Technological Improvements in the SIEDP

Alexandre Bezerra Viana, Agamenon Clemente de Morais Júnior

Escola de Música – Universidade Federal do Rio Grande do Norte (UFRN)
CEP 59075-970 – Natal – RN – Brazil

{viana,agamenon}@musica.ufrn.br

Abstract. *This paper presents the innovations developed for the Intelligent System for Piano Fingering Learning Aid – SIEDP, a software application utilized as fingering technique learning aid by beginner students of the Piano Courses. The original SIEDP have some limitations in both the user interface and in the genetic algorithm utilized to find the optimal fingering of a given piano melody. This paper shows some modifications that we have done to overcome these limitations. The new user interface allows to use commercial score editors to input melodies to the system. In order to accelerate the computation of the optimum fingering, the genetic algorithm used in the optimization process was improved.*

1- Introduction

During the learning stage of a musical score written for piano, the beginner student often loss his motivation due to the ignorance of the correct sequence of fingers to be played in the different keys of the instrument needed to execute the melody. In this stage, the presence of the teacher is fundamental for the learning progress of the student. The teacher gives him correct examples of piano fingering. This examples are followed by the student, and the teacher is responsible by his orientation, in order to the student execute the melodies without acquiring any mechanical vicious in his fingering. Mechanical vicious is prejudicial to the fingering proceeding and to the learning of the musical piece. Thus, a priori knowledge of the correct fingering sequence of a given melody is needed for the student execute, as best as possible, the musical score. Thus, piano learning demands a lot of teacher time, and learning aids capable of reduce this time are welcome.

The SIEDP – System to Piano Fingering Learning Aid, is a program created by professionals of the area of Music, Electric Engineering and Systems and Computation [1] [2] utilized to aid the beginner students in the search of the correct piano fingering (that demands the minimum possible effort by the executants). The optimum piano fingering allows the execution of a musical score in the most possible comfortable form (with the minor muscular effort) and, when the score demands execution speed, the piano player can do it in the best possible way [1]. The SIEDP is based on two main components: a) an application software which computes the optimum fingering of a melody by means of a genetic algorithm and an expert system; b) a robotic hand that executes the melody according to the computed fingering. In particular, the genetic algorithm was based on a set of fifty different fingerings for an input melody (a fingering population), whose evolution is guided through a fitness function, which is iteractively minimized through the algorithm.

In its original version [2], the SIEDP had some restrictions: not friendly user interface, genetic algorithm fitness function for fingerings limited only to the white keys, rules of the expert system limited to one octave. Moreover, the presence of repeated results (clones) in the fingering population also contributed to a lower convergence of the genetic algorithm. This paper presents a new SIEDP version, in which some of the limitations of the previous version described above were overcome.

2- Interface

The original SIEDP had a poor user interface, making the control of data input and the understanding of the processed results difficult.

2.1- Data Input

In the original version, the user needed to type or to load a file with the melody codified in numerical values attributed to the piano keys and note durations. Thus, the user of SIEDP would have previous knowledge of this code in order to convert the score into this numerical sequence (figure 1).

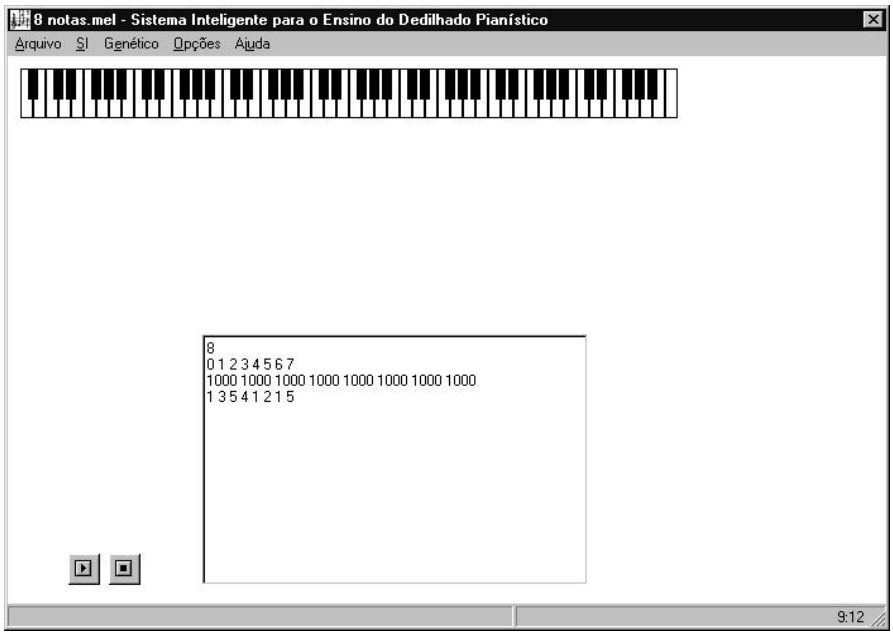

Figure 1. Main data input interface of the original version of the SIEDP

In the current version, the melody is loaded from standard MIDI file, which can be edited by means of popular commercial score editors, such as *Encore*® or *Finale*®, simplifying the data input task (figure 2).

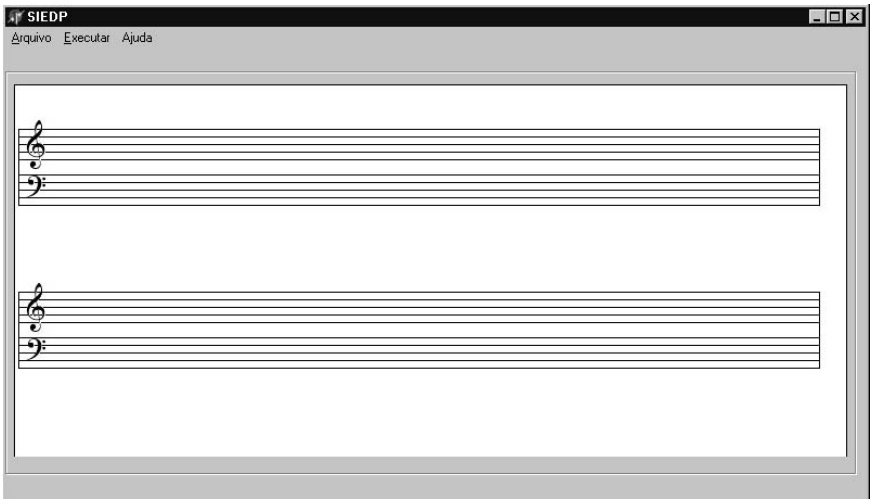

Figure 2. Main user data input interface of the current version of SIEDP

2.2- Output result interface

According to its specifications, the output results of the SIEDP processing are shown as a list of the ten best fingerings updated by the genetic algorithm. These fingerings are represented as numerical sequences, with integer numbers attributed to fingers. The student would need to choose one of the ten possible best fingerings. This is not an adequate mean to show the results, as long as the student do not have enough knowledge to decide which is the best of the ten presented fingerings (figure 3).

CENT=6 ITER=84 CM=29.70 TECLAS: 0 2 4 3 -1 1 -3 4

CROM	COMP	DEDILHADO
1	29	1->4->5->3->1->2->1->5
2	29	1->4->5->3->1->2->1->5
3	29	1->3->5->4->1->2->1->5
4	30	1->5->5->4->1->2->1->3
5	30	1->5->5->4->1->2->1->3
6	30	1->5->5->4->1->2->1->3
7	30	1->5->5->4->1->2->1->3
8	30	1->3->5->5->1->2->1->4
9	30	1->3->5->5->1->2->1->4
10	30	1->3->5->5->1->2->1->4

Figure 3. SIEDP output in the original version.

In the current version, the SIEDP analyzes the list of best fingerings, chooses that with the least *fingering length*, which it is shown to the non expert user (figure 4).

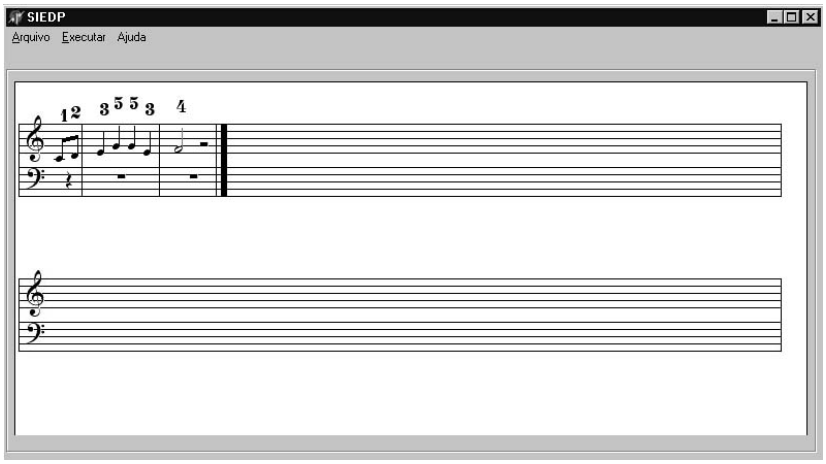

Figure 4. SIEDP output in the current version.

3- Fitness function

The fitness function is a measure of the "length" of a fingering obtained for a given melody. The Genetic Algorithm [3] utilizes this number to compare and sort fingerings, in order to select the best ones. In the SIEDP, the genetic algorithm operates on a fifty different fingerings (a population). At each time, the population is modified through genetic operators (cross-over, mutation and selection) to create a new and, probably, improved population (a new generation). As computation proceeds, the population iteractively evolutes, generation to generation, until its converges to a minimum fingering length population (the optimum fingerings). In the original version, the fitness function was limited to melodies based only on the white keys of the piano.

This fitness function was codified as part of the source code of the program and it was restricted to its original application. In the current version, the fitness function is stored in a file named fitness.sdp, which is constructed from environment configurations. These configurations are stored by the SIEDP user in an easily adjustable ambient file, named ambiente.sdp. In this way, the fitness function can be easily modified and applied to new different applications.

Figure 5 shows the values obtained from the new fitness formula, where Delta n is the analyzed interval (positive it will be ascending and negative it will be descending) and Delta D, the difference between the weights of the fingers following the formula: Delta D = d2 - d1, where d2 is the weight of the finger used to touch the second note and d1 is the weight of the finger used to touch the first note.

Delta D \ Delta N	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
-4	28	22	16	10	4	8	12	16	20	26	32	38	44	50	56	62	68
-3	33	27	21	15	9	3	7	11	15	21	27	33	39	45	51	57	63
-2	38	32	26	20	14	8	2	6	10	16	22	28	34	40	46	52	58
-1	43	37	31	25	19	13	7	1	5	11	17	23	29	35	41	47	53
0	48	42	36	30	24	18	12	6	0	6	12	18	24	30	36	42	48
1	53	47	41	35	29	23	17	11	5	1	7	13	19	25	31	37	43
2	58	52	46	40	34	28	22	16	10	6	2	8	14	20	26	32	38
3	63	57	51	45	39	33	27	21	15	11	7	3	9	15	21	27	33
4	68	62	56	50	44	38	32	26	20	16	12	8	4	10	16	22	28

LEGENDA
1º VALOR ÓTIMO
2º VALOR ÓTIMO
3º VALOR ÓTIMO
4º VALOR ÓTIMO

Figure 5. Values from the current fitness formula.

4- Limitation of Expert System [4]

In the original version, the SIEDP Expert System used rules were restricted to one octave. In the current version, the Expert System is composed of a set of rules that can be applied on scores with any size.

5- Clones

In the original SIEDP version, the convergence of the genetic algorithm was very slow due to the creation and permanence of clones (copies of the same fingering in the population). That clones remained in the list of the 50 best fingerings. The new version of the SIEDP has a routine that removes clones in each generation of the Genetic Algorithm. Therefore, better results are finding with same number of generations.

6- Conclusions

This paper presented the improvements done in the SIEDP, a tool used to find the optimal fingering of a piano melody. The initial system had some restrictions like the non friendly user interface, slow convergence of the Genetic Algorithm, little flexibility of the Expert System and fitness function limited to melodies based only on the white keys. From this research, a substantial improvement was done, solving the problems described above. Moreover, the concept of Neural Networks was added to the system, so that Expert System can be adapted to new situations.

We believe that the best form of testing a system is through its practical use. The main improvement in SIEDP, from the point-of-view of piano students, is the availability of a more friendly user interface, where they can now utilize the software without specific technical knowledge.

References

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