Quaternion-based Spectral Saliency Detection for Eye Fixation Prediction

Boris Schauerte, Rainer Stiefelhagen

Computer Vision for Human Computer Interaction, Karlsruhe Institute of Technology, Germany

Summary

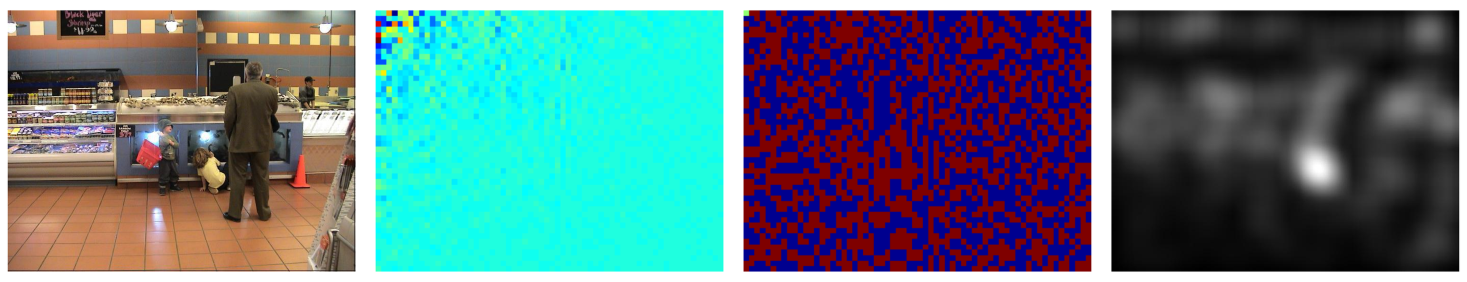
- Integration, extension and systematic evaluation of spectral saliency detection methods
- Evaluation on 3 eye-tracking data sets demonstrates outstanding results in predicting eye fixations …
- … at a runtime of less than 1ms

Motivation: Why Eye Fixation Prediction?

Predicting human eye fixations allows to quantify the quality of computational visual attention models and is thus interesting for research fields such as cognitive science. Moreover, good attention models are relevant for many applications such as, e.g., scene exploration and analysis in robotics, image retargeting, or predicting the attractiveness of advertisement.

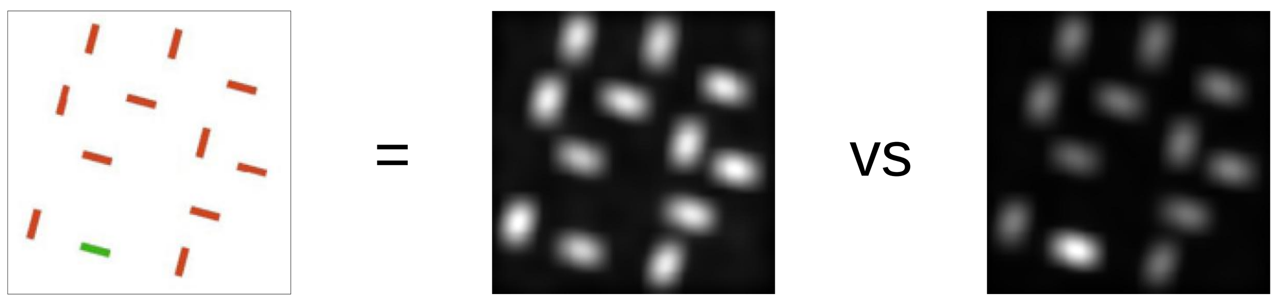
Algorithm Components

Spectral saliency algorithms manipulate the image's frequency-spectrum to highlight sparse salient regions.



e.g., $\mathbf{S} = |\mathrm{IDCT}(\mathrm{sign}(\mathrm{DCT}(\mathbf{I})))| * h_\sigma$

Quaternions allow for holistic color image processing, i.e. use the quaternion algebra to process the image as a whole instead of separating the color channels.



Intensity + color opponents | real-valued | quaternion-based

Quaternion component weights make it possible to adjust the relative importance of the feature/color space dimensions.

YUV | not weighted | weighted

Multiple scales are necessary to highlight salient regions of varying dimensions and detail.

single-scale @64x48 | multi-scale

EigenPQFT and EigenSR

Adaptation of Hou's SR and Guo's PQFT algorithms:
(a) quaternion-based spectral residual definition
(b) uses the quaternion eigenangle and –axis

$$\mathscr{S}_{\mathrm{ESR}}(\mathbf{I}_\mathrm{Q}) = \mathbf{h}_{\sigma_\mathrm{S}} * |\mathscr{F}_\mathrm{Q}^{-\mathrm{L}}\left[e^{\mathbf{R}_Q + \mathbf{E}_\gamma \circ \mathbf{E}_\Theta}\right]|$$

Summarized Evaluation Results

Overall: On average the best quaternion-based spectral approaches *outperform the best bottom-up baseline approaches by 8.32% (*).*

Quaternion- vs real-valued: Quaternions are 3.24% better for RGB, but worse for YUV?! The relative importance of the feature/color components is critical!

Quaternion component weights: If the influence of the feature dimensions is adjusted, then quaternion-based is on average *2.08% better than real-valued.*

Multiple Scales: Provide an *average performance improvement of 2.44%* (min. 1.73% @Kootstra and max. 3.75% @MIT).

EigenPQFT vs PQFT: On average *EigenPQFT achieves a 10.77% better performance than PQFT.*

Algorithms: The performance difference between spectral approaches is typically small; however, some algorithms are consistently better than others *(QDCT)*.

Runtime: Roughly 0.5ms (single-scale/-thread; Core i5@3GHz), which is far *more than 10,000x faster* than, e.g., Judd's method, Goferman's CAS, or Bruce's AIM.

(*): center-bias corrected ROC AUC, normalized using chance level and the ideal AUC

Contact

{boris.schauerte, rainer.stiefelhagen}@kit.edu

Computer Vision for Human Computer Interaction

http://cvhci.anthropomatik.kit.edu

Code is available at http://bit.ly/RAPmMk