**Extracting eye movement information from fMRI images**

Cemal Koba1, Jan K. Argasiński1

1Sano Centre for Computational Medicine, Czarnowiejska 36, 30-054 Kraków, Poland  
{c*.koba,j.argasinski*}@*sanoscience.org***Keywords**: eye movements, fmri, fixation, resting state, stroke

1. Introduction

Functional magnetic resonance imaging (fMRI) is a widely used tool to study functional alterations after brain stroke. Along with neural activity, fMRI signal can be used to extract information about non-neural physiological activity such as respiratory and cardiac oscillations at low-level frequencies [1,2]. Eye movements can be also detected using fMRI signal from eye vitreous [3,4]. This information is valuable as it allows direct comparison between oculomotor activity and neural dynamics without the need of additional eye-tracker device.

1. Description of the problem

In fMRI images (T2\* contrast), eye vitreous look bright and optic nerves are visible. However, those regions have low signal-to-noise ratio and the eyes look distorted. In addition, temporal resolution of eye movements are much faster that fMRI’s temporal resolution, therefore it is harder to catch the eye position at each volume.

1. Related work

Previous work successfully detected eye position over time using fMRI images [5]. However, they have used a deep-learning-based model trained on healthy population and the output is one position for both eyes. There is a need for unsupervised model that can be applied in any kind of population and decides the position for both eyes separately in case the sample represents a special population.

1. Solution to the problem

We used an fMRI dataset of stroke patients healthy controls [5]. Data was scanned during a resting-state paradigm and subjects were asked to fixate on the center of the screen during the experiment. After applying conventional fMRI preprocessing steps [6] on the dataset, we applied an affine registration on eye regions. We aligned each fMRI volume of eye regions to the first time point and saved 6 motion parameters (translation and rotation in x, y, and z directions). The 6 parameters were used to create a composite measure called “frame-wise displacement”, that shows the magnitude of movement compared to the first time point. This metric was used as a marker for eye movement information. The mean frame-wise displacement of each stroke patient (N = 84) was correlated with their lesion size (Spearman’s r=-0.25, p=0.02) and NIHSS score (indicator of stroke severity, r=-0.28, p=0.01).

1. Conclusions and future work

Unsupervised linear methods are promising to derive eye movement information from fMRI images. The extracted information can be used investigate the relationship between neural and oculomotor dynamics. The proposed method will be refined to characterize the exact location of the eyes in order to allow for more sensitive analyses.

Acknowledgements. This work was created within the project of the Minister of Science and Higher Education ‘‘Support for the activity of Centers of Excellence established in Poland under Horizon 2020’’ on the basis of the contract number MEiN/2023/DIR/3796, and has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857533. This publication is supported by Sano project carried out within the International Research Agendas programme of the Foundation for Polish Science, co-financed by the European Union under the European Regional Development Fund.

References

[1] Yunjie Tong, Kimberly P Lindsey, Lia M Hocke, Gordana Vitaliano, Dionyssios Mintzopoulos, and Blaise deB Frederick. Perfusion information extracted from resting state functional magnetic resonance imaging. Journal of Cerebral Blood Flow & Metabolism, 37(2):564–576, 2017

[2] Yunjie Tong, Jinxia Yao, J Jean Chen, and Blaise deB Frederick. The resting-state fmri arterial signal predicts differential blood transit time through the brain. Journal of Cerebral Blood Flow & Metabolism, 39(6):1148–1160, 2019.

[3] Michael S Beauchamp. Detection of eye movements from fmri data. Magnetic Resonance in Medicine: An Official Journal of the International Society for Magnetic Resonance in Medicine, 49(2):376–380, 2003.

[4] Markus Frey, Matthias Nau, and Christian F Doeller. Magnetic resonance-based eye tracking using deep neural networks. Nature neuroscience, 24(12):1772–1779, 2021

[5] Maurizio Corbetta, Lenny Ramsey, Alicia Callejas, Antonello Baldassarre, Carl D Hacker, Joshua S Siegel, Serguei V Astafiev, Jennifer Rengachary, Kristina Zinn, Catherine E Lang, et al. Common behavioral clusters and subcortical anatomy in stroke. Neuron, 85(5):927–941, 2015.

[6] Oscar Esteban, Christopher J Markiewicz, Ross W Blair, Craig A Moodie, A Ilkay Isik, Asier Erramuzpe, James D Kent, Mathias Goncalves, Elizabeth DuPre, Madeleine Snyder, et al. fmriprep: a robust preprocessing pipeline for functional mri. Nature methods, 16(1):111–116, 2019.