User-System Cooperative Evolution for Japanese Anagram Sentence Generation

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I.2 [**Artificial Intelligence**]: Problem Solving, Control Methods, and Search; F.1.2 [**Computation by Abstract Devices**]: Modes of Computation—*Interactive and reactive computation*

Keywords

Interactive evolutionary computation, user-system cooperation, user fatigue, qualitative and quantitative optimization

1. INTRODUCTION

Interactive Evolutionary Computation (IEC)[3] faces the trade-off problem between search performance and cost: EC algorithms can solve large-scale, complicated problems with a large population size and many generations, but an IEC search with even a very small population size and few generations can easily cause user fatigue during solution evaluation. This problem becomes more serious in real-world problems as they generally require the optimization of both qualitative and quantitative objective functions. Simultaneous optimization of the two objective functions exponentially increases computational cost and user fatigue.

Some models[1, 2] employ machine learning subsystems for the online assimilation of users' subjective fitness functions. However, these models require training data obtained from users, and it is difficult to trace the dynamic changes in user preference during a search.

On the other hand, little attention has been focused on the roles of a user and system in an IEC search. In general, the roles are pre-defined. Individual reproduction and quantitative evaluation are performed by the system, and qualitative evaluation is performed by the user. Further, the user is required to perform operations at a fixed frequency. However, the roles in the search and the timing and frequency of user operation vary in accordance with the user's domain knowledge, search progress, etc. For instance, a well-trained user may create a rough solution structure during the initial search, and then, the system can locally search for the optimal solution according to the user's solution. On the other hand, a user with insufficient knowledge about the target problem may require the system to search for a soluton non-interactively until it returns some useful idea. In the case of a local search for the optimal solution, user intervention is not necessary at every generation; a system-based search, user observation, and occasional user operation are sufficient. Therefore, these factors should be considered carefully to ensure that they do not interfere with user's creative thinking.

To resolve the above metioned problems in IEC, we propose a method called Cooperative Evolution by User and System (CEUS). CEUS allows a user to change roles dynamically, and it learns user preference even from a few user operations, thereby dynamically incorporating user heuristics and preference into EC searches and alleviating user fatigue even for problems involving both qualitative and quantitative objective functions.

We demonstrated the effectiveness of the proposed CEUS method by applying it to Japanese anagram generation, which is a word game involving quantitative objective functions for approximately evaluating the naturalness and a quantitative objective function for evaluating the uniqueness of the anagram.

2. THE PROPOSED METHOD

The proposed CEUS in this paper is based on the following two basic ideas. First, CEUS uses explicit fitness functions and predicting user evaluation. CEUS solves a problem involving both qualitative and quantitative objective functions simultaneously, by modeling the problem as any of a single- or multi-objective optimization problem. CEUS estimates user preference from past user operation by using Case-Based Reasoning (CBR). The proposed CEUS starts the prediction even with a few cases by directly reusing them unlike previous work using SVM, NN, etc., wherein a user is required a certain amount of individuals in the early stage of the search or in previous runs. CBR is also good at incremental learning, and this enables CEUS to follow changes of user preference.

Second, CEUS allows a user to adjust user operation timing and search role assignment at any time during the search. In this paper, the search roles are defined so that they correspond to the search processes in EC – qualitative evaluation, quantitative evaluation, and reproduction. Evaluation of qualitative objectives and individual reproduction can be assigned to any of the user and the system. This is because CEUS estimates a qualitative objective function value along

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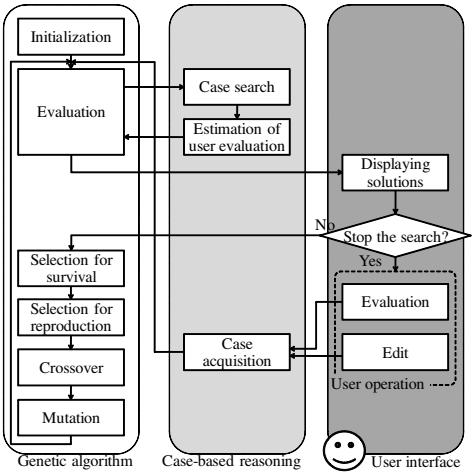


Figure 1: Algorithm of the proposed method.

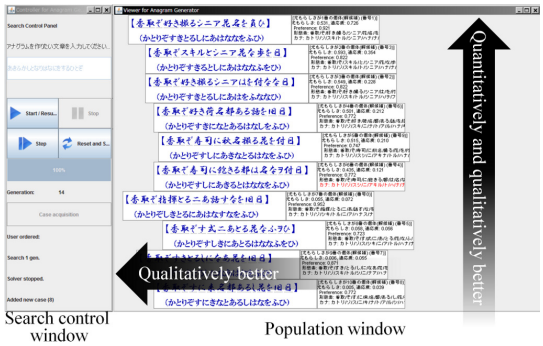
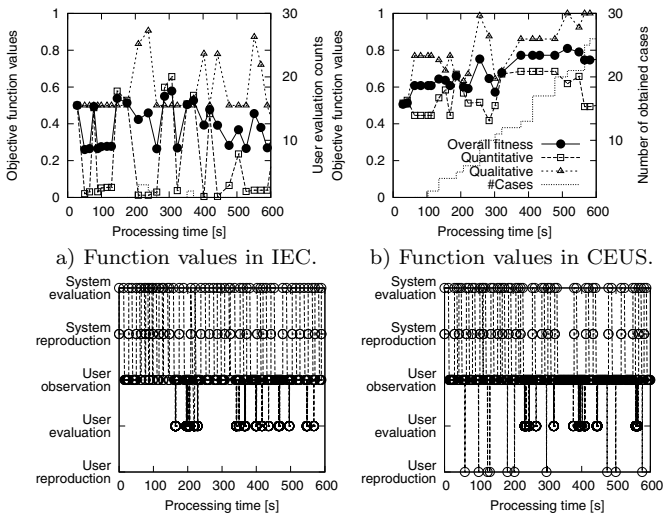


Figure 2: User interface of the proposed system.



a) Function values in IEC. b) Function values in CEUS.

c) Search role in IEC. d) Search role in CEUS.

Figure 3: Search role transitions.

with user evaluation, enabling the non-interactive search with qualitative objectives.

Fig. 1 shows the structure and the algorithm of the proposed method. The proposed CEUS conducts non-interactive search and suggests individuals unless a user stops the search.

The proposed method uses a case base to evaluate individuals in non-interactive search if cases are stored in the case base.

A user observes presented individuals, and stops the search whenever the user finds a favorite individual or whenever none of individuals suits the users taste. After the search stopped, the user gives an evaluation value to one, some or all individuals. The user can also directly edit an individual's chromosome. The edited individual is ranked as the most favorite one automatically. After evaluation or edit of individuals, the user resumes the search.

Individuals that are evaluated or edited by the user are stored as cases into the case base, and used later in the search. The user can also re-evaluate cases whenever a desired solution image is changed in the user's mind.

3. APPLICATION TO ANAGRAM GENERATION

Anagram is a word, a phrase, or a sentence generated by reordering the letters of a given, another word, phrase, or sentence. People have used anagrams as a word game, as pseudonym, or as cryptography. Designing an anagram sentence requires humans repeated trials and errors.

The proosed CEUS is applied to anagram design system whose example screen shot is shown in Figure 2. Figure 3 shows transitions of the search role allocation transitions as the changes of search status and user operations in general IEC and the proposed CEUS. Compared to IEC, in which the reproduction by the system and evaluation by the user and the system iterated at every generation, the user using CEUS frequently locked the part of chromosomes from the beginning of the search, and rated individuals from the middle of the search.

4. CONCLUSIONS

We proposed a cooperative evolution method named CEUS, wherein a user adjusts a search role allocation and determines operation timing according to user's domain knowledge, search progress, etc. For the purpose of predicting user evaluation from the earlier stage of the search, CEUS acquires a user operation log as a case and directly reuses it to predict user evaluation value based on CBR.

Acknowledgment

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