

# Constructing a Machine Evaluation System "MAESTRO" for Music Aesthetics of Allowable Solutions for Given Bass Task in the Theory of Harmony

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## ABSTRACT

Developed is a system that calculates aesthetic score for solutions of given bass, based on the weights obtained as the least squares solution for a set of linear equations expressing an aesthetics evaluation model. A series of aesthetic evaluation experiments was carried out to obtain the weights using several sets of allowable solutions of given bass tasks. Ten experts and 40 students majoring in music joined the evaluation experiments. It is confirmed that the system, named MAESTRO (Musical Aesthetics Evaluation System for Ional music in Regular and Orthodox style) can evaluate musical aesthetics as the same level as excellent students.

## INTRODUCTION

Advances in computer science and software engineering have yielded a lot of music software systems, such as playing systems, score-reading systems, accompanying systems, and so forth. There have been, however, no intensive study dealing with musical aesthetics, maybe because of its vagueness, complexity and diversity of music aesthetics itself.

As most of scientists interested in music seem to think that musical aesthetics is a kind of "sacred fields", they tend to refrain from treating it from a scientific viewpoint, in order not to profane Muse.

It is altogether difficult to investigate what features in music work on aesthetics. A comparative

aesthetic evaluation test is designable employing several allowable solutions of a “given bass” sequences as stimuli. It is expected to find aesthetic criterion based on a subjective evaluation test for a set of solutions of a given bass task, because solutions of a given bass task spread in a considerable range based on note arrangement characterized mainly by simple segments of the soprano line. Thus, “given bass” tasks are appropriate for investigating how listeners evaluate the aesthetics in music.

Miura et al. have constructed “BDS (Basse Donnée System)”[1,2] that can generate all the allowable solutions for given bass sequences within triads. A series of comparative aesthetic evaluation tests was conducted on each complete set of allowable solutions obtained by BDS for each bass sequence employing students majoring in music as subjects. The results are used for constructing a system for aesthetics evaluation that gives aesthetics scores for solutions of given bass sequences based on a set of weights obtained as the least-squares solution of a linear aesthetics model.

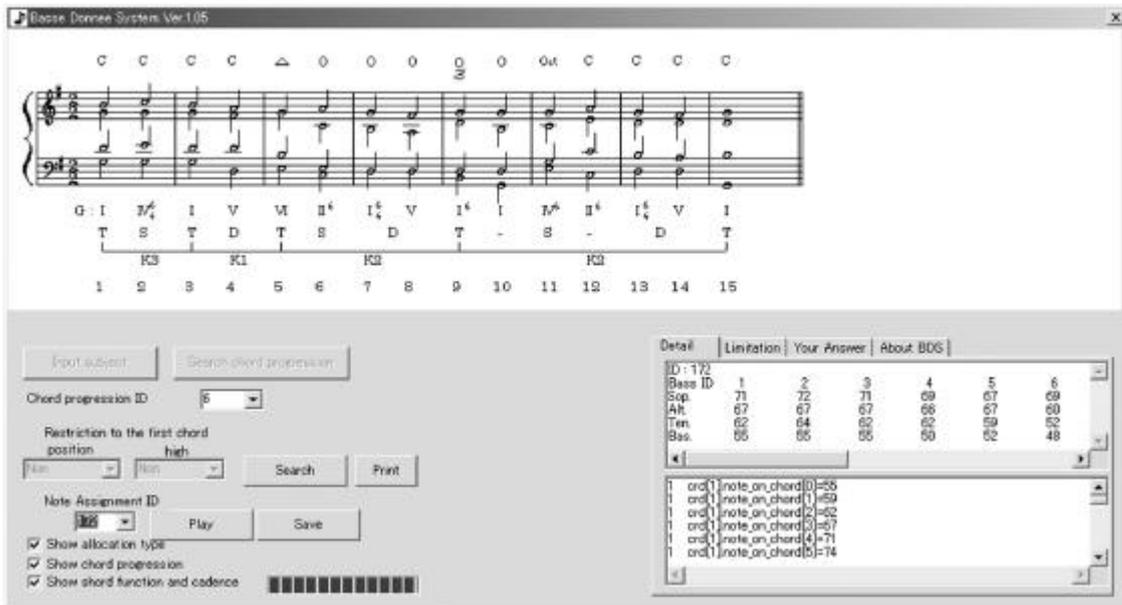
### **BASSE DONNÉE SYSTEM**

Miura et al. have proposed a conceptual design of a CAI system for learning of the theory of harmony. As its subsystem, they have constructed “Basse Donnée System(BDS)”, which can generate all the allowable solutions within triads for a given bass sequence. Figure 1 shows a display example of BDS. In Fig.1, BDS shows one (#172, in this case) of allowable solutions (321 solutions in total in this case), under chord progression #6 (among 6 chord progressions, for this particular bass sequence). BDS is downloadable at our URL[2].

Any of the solutions generated by BDS violate none of the inhibition rules given in the theory of harmony. As inhibition rules reflect musical aesthetics, most of the solutions given by BDS are beautiful, or, at least, sensationally acceptable, but there are some that are not so beautiful. Thus, various sorts of subjective tests concerning musical aesthetics come into sight to conduct research into musical aesthetics using the solutions obtained by BDS. For example, a test to investigate how people feel beautifulness in music, a test investigating what are features that work on music perception, a test to investigate whether people have common evaluation criteria in music aesthetics and so forth. All these tests are realizable by employing BDS as a tool to get allowable solutions for a given bass sequence.

### **AESTHETIC EVALUATION TEST**

A series of comparative aesthetic evaluation tests was carried out on each complete set of allowable solutions obtained by BDS for each given bass sequence. Ten experts in the theory of harmony and 40 students majoring in music participated in these tests. They are asked to give scores to each allowable solution evaluating it from an aesthetic viewpoint. Six bass sequences were employed in the current test. The result of the current test is shown in Fig.2, where the ordinate represents average score of all subjects, and allowable solutions are arranged along the



**Fig. 1.** A display example of Basse Donnée System(BDS).

BDS shows one(#172, in this case) of allowable solutions(321 in this case), under chord progression #6(among 6 possible chord progressions, for this particular given bass sequence). BDS can (1)play solutions using MIDI sequencer, (2)save them as a standard MIDI file, and (3) make hard copies of them. BDS is downloadable on <http://miguel.doshisha.ac.jp/~miura/BDS-e.html>

C : Close position, O : Open position,  $\overset{\circ}{C}$  : Close position without 3rd note,  $\overset{\circ}{O}$  : Open position without 3rd note.

Oct : Octave position, that means 1 octave degree between soprano and tenor.

. : Non standard position.  $\overset{6}{X}$  : 6<sup>th</sup> inversion of chord X,  $\overset{4}{X}$  : 4<sup>th</sup> inversion of chord X.

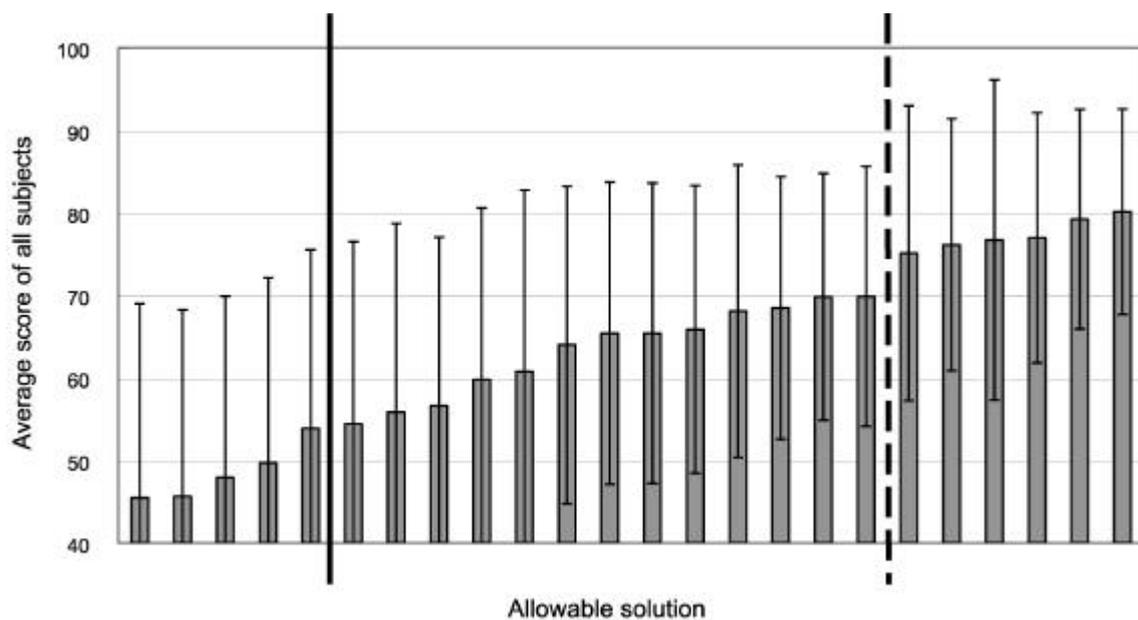
T : Tonic, D : Dominant, S : Subdominant.

K1, K2, K3: Cadences of pattern 1 (T-D-T), 2 (T-S-D-T), and 3 (T-S-T), respectively.

abscissa in the order of their average scores. Scores of the solutions located in the right hand side of the solid line are significantly higher compared to the lowest solution's score, and scores of the solutions located in the left hand side of the dotted line are significantly lower compared to the highest solution's score ( $p < .05$ ). As is seen in Fig.2, some solutions are evaluated definitely high by all the subjects, but there are others that are evaluated definitely poor. This fact implies existence of common evaluation criteria among subjects.

### MUSICAL AESTHETICS EVALUATION SYSTEM "MAESTRO"

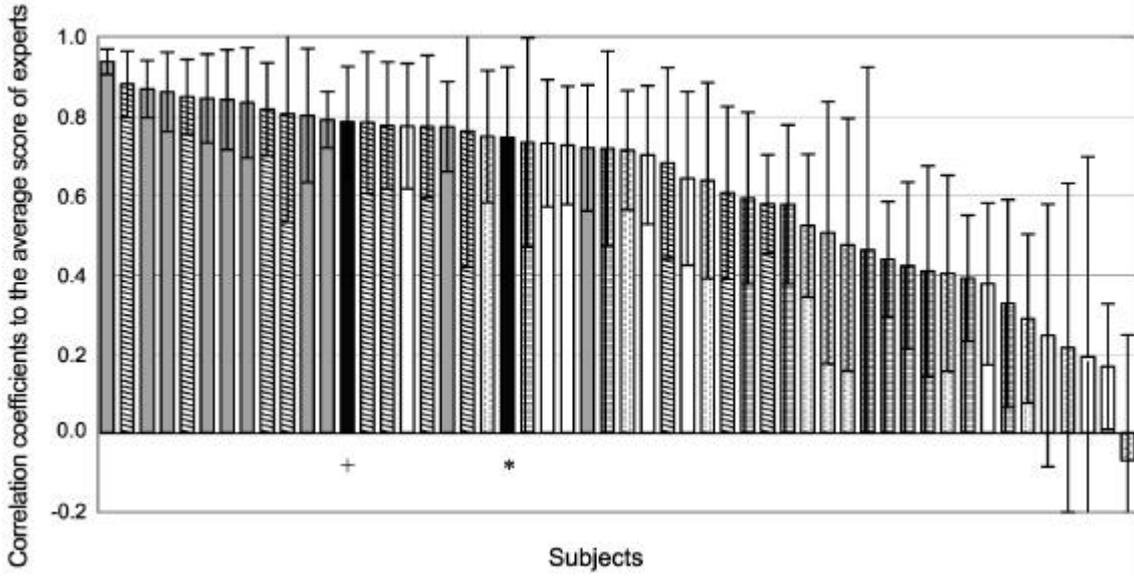
Twelve factors for aesthetic evaluation, listed in Table 1, are extracted from enquete to experts and are taken into account in the current evaluation system. The weights on those factors are determined by regression analysis based on subjective evaluation data and are used to estimate or predict the aesthetics score for a given solution. The system is named "MAESTRO (Musical Aesthetics Evaluation System for Tonal music in Regular and Orthodox style)".



**Fig. 2.** Average scores for allowable solutions of a given bass sequence. Ordinate: score. Abscissa: allowable solutions arranged in the order of average score.

**Table 1.** Twelve factors for aesthetic evaluation and the relative weights put on its occurrence frequency. All the factors are related to the soprano part.

ID	Factors for Aesthetic Evaluation
1	Same note repetition more than 3 times.
2	2 note sequence repetition more than 2 times.
3	The highest note appears only once.
4	The highest note appears more than or equal to 2 times.
5	Only 2 different notes appear in successive 4 notes.
6	Only 3 different notes appear in successive 6 notes.
7	Conjunct down motion after disjunct up motion.
8	Conjunct up motion after disjunct down motion.
9	Disjunct motion to the highest note.
10	Contrary motion with other voices.
11	Ending with the finalis lead by the lead note.
12	Ending with the finalis lead by a note other than the lead note.



**Fig. 3.** Correlation between aesthetic scores of the subjects and the average score of experts. Rods represent averages of correlation coefficients of the subjects to the average score of ten experts for six bass tasks, and horizontal ticks represent standard deviations. Abscissa: Correlation coefficient to the average score of experts. Ordinate represents subjects.  
 ■: expert group, ▨: student group majoring in composition, ▩: student group majoring in piano, □: student group majoring in instruments other than piano, ▤: student group majoring in music culture. +: outputs of MAES. \* represents output of MAES without input comparative weights of evaluation factors.

Aesthetics score represented as  $s_n$  for a solution  $n$  is modeled by the product of vector  $\mathbf{h}_n$ , representing occurrence frequency of each aesthetics factor, and weight vector  $\mathbf{w}$ . So,  $s_n$  is expressed as

$$s_n = \mathbf{h}_n \mathbf{w}, \mathbf{h}_n = [h_1, \dots, h_N], \mathbf{w} = [w_1, \dots, w_N]^T, \quad (1)$$

where  $N$  represents the number of factors (12, in this case). Scores given by experts for a number of solutions, allowing those given by different experts for a solution, are expressed as follows in a matrix form.

$$\mathbf{s} = \mathbf{H} \mathbf{w} \quad \text{where } \mathbf{s} = [s_1, \dots, s_m]^T, \mathbf{H} = [\mathbf{h}_1, \mathbf{h}_2, \dots, \mathbf{h}_m]^T. \quad (2)$$

The least-squares solution  $\hat{\mathbf{w}}$  for  $\mathbf{w}$  can be obtained as

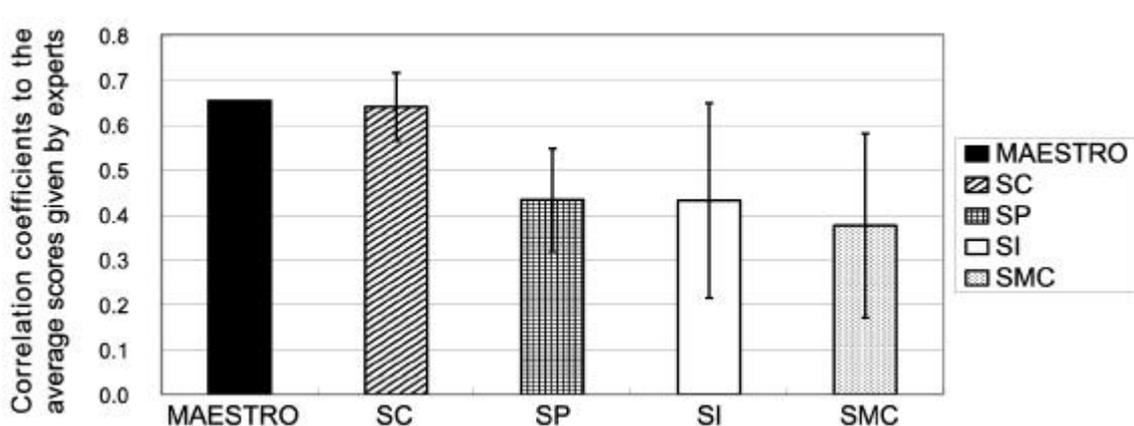
$$\hat{\mathbf{w}} = (\mathbf{H}^T \mathbf{H})^{-1} \mathbf{H}^T \mathbf{s}. \quad (3)$$

Using  $\hat{\mathbf{w}}$ , MAESTRO predicts aesthetics score  $s$  for a given solutions whose characteristic features are represented by a vector  $\mathbf{h}$  consisting of frequencies of the 12 aesthetic factors as

$$s = \mathbf{h} \hat{\mathbf{w}}. \quad (4)$$

### MAESTRO vs. HUMAN -Aesthetics Evaluation Competition-

An interesting test investigating who evaluates musical aesthetics more closely to experts is conducted using correlation to scores given by experts. Figure 3 shows the correlation coefficients between average scores given by experts and those of the subjects including MAESTRO, and Fig. 4 shows the correlation coefficients between scores given by experts and those given by each subject group including MAESTRO. The tests were conducted replacing training solutions and test solutions to make the test open. You can easily see that MAESTRO evaluates musical aesthetics as the same level as excellent students majoring in music composition. Although MAESTRO's approach to predict aesthetics scores is simple and straight forward, it can be said that MAESTRO gives reasonable values even for open tests.



**Fig. 4.** Correlation coefficients between average scores given by ten experts and those given by each subject group including MAESTRO.

Ordinate: correlation coefficient to experts. SC: Student group majoring in music composition, SP: student group majoring in piano, SI: student group majoring in instruments except piano, SMC: student group majoring in music culture.

### CONCLUSION

The high correlation among subjective scores given by experts signifies the existence of common aesthetics evaluation criteria among experts. It is shown that the proposed musical aesthetics evaluation system MAESTRO can estimate musical aesthetics as the same level as excellent students. Possibilities of effects of other factors will be investigated in the near future.

### REFERENCES

- [1] Miura, M., Shimoishizaka, T., Saiki, Y., & Yanagida, M., A Conceptual Design of a CAI System for Basse Donnée in Harmony Theory, *Proc. of ICMPC6*, Keele, UK, (2000).
- [2] <http://miguel.doshisha.ac.jp/~miura/BDS-e.html>