Generating Eye Movement during Conversations Using Markov Process

Supplemental Supporting Document

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1. Initial Probabilities

1.1. Initial State Probability

We determine the initial state of eyes to synthesize eye movements using the first order Markov process. The initial state probabilities we acquired from the actual measurements are shown in Table1.

Table1. Initial State Probability

Probability Initial State	Probability
Blink	22[%]
Saccade	14[%]
FEM	64[%]

1.2. Initial Element Probabilities

We determine the initial eye movement element values to synthesize eye movements using the first order Markov process. Eye movement elements represent "angular rotation", "angular direction", "duration time", "saccade time interval", "blink time" and "blink time interval". The each initial element probabilities we acquired from the actual measurements are shown in Table2～7.

Table2. Initial Angular Rotation Probability

Probability Initial Value	Probability
2.0～12.0[deg]	62[%]
12.0～22.0[deg]	28[%]
22.0～32.0[deg]	10[%]

Table3. Initial Angular Direction Probabilities

Probability / Initial Value	Probability
-45〜45[deg]	30[%]
45〜135[deg]	35[%]
135〜180[deg] -135〜-180[deg]	22[%]
-45〜-135[deg]	13[%]

Table4. Initial Duration Time Probabilities

Probability / Initial Value	Probability
0〜1.0[s]	72[%]
1.0〜2.0[s]	18[%]
2.0〜3.0[s]	10[%]

Table5. Initial Saccade Time Interval Probabilities

Probability / Initial Value	Probability
0〜1.0[s]	30[%]
1.0〜2.0[s]	32[%]
2.0〜3.0[s]	38[%]

Table6. Initial Blink Time Probabilities

Probability / Initial Value	Probability
0～0.2[s]	70[%]
0.2～0.4[s]	28[%]
0.4～0.6[s]	2[%]

Table7. Initial Blink Time Interval Probabilities

Probability / Initial Value	Probability
0～1.0[s]	52[%]
1.0～2.0[s]	38[%]
2.0～3.0[s]	10[%]

2. State Transition Probability

The state transition probabilities we acquired from the actual measurements are shown in Table8. The first column on the left represents the previous state of eyes and the first row on the top represents the next state of eyes in Table8.

Table8. State Transition Probabilities

Next / Previous	Blink	Saccade	FEM
Blink		69[%]	31[%]
Saccade	60[%]		40[%]
FEM	29[%]	71[%]	

3. Element Transition Probabilities

3.1.   Saccade Element Transition

3.1.1.   Angular Rotation
  The angular rotation represents the extent to which eyeballs move. The angular rotation transition probabilities we acquired from the actual measurements are shown in Table9. The first column on the left represents previous angular rotation of eyes and the first row on the top represents the next angular rotation of eyes in Table9.

Table9. Angular Rotation Transition Probabilities

Next〔Previous〕	2.0〜12.0[deg]	12.0〜22.0[deg]	22.0〜32.0[deg]
2.0〜12.0[deg]	73[%]	18[%]	9[%]
12.0〜22.0[deg]	30[%]	59[%]	11[%]
22.0〜32.0[deg]	24[%]	30[%]	46[%]

3.1.2.   Angular Direction
  The angular direction represents the direction in which an eyeball moves and is defined using the initial fixation point. The angular direction transition probabilities we acquired from the actual measurements are shown in Table10. The first column on the left represents previous angular direction of eyes and the first row on the top represents the next angular direction of eyes in Table10.

Table10. Angular Direction Transition Probabilities

Next〔Previous〕	-45〜45[deg]	45〜135[deg]	135〜180[deg] -135〜-180[deg]	-45〜-135[deg]
-45〜45[deg]	71[%]	12[%]	10[%]	7[%]
45〜135[deg]	35[%]	51[%]	5[%]	9[%]
135〜180[deg] -135〜-180[deg]	12[%]	5[%]	73[%]	10[%]
-45〜-135[deg]	2[%]	4[%]	12[%]	82[%]

3.1.3. Duration Time

The duration time represents the movement time of saccades. The duration time transition probabilities we acquired from the actual measurements are shown in Table11. The first column on the left represents previous duration time of saccades and the first row on the top represents the next duration time of saccades in Table11.

Table11. Duration Time Transition Probabilities

Previous \ Next	0～1.0[s]	1.0～2.0[s]	2.0～3.0[s]
0～1.0[s]	88[%]	9[%]	3[%]
1.0～2.0[s]	55[%]	40[%]	5[%]
2.0～3.0[s]	90[%]	10[%]	0[%]

3.1.4. Saccade Time Interval

The saccade time interval represents the time from one saccade to the next. The saccade time interval transition probabilities we acquired from the actual measurements are shown in Table12. The first column on the left represents previous saccade time interval of saccades and the first row on the top represents the next saccade time interval of saccades in Table12.

Table12. Saccade Time Interval Transition Probabilities

Previous \ Next	0～1.0[s]	1.0～2.0[s]	2.0～3.0[s]
0～1.0[s]	88[%]	9[%]	3[%]
1.0～2.0[s]	55[%]	40[%]	5[%]
2.0～3.0[s]	90[%]	10[%]	0[%]

3.2.   Blink Element Transition

3.2.1. Blink Time
  The blink time represents the eyelid movement time from closing to opening. The blink time transition probabilities we acquired from the actual measurements are shown in Table13. The first column on the left represents previous blink time and the first row on the top represents the next blink time in Table13.

Table13. Blink Time Transition Probabilities

Previous \ Next	0～0.2[s]	0.2～0.4[s]	0.4～0.6[s]
0～0.2[s]	80[%]	12[%]	8[%]
0.2～0.4[s]	50[%]	21[%]	29[%]
0.4～0.6[s]	100[%]	0[%]	0[%]

3.2.2.   Blink Time Interval
  The blink time interval represents the time from one blink to the next. The blink time interval transition probabilities we acquired from the actual measurements are shown in Table14. The first column on the left represents previous blink time interval and the first row on the top represents the next blink time interval in Table14.

Table14. Blink Time Transition Probabilities

Previous \ Next	0～1.0[s]	1.0～2.0[s]	2.0～3.0[s]
0～1.0[s]	62[%]	25[%]	13[%]
1.0～2.0[s]	45[%]	40[%]	15[%]
2.0～3.0[s]	70[%]	27[%]	3[%]