tempo and expressions [Iga96-b]. For lots of music pieces, we don’t need to synchronize the accompaniment with musician’s performance for all the time because of the independence of accompaniment. We do it only at some certain points where musician intentionally changes the tempo. In this system, in order to keep the independence of accompaniment and reduce the calculation time, we just follow
the musician's performance on those points specified by DAPHNE according to musical structures, and generate accompaniment performance, which has been got good comments from musicians [Sak99]. In example Sicilienne described in chapter 3.4, the starts of phrases where a soloist should lead performance are specified as fitting points.

5.2.3 Performance visualization system

Besides performance data visualization utility of DAPHNE, there are some other visualization systems for musical performance in PSYCHE [Iga96-a]. These systems are used for analysis and synthesis of musical performance [Hir97-a]. The analysis of performance that specifies the common way of playing is done by comparing performances by several different players. By visualizing musical performance in accordance with musical structures, the general rules of performance can be derived in terms of musical structures. Also the individuality of performance is described better if we consider musical structures. Using musical structures generated by DAPHNE, users can find performance characteristics easily. Users can select different parameters (like volume and velocity) to analyze performance and achieve different characteristics of performance. Based on these data and by making comparisons among different performances, we can find some general characteristics. These general characteristics, after being analyzed and proved, will lead to new performance rules. Besides, some visualization systems allow users to modify performance interactively.

Figure 39 depicts the results of comparing five professional pianists' performances. (Chopin's Polonaise)
5.3. Discussions

It's necessary and important to evaluate the performance of a computer-assisted system. However, due to the complicated and ambiguous nature of music, and the request for both music and computer knowledge during the evaluation process, finding a good method for evaluating musical information processing system still remains to be studied. For example, in a music analysis system, only part of the analyses can be done automatically. Users need to specify, judge or even modify the results manually. Thus it's difficult to evaluate the system simply by its correctness or speed.

According to the above reasons, we only made some simple evaluations for DAPHNE. Many people were involved in this process, including musicians and students. Some of them are lack of computer knowledge.

One of the evaluation topics is: How much does DAPHNE assist the automatic generation of performance.

By examining the evaluation results, we got the following conclusions:

➢ For some certain evaluation items like visualization of performance data, multi version scores, etc., the musician's opinion differs from the students' due to their different background and experience of both music and computer.

➢ Hereafter, the main problems of DAPHNE are the replenishment of analysis items and the enhancement of automatic analysis.