The Supporting Method for Creating a Character Gaze Animation based on Viewer’s Preference

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Abstract
The character animation is required to appear as natural as human motion. Toward that goal, there is an approach where the expression appears as natural as the human expression by adding gaze behavior to the contextual situation and the environment to the general behavior animation. However, detailed understanding of some gaze control parameters is required for the users to create the intended gaze behavior animation that is suitable for the situation using the gaze controller. And it is difficult for beginners and the users that have little experience creating the character animation that the user feels to be adequate because trial-and-error adjustments are required. In this paper, we propose a method for creating a character gaze behavior animation based on viewer’s preference such as “where to gaze” and “how to gaze” without setting manually the gaze control parameters.

We translate a character’s gaze motion into parameters for the gaze controller. And, we obtain the optimized gaze target and control parameters for the natural gaze animation that the viewer felt using the Interactive Genetic Algorithm (IGA). In experiment, we compare the impression of the method and result between the manual creation and the creation by the proposed method. We confirm that the user can create gaze behavior animation that has the quality of the manual creation quickly and easily using the proposed method.

Keywords: character animation, gaze behavior, interactive genetic algorithm

1 Introduction
The character animation is required to appear as natural as human motion. Toward that goal, there is an approach where the expression appears as natural as the human expression by adding gaze behavior to the contextual situation and the environment to the general behavior animation.

Recently, gaze behavior animation is able to be created using any 3DCG software which has a gaze controller that rotating joints, such as eyes, head, and chest, with specifying a gaze target on personal-use. However, detailed understanding of some gaze control parameters is required for the users to create the intended gaze behavior animation that is suitable for the situation using the gaze controller. And it is difficult for beginners and the users that have little experience creating the character animation that the user feels to be adequate because trial-and-error adjustments are required.

In this paper, we propose a method for creating a character gaze behavior animation based on viewer’s preference such as “where to gaze” and “how to gaze” without setting manually the gaze control parameters.

We translate a character’s gaze motion into parameters for the gaze controller. And, we obtain the optimized gaze target and control parameters for the natural gaze animation that the viewer felt using the Interactive Genetic Algorithm (IGA).

We incorporate users watching a character animation into the optimization system. Then, the suitable parameters of the gaze controller are calculated from the viewer’s preference.

2 Related Works
The behavior of turning one’s gaze to target is one of the important factors to improve the expression of character animation [1].

For this reason, example-based [2, 3, 4, 5] and movement characteristic-based [6,7] gaze behavior controllers that rotating joints, such as eyes, head, and chest are proposed to turn one’s gaze to arbitrary targets adaptively. [8, 9] are able to select the suitable gaze target based on cognitive feature and generate gaze behaviors of turning one’s gaze to the selected target in order to act based on a contextual situation and environment. Also, [10] propose the gaze controlled model to stylized gaze behavior animation of the several characters.

Recently, we can use a gaze controller on any 3DCG software for personal use [11]. However, it is necessary for the time, effort, and trial-and-error to create ideal gaze animation by manually setting the control parameters.

Interactive genetic algorithm (IGA) is one of the method of interactive evolutionary computing that get an optimized solution based on the user’s subjectivity. IGA is the method based on the genetic algorithm (GA). In IGA, the population is
evaluated by a user. IGA is applied to the researches in the field of computer graphics [12].

We proposed a gaze behavior animation optimization method using IGA [13]. In this research, we focused on the gaze behavior that turns one’s gaze to the intended target beforehand. Therefore, in this paper, we propose the supporting method for creating a character gaze behavior animation include the subject of selecting suitable gaze target from the multiple targets candidate.

3 Our Approach
In our approach, the gaze behavior animation in the scene is generated by evaluating the appropriateness of the character animation based on viewer’s preference. Figure 1 shows the overview of the proposed method.

The input is the population of the gaze behavior animation. The initial gaze behaviors are generated by adding the rotation of the eye, head, chest for any one of the gaze target to the general behavior animation by the gaze controller. The gaze behavior controller used in this paper is able to rotate the joints toward the target by the parameters of the point of gaze, time of rotation and the amount of rotation.

Therefore, gaze behaviors in the population are represented by the control parameters. The control parameters are optimized using Interactive Genetic Algorithm (IGA) based on the user’s subjectivity.

As a result, we obtain the optimized parameters for the natural gaze behavior animation that the viewer felt to be adequate.

4 Parameterized Gaze Behavior
In this work, we define gaze behavior as the following three action sequences: (i) switching one's gaze to, (ii) keeping one’s gaze, and (iii) removing one's gaze from. In our proposed method, we use the gaze controller to generate gaze behavior animation. The gaze controller adds gaze behavior in a contextual situation and the environment to the general behavior animation.

The gaze controller in this paper is the controller that is extended the existing controller [1][2] by reference to the asset in Unity [3] that is the 3DCG development environment. A point of gaze target is represented by three-dimensional coordinates \((p_x, p_y, p_z)\) of the object coordinate system. The temporal parameters are the switching start time \(t_{\text{start}}\), keeping start time \(t_{\text{in}}\), keeping end time \(t_{\text{out}}\) and removing end time \(t_{\text{end}}\).

Figure 2 shows relationship the rotation of the head to each vector.

The \(\mathbf{v}_{\text{forward}}\) is forward vector and the \(\mathbf{v}_{\text{gaze}}\) is gaze vector of joint \(i\) of the character coordinate system. The horizontal angle \(\theta_{hi}\) and the vertical angle \(\theta_{vi}\) are defined as the angle between \(\mathbf{v}_{\text{forward}}\) and \(\mathbf{v}_{\text{gaze}}\). The rotation angle of joint \(i\) \(\mathbf{T}_i^j = \left[\theta_i^j, \theta_i^j, \theta_i^j\right] \) is represented as follows:

\[
\mathbf{T}_i = BM_i \mathbf{T}_i^j, \quad (1)
\]

subject to \(TA_i \leq \theta_i, \theta_i \leq MA_i, \quad i = \text{eye, head, chest}\).

\(BM_i\) is the blending rate, \(TA_i\) is the threshold angle at which each of these begins to bend and \(MA_i\) is the maximum angle limitation of joint \(i\).

Therefore, a gaze behavior against an arbitrary target \(j\) is represented as \(g = \{\text{target}_j, p_x, p_y, p_z, t_{\text{start}}, t_{\text{in}}, t_{\text{out}}, t_{\text{end}}, BM_e, BM_h, BM_b, TA_e, TA_h, TA_b, MA_e, MA_h, MA_b\}\).
Optimized the Gaze Animation using IGA

Interactive genetic algorithm (IGA) is the method based on the genetic algorithm (GA). In IGA, the population is evaluated by a user based on the user’s subjectivity. In our work, the gene is the gaze control parameters $g$.

The steps of following (1) to (7) are performed according to the procedure of GA.

(1) Generating initial population
The gene is the gaze control parameters $g$. $g$ is composed of the index of a gaze target and 16 real-valued parameters. Figure 2 shows the gene coding of $g$.

The number of gene in the population is eight to relieve the burden on the viewer. The numbers of each gaze target occupying the initial population are set equally because the gaze target is optimized too.

(2) Animation presentation
The gaze behavior character animation as a gene is displayed to a viewer. The two animations to be compared are displayed side-by-side to evaluate by paired comparison in the evaluation phase.

(3) Evaluation by viewer’s preference
A viewer evaluates gaze animations by paired comparison tournament method. Each gene in the population is placed in the first round of the tournament and presented by two genes in accordance with the tournament (Figure 3).

The displayed two animations as a gene are weighed up which is more suitable animation by the viewer. There are four evaluation buttons in the evaluation UI (Figure 4). The viewer presses the evaluation button according to the evaluation scale as follows.

- In the case of “the animation A is clearly more suitable than the animation B”, viewer presses the A-1 button.
- In the case of “the animation A is more suitable than the animation B”, viewer presses the A-2 button.
- In the case of “the animation B is more suitable than the animation A”, viewer presses the B-2 button.
- In the case of “the animation B is clearly more suitable than the animation A”, viewer presses the B-1 button.

The evaluation value of each animation as a gene is given depending on the match result between the competition two animations and the result of the tournament.

(4) Selection
The genes of crossover target are selected by the ranking selection method and the elite selection method based on the evaluation value.

(5) Crossover
The gaze control parameters $g$ used as a gene is composed of the index of a gaze target and 16 real-valued control parameters. The crossover of the 16 real-valued control parameters is operated by the unimodal normal distribution crossover (UNDX) [21].

And the crossover of the gaze target is operated by the probabilistic approach based on the evaluation value (Figure 7). The selection probability $Pr^j$ of the gaze target $target^j$ is represented as follows:

$$Pr^j = \frac{g_j}{\sum g_i}, \quad (2)$$

$$g_j = \sum_{k=0}^{1} \frac{e_k}{n}, \quad (3)$$

$g_j$ is the sum of the evaluation value of the gene that has the gaze target $target^j$. $e_k$ is the evaluation value of the target.

The gaze target of each gene of the next generation is operated according to the selection probability $Pr^j$.

(6) Mutation
The new real-valued parameters are generated by the uniform random numbers mutation in the valid range of value

(7) End condition
The solution search is terminated at the maximum 10 generations to relieve the burden on the viewer.

The gaze target and the control parameter is calculated based on the viewer’s preference by the above processing, and the suitable gaze behavior animation that the viewer felt is generated by these parameters.

6 Experiment

6.1 Overview
In order to show the effectiveness of the proposed method, we compare the impression of the method and result between the manual creation (called HAND) and the creation by the proposed method (called IGA).

The situation of animation is that the male character gazes the one of the targets from the multiple targets candidate when he crosses the crosswalk (Figure 4). The targets candidate is the right side of the direction of movement of the road, the car, and
the passing pedestrian. The evaluator selects the one of the gaze targets and creates the suitable gaze behavior animation. The evaluators are 20 students of the 20’s that have little experience creating a character animation.

6.2 Experimental procedure
The experiment was carried out in the following steps.
- (1) Creating the animation by HAND or IGA.
- (2) Creating the animation by IGA or HAND.
- (3) Evaluating each result.
The evaluators answer the questionnaire about the creation method after the creation in the creating step of (1) and (2). And the evaluators answer the questionnaire about the creation results in the step of (3) on the day after creating it in the step of (2). At that time, the each created animation was displayed to the evaluator.
The questionnaire items about the creation method are the Q-S1 “ease of creation work” and Q-S2 “operability”. And the questionnaire items about the creation result are the Q-R1 “the impression of the animation”, Q-R2 “adequacy of gaze target”, Q-R3 “adequacy of gaze motion” and Q-R4 “adequacy of the timing of gaze behavior”. The evaluator rates questionnaire on a scale of -3 to 3 for each item.

6.3 Result
6.3.1 A result of creating gaze behavior to the same gaze target in both conditions
Figure 7 and 8 show a result of created gaze behavior animation by an evaluator. The gaze behavior animations to the same gaze target are created in both conditions (Figure 5, 6). A little rotation of the eye and the head of the character at the end time of keeping his gaze is confirmed in IGA condition (Figure 7(b)) On the other hand, each joint of the character are hardly rotating at in HAND condition (Figure 8(b)). And the evaluator rates the animation that is created in IGA better than the animation that is created in HAND at the evaluation of each result in items other than Q-R4. These results are considered that the evaluator doesn’t tune the suitable gaze control parameters in HAND but get the gaze control parameters of performing the suitable gaze behavior in IGA.

6.3.2 A result of creating gaze behavior to the different gaze target in both conditions
Figure 11 and 12 show the result of created gaze animations to the different gaze target in both conditions. The gaze target of the animation in IGA (Figure 9) is the car, and the gaze target in HAND (Figure 10) is the right side of the
direction of movement of the road. The character follows the car with his eyes when the car passes him in Figure 9. The character makes sure cars are not on the right side before crossing the crosswalk in Figure 10. The evaluator rates the animation that is created in HAND better than the animation that is created in IGA at Q-R3. However, the evaluation values at Q-R1, Q-R2 and Q-R4 are even. Then we got a comment by the evaluator, “I felt that the gaze behavior directing to the car is also natural in the production process using IGA UI.” Therefore, a suitable gaze behavior animation for different gaze target of his own plan can be created using IGA.

6.4 Evaluation result
The average score and standard deviation of the evaluation value of the creation method are shown in Figure 13. And the average score and standard deviation of the evaluation value of the creation result are shown in Figure 14. We evaluate each item by Wilcoxon signed-rank test. Q-S1 “ease of creation work” and Q-S2 “operability” that are the questionnaire items about the creation method differ significantly between IGA and HAND. However, Q-R1 to 4 that are the questionnaire items about the creation result don’t
differ significantly between IGA and HAND. The average time of the creation in IGA is 7.5 minutes and in HAND is 10.5 minutes. The creation time of both conditions was observed a weak positive correlation with $r = 0.23$. Therefore, it is considered that the user can create gaze behavior animation that has the quality of using HAND quickly and easily using IGA.

7 Conclusion
In this paper, we propose a method for creating a character gaze behavior animation based on viewer’s preference such as “where to gaze” and “how to gaze”. We translate a character’s gaze motion into parameters for the gaze controller. And, we obtain the optimized gaze target and control parameters for the natural gaze animation that the viewer felt using the Interactive Genetic Algorithm (IGA).

From the result of the created animation by users have little experience creating a character animation, it is considered that the user can create gaze behavior animation quickly and easily using our proposed method. However, the gaze behavior animation created using IGA depends on the initial gaze behaviors in the population. For future work, it therefore requires consideration of setting up the initial population based on the preferences of the user.

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