Elitist Strategy of Genetic Algorithms for Writing Tang Poetry

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Abstract: *Automatic Chinese Tang poetry composition arouses researchers' attention these years and faces a lot of challenges. Most existing poetry generation systems can only generate poems without human interaction; thus, these poems cannot always express the human mind accurately. To improve this disadvantage, this paper proposes a modified elitist genetic algorithm to generate poetry with arbitrary interaction from the user, which means that the user can specify the poem's emotion and input words or verses to be used in the poem. The modified algorithm comprises an improved elitist strategy to retain keywords or verses provided by the users, and a new concrete fitness function for more accurate and effective quality evaluation of poems. The Turing test and fitness function contrast experiments show that the proposed algorithm could generate poems using given keywords or verse and the poems generated by the algorithm receive higher ratings and recognition than the original poems written by a human. The experimental results demonstrate the effectiveness of the proposed algorithm and prove that this research can make practical and theoretical contributions.*

Keywords: *Elitist strategy, adaptive genetic algorithm, automatic generation, tang poetry, self-help writing.*

Received October 24, 2019; accepted December 15, 2020
https://doi.org/10.34028/18/4/13

1. Introduction

Tang poetry is a form of literature with a long history, which uses concise words and flowery language to convey author's feelings [21]. However, poetizing can be a challenge for those with little literacy and want to write poems. With the development of computer technology and artificial intelligence, computers can be used to generate various types of poems, such as Chinese poetry and couplets [13, 14, 33, 35], Japanese haiku [34], and European poetry [7, 10].

The initial common methods used to generate poems were mainly achieved by using templates designed based on statistical analysis and modelling of existing poems [37]. As a result, the quality was determined by the design of these templates [23]. The users could not accurately express their feelings, and they could not modify the poems. In general, these methods do not have user interactions [4].

Another common method is a poetry generation system based on Case-Based Reasoning (CRB) [5]. It emphasizes on solving new problems using the solutions accumulated for similar problems, with appropriate modifications. CRB has advantages of knowledge acquisition, calculation efficiency, solution quality, and accumulation of knowledge for poetizing, which can generate high-quality poems [18]. However, the automatic optimization and modification algorithm has become a bottleneck.

Genetic Algorithm (GA) [3, 8] is a random search and optimization algorithm that has been developed rapidly in the recent years. It searches from the middle of the solution for large coverage; this ensures that a local optimal solution is not chosen, as in traditional algorithms. GA leads to the concept of "natural selection" [17], because of which the poem has great relevance and high quality. GA search is combined with Darwin's "survival of the fittest" and randomly exchanges of information [36]. The former eliminates unsuitable factors from the solution, and the latter uses existing knowledge of the original solution to increase the speed of the search process. Details on GA and concrete realization are discussed in later sections.

The GA algorithm based on the elitist strategy is widely used in various fields. The elitist strategy was introduced into GA to improve convergence and optimization results. The method can be applied to the topology optimization of complex engineering structure, and it can provide multiple initial design schemes [20]. Elitist strategy is also used to improve the Quality of Service (QoS) [19].

The application of the elitist strategy in industrial field and computer technology has increased in recent years, indicating the strong function of the elitist strategy and its feasibility in other fields [31]. However, its application in computer poetics is limited; the successful application in other fields implies that elitist strategy can provide strong technical support and technical innovation to this field.

In the GA system, the users could only choose the emotion to generate poetry, and there was a lack of interaction, which led to the generation of poetry that could not express the users' intention and meet their

requirements [32]. It is very meaningful to realize the automatic generation of Tang poetry with more interactive algorithms for those who cannot write the poems well.

To achieve this, we modified the elitist strategy of GA. In this paper, we explain in detail the steps for obtaining the auxiliary function of the Tang poetry generation system with the modified elitist GA.

The modified elitist GA has the following specific functions:

1. The auxiliary function has an original basis that allows the users to input words or sentences to be used in the high-quality poem. The auxiliary function has an innovation on the original basis, allowing the users to input words or sentences they want to be used in their poem. Based on the input, the system could generate verses with high quality, achieving the system function of self-help writing.
2. The fitness function evaluates the quality. Through assigning appropriate fitness scores to the content that needs to be retained, the elite strategy can play the key role.

2. Research Background

Computer-assisted research on ancient poems started in the middle of 1990s [12]. Thus far, the research in this field has developed in the establishment of corpus, analysis of lexical semantic, and analysis of creative style.

Professor Chou first proposed the concept of "computer poetics," and then he established a research group. This group developed automatic systems to generate SONGCI [13].

Although research in the field of automatic generation of Chinese ancient poetry has progressed in recent years, studies on auxiliary writing are limited.

2.1. Emotion Analysis

Poetry is the art of emotion, and emotion is the soul of poetry. Typical emotions include lofty sentiments and aspirations, loneliness, sadness, love, nostalgia, homesickness, and bidding farewell [11].

2.2. Semantic Relatedness

Latent Semantic Analysis (LSA) is commonly used to calculate semantic relatedness [28], in which semantic relatedness was used to calculate words with high correlation degree based on the given keywords. Semantic relatedness is also considered a part of the fitness function for calculating the semantic relatedness between words and verses in GA [6].

2.3. Poetry Participle

Tang poetry is composed by using words or phrases in strict accordance with poetical metrics, which can be better understood through the Chinese participle technology. A database [1] was created based on existing Tang poems, including thousands of words and phrases. Through the statistics of the database, its meaning, frequency, and emotion can be labelled; these are used to calculate the fitness score.

2.4. Elitist GA

The GA based on the elitist strategy includes the following main steps [21]:

1. Generation of initial population: population is randomly generated according to relevant emotions or keywords.
2. Fitness function: the fitness function we set is mainly based on the patterns of level and oblique tones, the antithesis of Tang poetry, as well as word frequency and pattern matching. The adaptive function determines the merits of the individuals, and uses the value to eliminate.
3. Selection operation: This operation is also called the copy operation; it selects the high fitness individuals to reproduce the next generation. The lower fitness individuals breed less or can even be eliminated.
4. Crossover operation: The crossover operation selects two individuals, exchanging some of their gene position, thereby generating a new generation of individuals.
5. Mutation operation: The mutation operation is based on the principles of genetic variation in biogenetics to change the value of a gene or genes in an individual coding string according to a certain probability, thereby generating a new generation of individuals.

2.5. Elitist Strategy

Four main points [27] are set to calculate the fitness score. We are accustomed to separating one verse into several genes, and the genes can always be one word or two words. The points are

1. Frequency. We use the genes' frequency of occurrence in the existing poems. If the genes have high frequency, the fitness score is high as well.
2. Emotion. If the gene conforms to the emotion selected, it obtains a high fitness score.
3. Repetition. If a gene repeats in the poem, it gets a low fitness score.
4. Landscape scenery. If the genes are used to describe natural landscape, they receive a high fitness score; this is set as a bonus point.

We adopt elitist strategy, roulette algorithm, and sons competitive in selection operation. This competition mechanism retains individual with higher quality and helps to keep the superior genes and to improve the convergence speed [30]. This research set the words

given by the users as the optimum solution with a high fitness score. Details on the fitness function and roulette algorithm are discussed in later sections. We combined two methods to generate poems, ensuring that the words given by the users are retained until the final child generation to obtain the best output poem.

Another method we called "violent substitution" is also used; the algorithm places the keywords into the output poems in final step. This method can guarantee the retention of keywords; however, the quality can be very poor, breaking the flow of words. In comparison, our methods retain the flow and output a high-quality poem after several steps.

3. Proposed Algorithm

3.1. Fitness Function

The quality of Tang Poetry is mainly based on the parameter level and oblique tones, emotional representation, antithetical parallelism, and the prevalence of the words. Considering the user's input words and initial score of the poem, its total fitness score Q can be calculated as

$$Q = \sum_{i=0}^{5} P_i \quad (1)$$

Where P_0 is the initial poem's score, P_1 is the level and oblique tones score, P_2 is the emotional score, P_3 is the antithetical parallelism score, P_4 is the popularity word score, and P_5 is the input words score.

The initial fitness score of the poem is given as

$$P_0 = (S - (W/L)) * \lambda_0 \quad (2)$$

Where S is the number of poem segments, W is the total number of words, and L is the number of lines.

Except P_0, other P_i can be calculated as

$$P_i = \lambda_i \sum_{i=1}^{N} f_i \quad (3)$$

Where λ_i is the score coefficient, and f_i is the corresponding word or segment value. Table 1 lists detailed information on each P_i.

Table 1. Calculation of fitness function.

P_i	Description
$P_1 = \lambda_1 \sum_{i=1}^{w} f_1$	Level and oblique tones are essential elements of Tang poetry. Every word needs conform to these. Therefore, if the word satisfies requirements, f_1 is 1, otherwise f_1 is 0.
$P_2 = \lambda_2 \sum_{i=1}^{S} f_2$	This function is used to calculate the emotional value of the poem. When the gene words are same as the emotion selected by the user, f_2 is 1, otherwise f_2 is 0 (we set lonely, helpless, and sad as one type; heroic and carefree as one type).
$P_3 = \lambda_3 \sum_{i=1}^{w} f_3$	Antithetical parallelism can improve the poem quality; this function calculates the antithetical parallelism score of poetry.
$P_4 = \lambda_4 \sum_{i=1}^{w} f_4$	Some words have high probability of occurrence in Tang poetry, and these words often make the poem more elegant. This function calculates the popularity score of the poem. w is the total number of words in the poem. f_4 is the total number of times a word appear in tens of thousands of poems.
$P_5 = \lambda_5 \sum_{i=1}^{w} f_5$	The equation is used to retain the user's input words. If word i is the input word entered by the user, f_5 is 1, otherwise f_5 is 0.

λ_i needs to be set correctly. In particular, the value of λ_5 cannot be very low; once it too low, the words input by the user will be replaced by higher-valued words, making the function of self-help writing poetry invalid. A very high value will reduce the times of evolution. Although the generation of the poem will have a high degree of fitness score, the quality may be not good [16, 24].

3.2. Roulette-Wheel Selection

We select the remaining individuals using the roulette algorithm. In other words, the string in the population is selected with a probability proportional of *Fi* we use to indicate the total fitness score of the group, indicates the fitness score of a poem, and n is the Q_i population number. Finally, we can determine the probability that the individual will be selected.

$$F_i = \frac{Q_i}{\sum_{i=1}^{n} Q_i} \quad (4)$$

3.3. Achievement of Self-help Writing Poetry

We have designed two methods in which self-help writing can be realized.

- *Method* 1: Including the keywords of the user in the database-generating multiple groups of poems-and then appropriately improving the fitness score of the keywords. After the selection and evolution, the poem with the highest fitness score is obtained as output.
- *Method* 2: Retain the keywords of the user in the poem. After the selection and evolution, the poem with the highest fitness score is obtained as output. The proposed framework is shown in Figure 1.

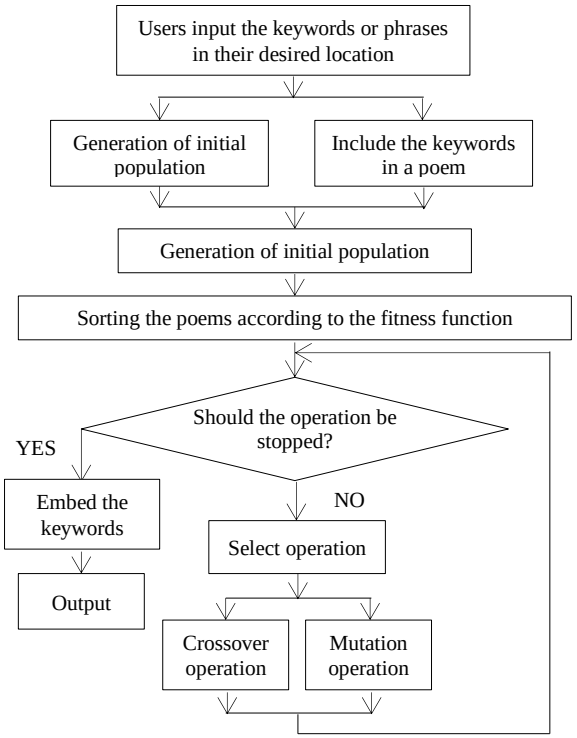

Figure 1. Framework of the self-help writing poetry system.

1. Generate multiple initial populations by randomly

selecting words from the database we set before.
2. Set the fitness score of the keywords that the user input to a suitable value.
3. Sort the poems according to the fitness score.
4. Replicate the individual adaptation to the sub generation, calculate the fitness score of the child, and compare the fitness score of the offspring.
5. Conduct crossover and mutation operations.
6. On repeating above operations and the best individual in the population is produced. When the number of times or the values are limited, the output is derived.

4. Experimental Results

4.1. Turing Test Experiment

To test the quality of our user self-help writing poems, we curated a set of comparative topics, including ten groups of contrast poems. For the first five groups, each group comprises two poems. One is a piece of the original poem (poems written by a human), and the other is a self-help writing poem based on the former poem (we randomly selected two lines from the poems written by a human; we then input it to the system). For the remaining five groups, each comprises three poems. One is written by a human, the other two are generated by the system based on the original poem-the fitness score of one of the poems is high and the other is random. We asked participants to choose their favourite poem in each group.

We organized a group of volunteers, comprising 48 subjects from a society with different identities. Figure 2 shows the result of 10 groups of Turing test. The blue, red and green bars represent the percentages that people support the original poem, the self-help writing poem with a high fitness score, and the self-help writing poem with a random fitness score respectively in each group.

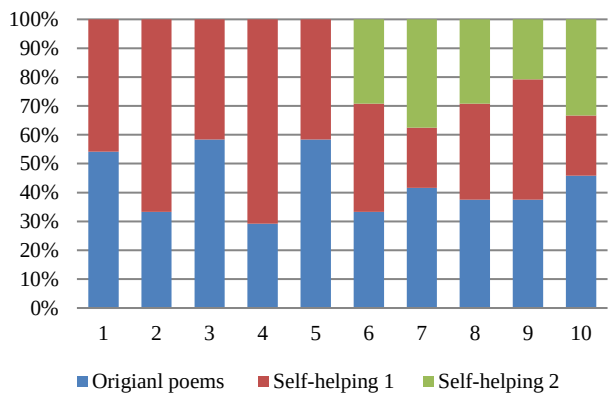

Figure 2. Turing test.

In this experiment, self-help writing poems of six groups obtained an evaluation higher than that of the original poems. The highest is the fourth, reaching 70.83%, far exceeding the number of supporting original poems. The disparity of other groups remained at the level of 20%. Because the preferences of poems of the participants are always different, even the famous works may obtain relatively lower scores. The final results demonstrated that most of the poems generated by the system are in line with the preferences; it can also be inferred that Tang poetry generation system based on elitist strategy of GA is an artificial intelligence system [9, 15, 22, 29].

4.2. Experiment of Fitness Function

In the variable parameter setting of Tang poetry generation system, there are initial population number, evolution times, mutation probability, elitist probability, crossover probability parameter, emotion category and other parameters.

In order to verify whether our system could produce better poetry and tested the influence of elitist probability on the quality of self-help poetry writing, we fixed the setting of other parameters, leaving only emotion and elitist probability as variable parameters [2].

We selected 60 poems from the Tang Poetry Library, which expressed four different emotions: nostalgia, nature, love and homesickness. We first used the system to calculate the fitness value of the original poem, and then extracted two paragraphs from the original poem. Under different elitist probability, the system automatically generated complete poems, and then calculates the fitness value of these poems for comparison [25]. The comparison elitist probability were set to 0.05, 0.1 and 0.15 respectively. The statistics are as listed in Table 2 in a certain range

4.3. Results and Discussion

The experiment indicated that the poems written by system obtained higher fitness scores than the original poems. Further, with the increase of elite probability, the smaller was the fitness score. As the system give the keywords used to describe "natural scenes" a bonus point in fitness function, poems on nature always exhibited a higher fitness score.

The experiment indicated that the poems written by system obtained higher fitness scores than the original poems which could been obviously observed from Table 2. Further, with the increase of elite probability, the fitness score became smaller. Through observation, we could also find that poems on nature always show high fitness scores, which was only because the system added a bonus to the keyword describing “natural scene” in the fitness function.

Table 2. Experiments based on different emotion and elitistprobability.

Selected emotion	original poems		Self-helping/elitist probability(0.05)		Self-helping/elitist probability(0.1)		Self-helping/elitist probability(0.15)	
	average	variance	average	variance	average	variance	average	variance
Nature	845.4	78671.6	1283.1	16850.5	1212.8	158437.2	1132.6	18234.7
Love	710.2	65325.7	1003.9	70814.6	954.6	63101.6	858.7	51813.1
Homesick	698.1	29879.3	909.9	56614.9	848.7	39228.7	799.8	10034.7
Nostalgia	525.9	25083.2	778.1	12334.4	720.0	8665.5	674.2	38468.3

Table 3. ANOVA of selection emotion and elitist probability.

Source of variation	SS	df	MS	F	P-value	F crit
Sample	4953367	3	1651122	33.17745	2.23E-18	2.636845
Column	38856315	4	9714079	195.1935	1.08E-79	2.403885
Between Groups	1532416	12	127701.4	2.566016	0.003067	1.786856
Within Groups	13934592	280	49766.4			

The two-way Analysis Of Variance (ANOVA) is an extremely powerful and important statistical technique used to look at the possible interaction of two different variables. It was used in the experiment to estimate how the mean of scores changes according to the levels of emotions and elite probabilitie. The analysis of variance was summarized in Table 3.

According to Table 3, we analyzed the influence of emotion and elite probabilities on scores. From the statistical results of P value which were less than 0.05, we can see that different emotions and elite probability have a significant impact on the fitness score. The F-statistics fall in the critical area, which indicates that there are significant differences in fitness scores under different emotions and elitist probabilities. From the comparison between groups, the p value was also less than 0.05, indicating that the influence of emotional factors and elite probability factors on the score was independent.

Our system is validated as higher fitness scores were obtained. Meanwhile, the elitist strategy auxiliary function in this system that helps users generate high-quality poems is available and effective.

5. Conclusions and Future Work

Auxiliary writing is crucial to generate poetry. This paper highlights interaction design, application of an elitist strategy, and concrete design of fitness function [26].

Our system overcomes the limitations of traditional generating systems as it allows users to input the words or verse they require and generate a poem based on the degree of association. The proposed system can be considered as a semi-autonomous poetry system. Furthermore, the modified elitist GA helps the generated poem express the emotions and thoughts, which cater to the requirements of the users.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgment

The authors of this study express their gratitude to the Public Welfare Project of Zhejiang provincial Science and Technology Department (2017C31110) for the financial support for this study. The authors are also grateful to the anonymous referees who provided their valuable comments and suggestions to improve the presentation of this paper.

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