# The Human-based Evolutionary Computation System Enabling Us to Follow the Solution Evolution

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### ABSTRACT

Human-based evolutionary computation (HBEC) is evolutionary computation in which agents of implementing evolutionary operators are multiple humans and can solve problems in our human society, where only humans can judge the qualities of their solutions. In this study we add a new function that enables us to follow the solution evolution to our previously developed HBEC system, in which a tag cloud is used as a place for the solution evolution. Also, we show the usability and the traceability of the HBEC system through an experiment.

### **CCS CONCEPTS**

• Human-centered computing → Collaborative content creation; Social tagging systems; • Computing methodologies → Self-organization;

### **KEYWORDS**

human-based evolutionary computation, traceability, representation of solutions, Web system

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### **1** INTRODUCTION

Evolutionary computation (EC) is a framework of optimization algorithms inspired by biological evolution. There are two main steps in EC: "selection", which mimics natural selection, and "operations", which mimic crossover and mutation. The steps can also be seen as the actions of agents, and therefore, we can view EC as a multiagent system. If human agents perform both the selection and the operations, it becomes human-based EC (HBEC) [2].

We previously developed the HBEC system for solving problems where their solution candidates are represented by tags [1], for example, a problem to assign an appropriate tag to an image. The HBEC system uses a tag cloud as a place to display and evolve

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solution candidates. However, the system cannot handle problems in our human society. The problems in our human society and their solutions are both represented by sentences in a natural language. In addition, the system does not enable us to follow the solution evolution in details. To make the system really trusted for users, the system should be able to do so.

In this study we develop the HBEC system that is applicable to problems that need solutions described in sentences and also that enables us to follow the solution evolution. Besides, we show the usefulness of the system through a human subjective experiment and provide the visualization of the solution evolution.

## 2 THE HUMAN-BASED EVOLUTIONARY COMPUTATION SYSTEM

### 2.1 Representation of Solution Candidates

Solution candidates are represented in two ways. One is a tag which summarizes the contents of a solution candidate described in sentences. The other is sentences which are the details of a solution candidate. The sentences as details of a solution candidate can also be reasons for recommending the solution candidate represented by the tag.

# 2.2 Place to Display and Evaluate the Present Solution Candidates

The solution candidates in the form of tags are displayed in a tag cloud. Figure 1 shows the main window of the system, and the part of (0) in Figure 1 is a place to display a problem to be solved, and the part of (1) is the tag cloud.

When clicking a solution candidate in the form of a tag on the tag cloud for displaying the tags, the clicked tag is displayed at the part of (2) in Figure 1 and the sentences corresponding to the clicked tag are displayed at the part of (3). To increase the fitness value of the clicked solution candidate in the form of a tag, it is necessary to push the button of "voting" at the part of (5) in Figure 1. Larger fitness values are better. The font size of the tag depends on the fitness value of the tag. The better the fitness value is, the larger the font size is.

### 2.3 Place to Create Solution Candidates

When pushing the button of "generation of a solution candidate" at the part of (7) in Figure 1, the main window is changed to another window shown in Figure 2. The part of (8) in Figure 2 is a place to input a new solution candidate in the form of a tag and the part of (9) in Figure 2 is a place to input a new solution candidate in the form of sentences. By pushing the button of "confirmation of

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8	演した人へ難難を与える 課を必導料目にする (6)	∞ (5)	

Figure 1: The main window of the developed HBEC system. The numbers from (0) to (7) are for explanation and are not included in the actual window.



Figure 2: Another window to produce a solution candidate.

the generation", the generation of the new solution candidate is actually executed.

## 2.4 Place to Obtain Information Required for Following the Solution Evolution

The part of (10) in Figure 2 is a place to select the preset solution candidates that influence the new solution candidate that is about to be produced. The present solution candidates stand for the tags displayed in the tag cloud at the moment. The part of (10) is a check box that consists of the present solution candidates. Human agents of the HBEC system can select an arbitrary number of the present solution candidates in the check box.

### **3 HUMAN SUBJECTIVE EXPERIMENT**

### 3.1 Settings

The number of participants of the experiment is 18, who are all university students. The problem that the participants solve is "What is the most important thing to live a happy life?". For the problem, the participants use tags for representing solution candidates



Figure 3: The evolution process of the solution candidates displayed in the tag cloud at the end of the problem solving.

themselves and sentences for representing reasons for recommending the solution candidates. Before starting the problem solving, all participants independently think and record their personal best solutions.

### 3.2 Results

After the problem solving by the HBEC system, we asked each participant the question if the HBEC system created better solutions than his/her personal best solution. The number of participants who answered yes was 15. We can say by applying the sign test to the result that the solutions created by the HBEC system are statistically better than the personal best solutions at the significant level of 0.1%.

Figure 3 shows the evolution process of the solution candidates that were displayed in the tag cloud at the end of the problem solving. The 10 rectangles at the leftmost of the tree structure in Figure 3 stand for the final solution candidates and all other rectangles stand for the solution candidates that influenced the final ones. The numbers inside the rectangles represent the order of creation. The line between two rectangles represents that the rectangle at the right side influenced the one at the left side.

As shown in Figure 3, we can follow the solution evolution in details by the tree structure representing the evolution process of the solution candidates and the list of the contents of the solution candidates.

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