Creativity Mining:

Humane Technology for Creating a Creative Society

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***Abstract*—This paper proposes a novel concept called "Creativity Mining." Even though it is quite difficult for general people to create novel things, that does not mean that we are not creative. We all potentially have creativity. We simply cannot manifest our potential creativity at will or are unaware of its existence. In this sense, perhaps we are not uncreative but *not-yet-creative*. To increase creative human resources to establish the coming "Creative Society," we require new technologies for finding the buried creativity deep within not-yet-creative people and for supporting its manifestation. Although creativity support technologies have been widely studied, they have supported the creative activities of already creative people. They are not useful for supporting not-yet-creative people. In contrast, creativity mining technology supports not-yet-creative people to find and confirm their potential creativity. We illustrate two example systems developed at the author's laboratory and discuss how they work as creativity mining systems and their requisites.**

Keywords-component: creativity mining, potential creativity, finding creativity, exerting creativity, creative society

I. INTRODUCTION

Being creative is not easy for general people. Creating novel products and impressive music is quite difficult. However, this does not mean that such general people are not creative; everybody has the potential to be creative. I believe that we are all endowed with creativity. The problem is that we cannot manifest our potential creativity at will, and often we are not even aware of its existence. We often mistakenly believe that only the "gifted people" possess creativity. This situation is very regrettable.

At the end of the 20th century, the "Age of Capitalism" became the "Knowledge Society" [1], and now the Knowledge Society is becoming the "Creative Society" [2], where creativity is the most essential resource to produce wealth. To survive in the Creative Society and strengthen the competitiveness of enterprises and nations, creative human resources must be increased. However, presently few so-called gifted people are actually playing active roles in creative tasks. We require effective ways for immediately breaking our dependence on a few, selected gifted people.

At this time, the usual way to increase creative human resources is creativity education for making not-yet-creative people creative. This step is especially necessary and effective for fostering children's creativity. However, it is not always efficient. There are two problems: 1) creative education actually contains much education on uncreative tasks that might conceal the real creative talents of the educatees and 2) it usually takes a very long time to determine whether the educatees have the creative talents for the target domain. As a result, unfortunately, after long and enormous effort, it often becomes evident that many educatees do not have enough creativity in the target domain and that they are not the right people for it.

"Creativity mining," which is a novel technology for solving these problems, allows us to quickly find and confirm buried potential creativity before starting creativity education or training. It uncovers hidden but real creativity due to the uncreative aspects within creative tasks. Creativity mining technology will efficiently increase the creative human resources that are required by the Creative Society.

The rest of this paper is organized as follows. Section II overviews related works on creativity support and discusses how they differ from creativity mining technologies. Section III introduces two examples of creativity mining tools in music that were developed in our laboratory. Section IV discusses the necessity and future of creativity mining based on these examples. Section V concludes this paper.

II. CREATIVITY SUPPORT

Creativity support technologies have been studied and developed for many years in predominantly three approaches. The first approach implements such existing methodologies for idea creation onto computers as brainstorming [3] and the KJ method [4]. Although such methodologies and systems (e.g., [5], [6]) can be used by not-yet-creative people, they are not universally useful. Some methodologies and/or systems are useful for some, but not for others.

The second approach supports the externalization of thoughts to enhance reflections. People usually cannot generate complete creative-images just within their brains; such "cognitive artifacts" [7] as paper and pencil are necessary. We externalize tentative images as sketches and fragments of sentences using cognitive artifacts and refine them by objectively viewing and revising the externalized images so that progress is gradually made toward invisible goals. Such a process is called "reflection-on/in-action" [8]. Tools have been

developed that help externalize inner images and reconstruct externalized images (e.g., [9], [10]). Such tools are useful for people who already have skills for externalizing their inner images. However, not-yet-creative people who lack skills for externalizing their inner images cannot use these tools.

The third approach is learning from professional creativity experts by investigating their creative activities (e.g., [11], [12]). Based on implications obtained from analyzes, useful support tools for professionals have been developed (e.g., [13]). However, this presupposes that the tool users have professional knowledge and skills. Hence, they are not always useful for non-professionals.

Although creativity support technologies are seemingly analogous to creativity mining technologies, they are essentially different. The former supports already creative people, but the latter supports not-yet-creative (potentially creative) people.

III. Two Examples of Creativity Mining Technologies

This section demonstrates two systems developed in our laboratory that work as creativity mining systems in musical performance.

A. Coloring-in Piano

1) What Conceals Potential Musical Creativity

The first example is a musical instrument called "Coloring-in Piano" for re-creating types of music. For example, most typical classical music pieces like Chopin's piano works belong to this type of music. When a performer performs such a musical piece, she must perfectly reproduce the sequence of notes described by its score. Changing just one note is not permitted even if she thinks that is an improvement. Since the performer does not have freedom to choose notes, her creativity cannot be reflected in the reproduction of the sequence of notes.

Where the performer's creativity can be reflected is in the "expressions" that are added to the accurately reproduced sequence of notes. Expressions are mainly composed with *Dynamik*, which means the change in the loudness of the notes, and *Agogik*, which denotes slight changes of tempo and rhythm. By adding *Dynamik* and *Agogik* to the reproduced sequence of notes based on the performer's interpretation of the musical piece and her musical inspiration, she can creatively express her musical impressions.

Thus, we conclude that the creation of expressions is the principal task for performers who re-create such music. Although perfect reproduction of a given sequence of notes is indispensable for performing such music, it is not at all creative for performers. However, we must first complete this uncreative task before tackling the principal task, perhaps creating expressions. Furthermore, it is actually very difficult to perfectly reproduce a given sequence of notes as described in the score using a conventional musical instrument like a piano. It takes a very long time and requires enormous effort. Eventually, many abandon the musical piece before arriving at the principal and creative stage.

However, just because someone gave up performing a musical piece of the re-creation type does not mean that he does not have musical creativity for creating musical expressions. He just could not acquire uncreative motor skills for reproducing the given sequence of notes. Even if he cannot perform a musical piece, it remains unclear whether he has musical creativity. The creativity for making excellent musical expressions may be buried deep within him.

Thus, what conceal potential musical creativity are conventional musical instruments. If we overlook the uncreative reproduction process and directly confront the creation of musical expressions, it is possible to efficiently determine whether we might have creativity for musical expressions. At this point, it is not too late to start diligent practice of a musical instrument.

2) System Setup

It used to be impractical to adaptively reorganize the structure of a musical instrument while performing a musical piece with it. Traditional musical instruments were designed universally independent from any particular musical pieces. For example, a certain pitch is always allocated to a specific key of conventional instruments even if that certain pitch is never used in a musical piece when it is performed. However, at present, a musical instrument's structure can be dynamically reorganized by computer [14]. We are free from the uncreative burden of reproducing a given sequence of notes.

Figure 1 illustrates the system setup of the Coloring-in Piano. Before starting a performance, the player inputs the score data of the musical piece that he wants to play. The score data consist only of the sequence of pitch data as Musical Instrument Digital Interface (MIDI) note numbers. It is not necessary to input such other data as the time value of each note and the dynamic marks. Then the player strikes the keyboard. However, he doesn't need to worry about which key should be hit. Whichever key is hit, the system replaces the pitch of the played note (MIDI note number) with the correct one by referring to the prepared score data. Mistakes are never made in the reproduction of the sequence of notes. Only correct notes are sequentially output. However, the timings of the key hit and the key release and the strength of the key hit are

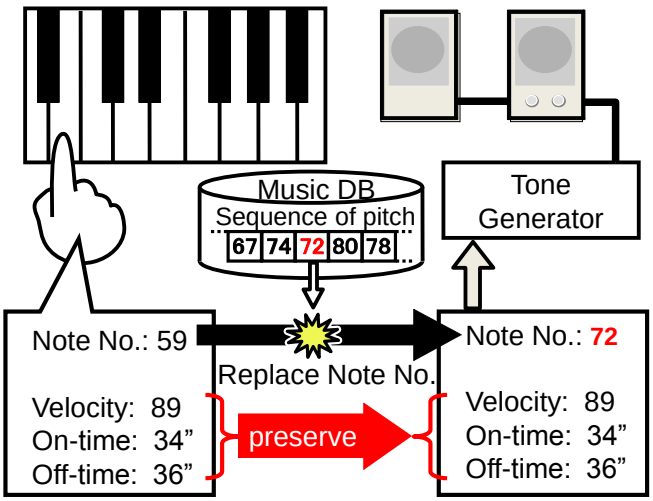

Fig. 1 System set up of Coloring-in Piano

preserved and output as they are performed. In other words, the player controls all the expressive elements by himself. Thus, he can directly tackle the creation of his own expressions and omit the reproduction of the correct pitch sequence.

3) Brief Summary of Results of User Studies and Discussions

We conducted user studies using the following three systems[1]:

1. Coloring-in Piano, described above
2. A standard piano
3. Step-by-step input method of score data that is usually used in a desktop music system. In this method, all of the performance data such as pitch, loudness, and length of each note are discretely input as numerical data.

We employed ten undergraduate music education majors as subjects. All have been playing the piano for over ten years. The test piece was the solo violin part (bars 95-102) of the 1st movement of "Violinkonzert D-dur op.77" by Brahms. This piece is very difficult, and pianists are not familiar with the note sequence. The subjects performed the test piece as expressively as they wanted using all three above methods. After they finished playing, we asked them two questions: 1) how difficult was the piece to perform? and 2) how satisfied were you with your performance with each method?

Our results showed that it was quite difficult even for experienced piano players to correctly perform the test piece using a standard piano; aside from satisfaction about their expressions, they weren't satisfied by their reproduction of the note sequence. With the step-by-step input method, they could easily reproduce correct note sequences, because the pitch sequence is intrinsically discrete. However, they weren't satisfied by their expressions. In contrast, with Coloring-in Piano, they could immediately perform not only the correct sequence of notes but also satisfactory expressions using it.

We also employed ten subjects with little piano playing experience. They played "Travelling," a famous Japanese pop tune by Hikaru Utada, using the above three systems. They could not play it at all using a standard piano, but they could immediately do so using Coloring-in Piano.

These results show that Coloring-in Piano allows everybody to skip the uncreative reproduction process of a given note sequence and to quickly tackle the principal and creative stage for creating expressions. With Coloring-in Piano, we can efficiently ascertain whether we potentially have creativity for making musical expressions before starting lifelong piano practice.

B. *Family Ensemble*

1) Serendipitous Association with Potential Creativity

Once one of my friends said, "Recently my daughter began piano lessons. Listening to her practice at home, I felt like playing with her." Many parents have similar dreams. However, they cannot play the piano, and they do not have time to practice it. Such dreams often don't come true. Such people are not actually motivated by any creative instincts in music. They do not intend to learn piano, they do not want to create their own music, and they do not have any concern about musical creativity. They only want to enjoy time with their children and to form memories.

We developed a piano duet support system named "Family Ensemble" to bring benefits to such fathers and mothers. Family Ensemble works not only as an entertainment system but also as a system that opens the eyes of to their potential musical creativity.

2) System Setup

Figure 2 illustrates the system setup of Family Ensemble. This system has two interfaces for a child and a parent, but they are actually two parts of one piano keyboard. The lower 12 keys are usually assigned to the parent, and all the other keys are assigned to the child, who is studying piano and has learned enough to actually play a standard one. If, for example, we provide Coloring-in Piano or a similar support system to the child, she will not be able to master the piano. Family Ensemble does not systematically support the child. The child's performance data are directly input into the MIDI sound module without any modifications, and sound is output as the instrument is performed. For the child, Family Ensemble is the same as a standard piano.

In contrast, the parent doesn't have to be able to play the piano. Since he only wants to have fun with his child, Family Ensemble completely supports him. Family Ensemble observes the child's performance data and the score tracking module compares it with the score data of the child's part to find where it is performed at all moments. Then the score tracking module refers to the parent's part of the score and decides what note should be played by the parent now. The parent can play any key on his/her keyboard. Similar to Coloring-in Piano, even if a wrong key is hit, Family Ensemble replaces it with the correct note obtained beforehand. Finally, the modified performance data of the parent are input to the sound module and sound is output.

As long as the child does not make any mistakes, the

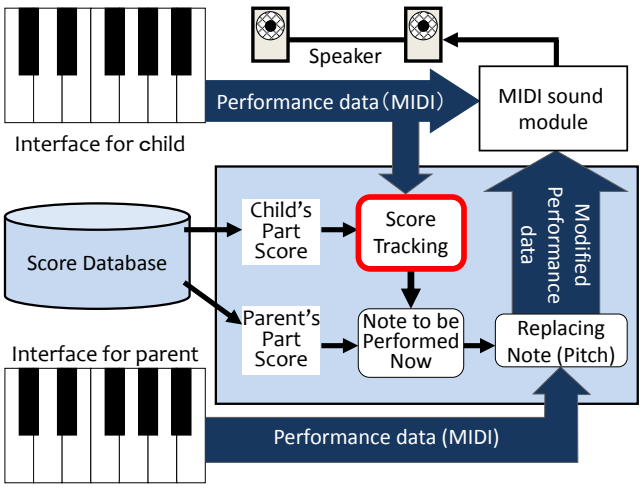

Fig. 2 System setup of family ensemble

[1]For more details about the results of the experiments, please see [15].

parent can always output the correct notes. If the parent plays the wrong notes, that reflects the child's mistakes. Thus, the parent doesn't need to wonder about which note should be performed at any time. However, the parent can control all of the expressive elements by himself or herself as in Coloring-in Piano. Therefore, the parent can create music expressions.

3) Brief Results of User Studies and Discussions

We conducted user studies to compare Family Ensemble with a standard piano[2]. We employed five pairs, each of which consists of one who can play the piano a little bit (child or novice) and another one who cannot play the piano at all or hasn't for many years (parent or inexperienced one).

Using a standard piano, not all pairs could play the piano duet. The inexperienced subjects could only search for keys that should be hit on the keyboard. Since the novices were busy telling the inexperienced ones which key should be hit, they could not practice the child's part at all. In contrast, using Family Ensemble, all pairs could immediately play the duet. Although our result is not amazing, we accomplished our initial purpose: making it possible for inexperienced parents to enjoy playing the piano with their children.

The most interesting result was that co-creation of musical expression arose. In particular, one of the pairs consisted of a father who had never played the piano and his elementary school daughter who had just started piano lessons. They co-created musical expressions. Furthermore, this co-creation was initiated by the inexperienced father, not by the daughter. The father noticed that the timing of a dotted note was inharmonious. He pointed it out to the daughter, and then they practiced the problem part together and achieved better musical expression.

This is a very important case. The father had never played the piano before. Therefore, he was not aware that he had any musical creativity. However, by providing Family Ensemble, he began to create musical expressions. Family Ensemble helped uncover his latent musical creativity.

IV. DISCUSSIONS

People can be classified into the following four types from a viewpoint of the awareness of creativity and its usage[3]:

1. People who know they have creativities and can use them
2. People who know they have creativities but cannot use them due to obstacles
3. People who are not sure whether they have creativities (but hope so) and
4. People who are completely unaware that they potentially have creativities

As discussed in Section 2, most conventional creativity support technologies only support the first type of people. In contrast, creativity mining technologies support the other three types. The two systems described in the previous section demonstrated the practical possibilities for supporting the three types of people.

Coloring-in Piano can support the second and third types of people. An example of the second type might be a pianist who lost several fingers in a traffic accident. Although he retains musical creativity, he cannot play the piano any more. In such a case, Coloring-in Piano can bring out his musical creativity again. An example of the third type person might be a beginner who starts piano lessons believing that she has musical creativity. However, whether this belief is true is only determined after many years of long training. If she finds that she does not have much musical creativity after all that training, she has wasted her time and her life. Coloring-in Piano allows such beginners to quickly confirm whether they have musical creativity without motor skill training for the piano.

The most innovative point of Family Ensemble is that it can also support the fourth type of people who have no intention of performing the piano by themselves. It is difficult to let them play musical instruments by themselves. Other motivations are required that are different from musical performances. Family Ensemble is not a musical instrument to create music for the parent; it is an entertainment tool to be shared with a child. However, once parents and children start to perform piano duets using Family Ensemble, it gradually changes from a mere toy to a musical instrument. They start to create musical expressions together and eventually the parent realizes that she actually has musical creativity without previously being aware of that fact.

Thus, creativity mining technology allows everybody, including the not-yet-creative people, to quickly ascertain whether they have a particular type of creativity. If they learn that they potentially have it, they will become able to concentrate on studying, practicing, and training skills for confidently manifesting it rather than having no confidence. This can foster people's creativity more efficiently through creativity education and increase creative human resources for the Creative Society.

Finally, note that creativity mining tools do not execute essentially creative tasks that substitute for humans. Creativity mining is *not* the automatization of creativity. For example, a CD player is an extreme example of the automatization of music creation because it allows everybody to effortlessly output previously recorded music without reflecting any user creativity at all. Such essentially creative tasks must be preserved for the user; what should be changed are approaches to essentially creative tasks. When designing creativity mining tools, we must concentrate on this point.

V. CONCLUSIONS

This paper proposed a new concept called "Creativity Mining" that supports not-yet-creative people to find their potential and latent creativity and to manifest it. We illustrated two example systems developed at our laboratory to exemplify how creativity mining can be achieved. I believe that creativity mining technologies will contribute to the establishment of the coming Creative Society that will require many more creative human resources.

In this paper, I only demonstrated music-related examples. However, of course, our results are not limited to the musical domain. The Center for Innovative Lifestyle Design, the Japan

[2]For more details about the results of the experiments, please see [16].

[3] I believe all people have creativity.

Advanced Institute of Science and Technology is vigorously promoting research and development of creativity mining tools for such domains as image creation and industrial design. Through these efforts, our center aims to create a new society where all people can feel that their lives have value by enabling creative contributions to other people, enterprises, and the world. In future, we seek to promote our research and development of creativity mining technology and to widen its applicable domains.

Finally, I stress again that creativity mining technology does not seek to simplify creative activities. It may make the uncreative stages within creative activities easier or may allow people to skip them. However, it does not (and should not) change the essentially creative stages at all. It should not make them easy, and it should not allow people to skip them. Such a perversion of the essentially creative stages will spoil people's creativity, which will eventually impede establishment of the Creative Society. Creativity mining technology digs out hidden gems. It should not facilitate, which is a human job.

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