Analysis and Synthesis of Realistic Eye Movement in Face-to-face Communication

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1. Introduction

During face-to-face conversation, human eyes always rotate irregularly. Therefore, it is essential to synthesize such complex eye movements for the achievement of realistic human facial animation. In the conversation, there are two kinds of eye movements, Saccades and Fixation Eye Movements (FEMs). Saccade is a relatively large scale motion in eye movements compared with FEMs' smaller one. Gu et al [2007] mainly focused on saccades and suggested probability models based on their measurements. In their research, they treated FEMs as a part of saccades, even though saccades and FEMs are totally different kinds of eye movements. Thus their approximation is insufficient and brings unnatural appearance especially in conversations. Moreover, they avoided to provide an approximation of blinks' motions.

We therefore aim to analyze saccades, FEMs and blinks efficiently and synthesize these movements using those probability models. First, we measure eye movements including FEMs and blinks in actual conversations. Second, we separate the acquired eye movements into two different movements, saccades and FEMs. Then, we approximate these eye movements and blinks using probability models respectively. Finally, based on the probability models, we synthesize cyclic eye movements between saccades and FEMs and add blinks to the resulting eye movements. As a result, we can automatically generate realistic eye movements in face-to-face communication.

2. Measurement of Eye movements and blinks

To acquire reliable eye movements, it is necessary to control experimental environment strictly.

We measured 24 subjects' eye movements in various actual conversations using the NAC EMR-9 eye tracker and video camera. The eye tracker can measure eye movements by comparing the corneal reflection of the light source relative to the location of the pupil center. Primarily, we requested the subjects to be seated at 1.5 meters for having usual conversations between two subjects, one is speaker and the other is listener. Then we measured the eye movements and blinks of subjects during conversations. Additionally, to acquire subjects' FEMs precisely, we put a gaze point on a wall at 1.0 meters and asked subjects for focusing the point. In both two measurements, we requested the subjects to stop their head motions for obtaining eye's rotations without a neck motion.

3. Analysis and Synthesis

Eye movements in conversations include two different motions, saccades and FEMs. Initially, based on our measurements, we defined saccades as eye movements more than 2 degrees of rotation angle of eyeballs. Conversely, we defined FEMs as motions less than 2 degrees. Next, we averaged out results of eye movements' measurement and approximated it using probability models with the combination of Exponential, Gaussian and Trigonometric Functions.

As for saccades, first, we separate eye movements in conversations by speakers and listeners. Second, we approximated rotating angle (magnitude), direction angle, transient and continuous time by probability models. In regard to FEMs, as shown in Figure.1, we were able to observe that there were two types' velocities; fast and slow. Therefore, we first divided FEM's velocities into fast and slow setting a threshold (0.05deg/frame). Then, we approximated these two types of velocities using probability models respectively. In addition, we approximated time interval of large peaks and continuous time using probability models. Finally as for blinks, we acquired the upper eyelid's moving velocity, then, approximated blinks' time and interval of blinks using probability models.

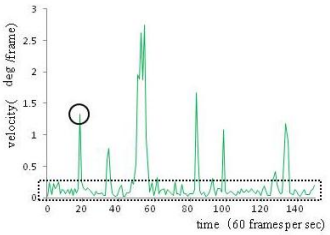

Figure1. Variation of velocity of FEMs per 1/60 second

Figure3. Result of synthesis

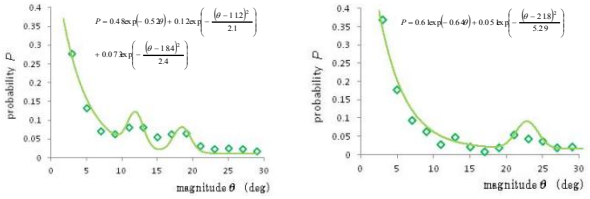

Figure2. Rotating angle of speakers (left) and listeners (right)

4. Result s and Discussions

The approximation of obtained eye's motion as a probability function is shown in figure 2, and figure 3 is an example of synthesized eye's motion according to the function. Figure2 indicates that large eye movements of speakers will occur more often than of listeners. In this way, our method can generate differences of eye movements about different situations, gender and so on. Moreover, our method can analyze eye movements associated with contents of conversations using voice data in video camera. More details of our probability-based eye's motions are described in supplemental materials.

In our research, we separate eye movements into Saccades and FEMs, and propose probability functions of each kind of eye movements. Additionally, we also approximate the motion of blinks in conversations using probability models and the models to CG character. Besides, we analyze eye movements of speakers and listeners respectively. However, we analyze eye movements after averaging out 24 subjects' eye movements', so we couldn't express individuality of eye movements. More detailed Analysis will further increase the realism of eye movements.

References

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