Simulating Human Saccadic Scanpaths on Natural Images

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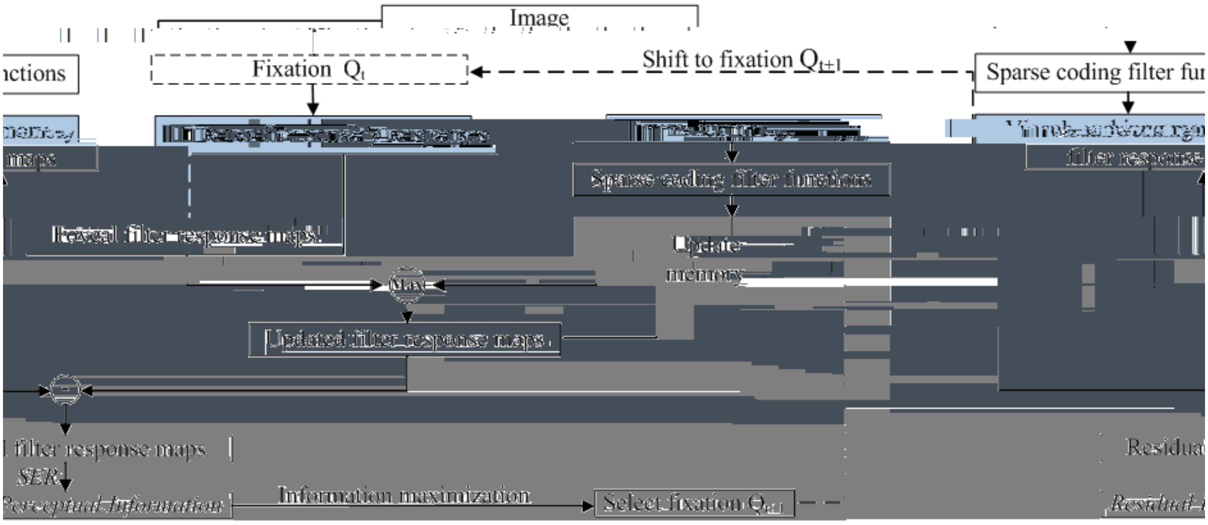
Abstract

Human saccade is a dynamic process of information pursuit. Based on the principle of information maximi ation, we propose a computational model to simulate human saccadic scanpaths on natural images. he model integrates three related factors as driven forces to guide eye movements se uentially reference sensory responses, fovea-periphery resolution discrepancy, and visual working memory. For each eye movement, we compute three multi-band filter response maps as a coherent representation for the three factors. he three filter response maps are combined into multi-band residual filter response maps, on which we compute residual perceptual information (RPI) at each location. he RPI map is a dynamic saliency map varying along with eye movements. he next fixation is selected as the location with the maximal RPI value. On a natural image dataset, we compare the saccadic scanpaths generated by the proposed model and several other visual saliency-based models against human eye movement data. Experimental results demonstrate that the proposed model achieves the best prediction accuracy on both static fixation locations and dynamic scanpaths.

1. Introduction

Proposed method



F. 1.

so far

Site Entropy Rate (2) ... residual perceptual information (RPI) ... RPI

SER ... Q_{t+1},

A ... multi-band filter response maps

1.1. Related work

I ... et al. [1] ... et al. [1] ... et al. [1] ... et al. ... self-information ... H ... et al. [1] ... M ... et al. [13] ... [1] ... H ... et al. [1] ... A ... et al. [1] ... I ... et al. [2]

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2. Our Approach

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2.1. Coherent representation of three factors

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2.1.1 Sparse coding filters

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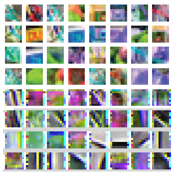

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2.1.2 Foveal imaging

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F . . 3. A . . . O . .
F . fi .

2.1.3 Visual working memory

O , fi . ʊ , , . , , , fi . I fi .

Simulating the forgetting properties. I , fi ϵ $\leq \epsilon \leq$. I $\epsilon =$, $\epsilon =$, . I S 3.4, ϵ.

Updating visual working memory. ʊ fi . I , fi fi fi . A *Max* 4. fi , $f_k^v\ x, y, t$ $f_k^w\ x, y, t$ k fi t x, y .

$$f_k^w\ x, y, t \leftarrow \quad f_k^v\ x, y, t\ , \epsilon \cdot f_k^w\ x, y, t - \quad . \qquad 1$$

Computing residual filter response maps. fi fi F . 1 . P fi . A , fi . fi $r_k = |f_k^o - f_k^w|$, f_k^o k .

2.2. Measuring residual perceptual information

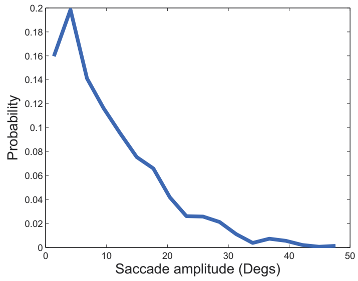
F , fi . fi . I , *Site Entropy Rate* SER 2 fi . *Site Entropy Rate* fi . R . . I , fi SER SER , SER i

$$S_i = \sum_k SER_{ki} = -\sum_k \pi_{ki} \sum_j P_{kij} \quad P_{kij} \qquad 2$$

π_{ki} i k fi , P_{kij} i j k fi . A 2 , SER , . P 2 SER . SER . F , SER fi . M , fi , *e.g.*, , . S , SER , . . .

2.3. Saccadic amplitude

U , F . 4. I ∘ fi . , , fi Q_{t+1} fi Q_t. F , $Z \times Z$ fi Q_t , $Z/$ 4 ∘ . SER



F . . 4. . . .

Q_{t+1}. N , Q_{t+1} . $p\ z \leq Z/$, .

F . . 4. A fi Q_{t+1}, . . .

3. Experimental Results

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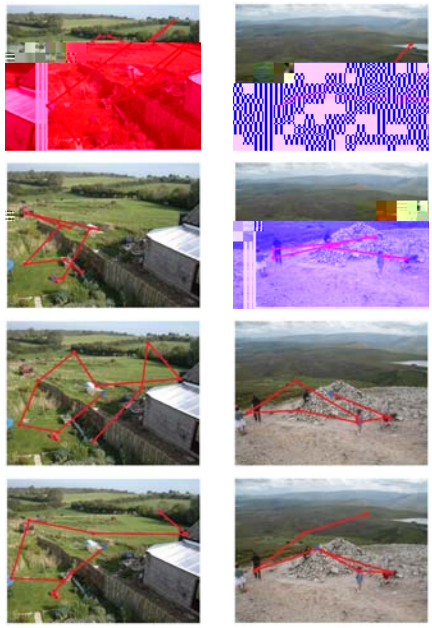
3.1. Dataset and eye movement data collection

2 . I . . . , . . , . , . 24 . . . . SMI H . . S. . 3 21 CR . . , 3 1 . A . . fi fi . . . .

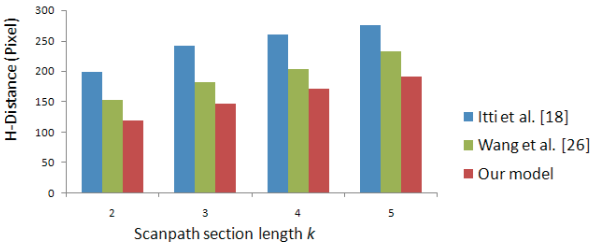
3.2. Evaluation of fixation order

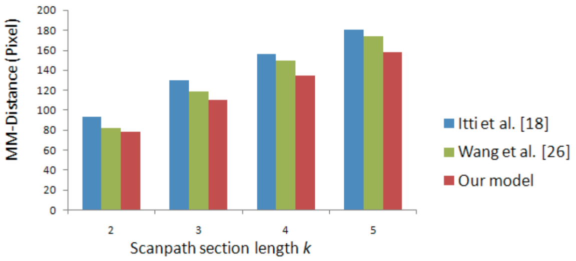
. . . A , . 1 . . . . R . *et al.* 22. . , , . . N , I *et al.* 1 . .



F . . . C . . . . 1 . , 2 . , . , . , . . . fi .

A . I R . . . . . . , . . H , . I *et al.* . M , ... , ... 1 . . 2 . , . . . A I R . . 1 . , . . . 1 . . . , . fi . . fi . . . , fi . . . . ∼ fi . , . fi . . . . . . , . , I *et al.* 1 . . . . 2 . , . R . , . . . S. . , ... A F . . , ...



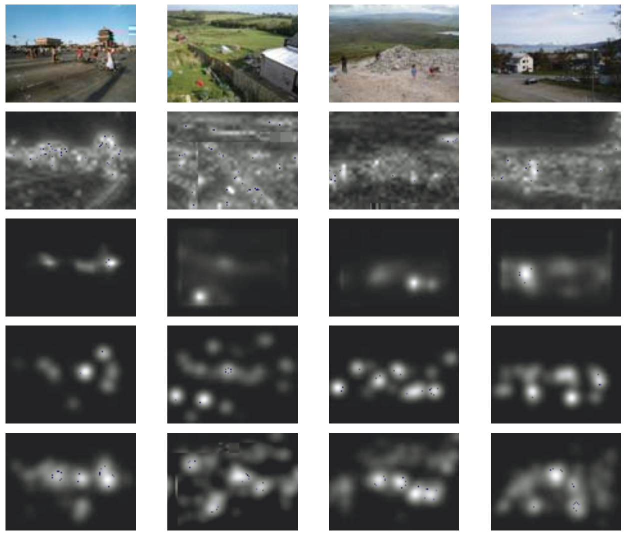


F . . . C . . , 1 . 2 . . . H . . k.

3.2.1 Distance of scanpaths

I . . , *time-delay embedding*, . . 23. . S fi , . k, . . C^k_m t c_m t , $\cdots c_m$ $t + k -$ k . , . t fi . m. / . t, . k . X $\{C^k_m$ t $\}_t$ $\subseteq \mathbb{R}^k$. S Y $\{C^k_h$ τ $\}_\tau$ k . . I . k , fi . C . . X Y $\mathbb{R}^k$ . .

F . k x C^k_m t $\in X$, fi . d_k x, Y $_\tau\{\|x - C^k_h$ τ $\|_2\}/k$. I , . . k . . . , d_k x, Y . . x. . , ' . , ... H .



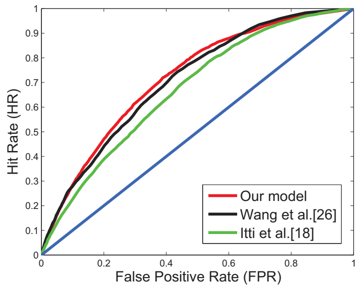
F . . C . . fi . . . . , 1 . , 2 . , . , . fi , .

H D . . , fi

$$d^k_H \quad { }_t \{ { }_\tau \{\|C^k_m \; t \; - C^k_h \; \tau \; \|_2\}\}/k \qquad 3$$

$$\quad { }_t \{d_k \; C^k_m \; t \; , Y \; \}. \qquad 4$$

mean minimal distance MM D , , fi d^k_M $_t$ d_k C^k_m t $, Y$. I . , . . . ϵ . , Z , . . . °. F . . .



F . . . ROC . .
2 . 1 . .

1. ROC

	I *et al.* 1 .	. *et al.* 2 .	O.
ROC	.	. 1	. 1 3

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ROC . ROC
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3.4. Assessment of the forgetting factor

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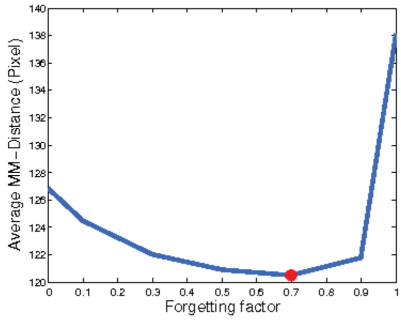

F . . 1 . . . k
ϵ. $\epsilon = 0.7$.

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4. Conclusion, Discussion and Future Work

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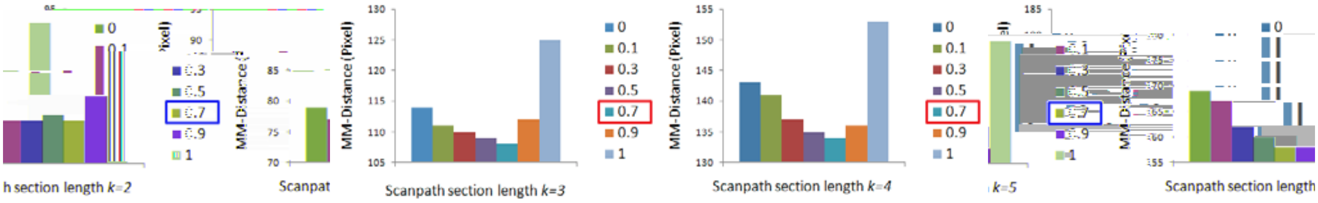

F. . . A

I . , . *edit distance*

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I . . ,

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fi

. I

Acknowledgments

N S F .

C . N . 2 12 2 ,

N R 3 P C

N . 2 C 32 4.

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