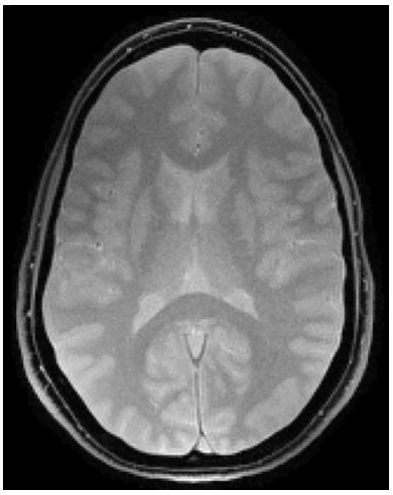
**Biomedical Imaging FS 2019**

**MRI 3**

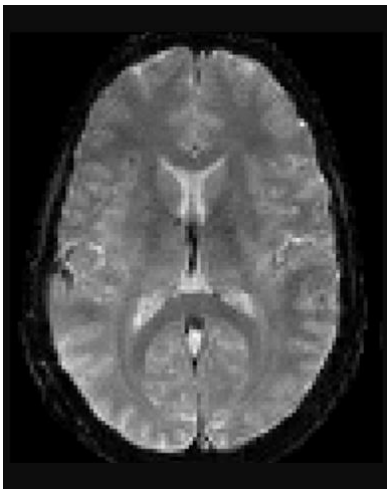
**Exercises**

The topic of this exercise is fMRI, i.e., functional MRI of the brain. Its goal is to detect brain activity based on a time series of images obtained while stimulating the brain with visual input.

Imaging was limited to a single transverse slice and performed with an echo-planar technique, scanning all of k-space for each image in one go (in 40 msec). Imaging was repeated every 3 sec, yielding 200 frames in a total of 10 min.

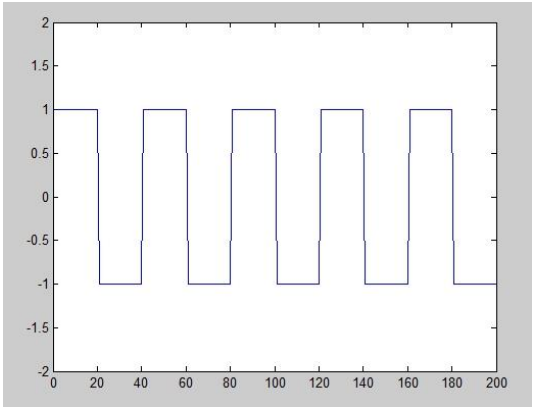


Anatomical image



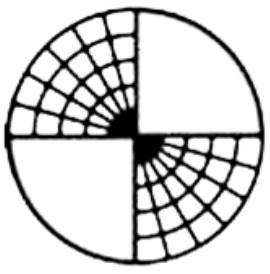
One frame of the time series

During these 10 minutes the brain was stimulated by visual presentation of (on-off) flickering patterns. The stimulation scheme ('paradigm') consisted in alternating between the two complementary wedge patterns shown below, comprising 10 episodes of 1 min each.

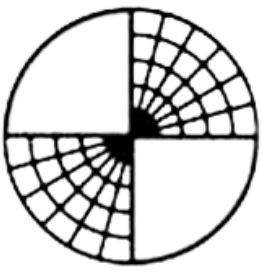



Stimulation paradigm, 10 min

Flickering patterns



Input = 1



Input = -1

The prepared code reads in

- a high-resolution anatomical image of the slice
- the paradigm
- the fMRI data set

**Tasks**

1. Display and study the signal time series of individual pixels of your choice. Try to find pixels whose temporal fluctuation resembles the paradigm.
   Pixels whose signal follows the paradigm are found in the very back of the head.

2. Quantify the resemblance with the visual paradigm by calculating the scalar product (= product summed over time) of the pixel time series and the paradigm. Calculate the scalar product for all pixels and display the results as an image ('activation map').

3. Calculate the temporal standard deviation of the time series and display it as map. Estimate the thermal noise level from an area without activation.

4. To distinguish activations from noise choose a threshold and mask the activation map accordingly. Display the masked activation superimposed on the anatomical data. Propose an interpretation of the result. What does the sign of the activation indicate?

   A safe threshold is obtained by multiplying the noise level with a safety factor (set to 5 in the code). Activation above this threshold can be considered real with a high level of confidence.
   Interpretation: The observed signal responses to the visual stimulation reflect activity of those parts of the brain that process visual input. These are indeed located in the back of the head, in the so-called 'visual cortex'. The first processing stages in the cortex have similar spatial arrangement as the sensor cells in the eye from which they receive their inputs. The sensor cells in the eye are stimulated by an image produced by the eye's optical apparatus the back of the eye. So the spatial arrangement of stimulated cells in the cortex corresponds to the patterns shown during the experiment. The left cortex processes the right visual half-field and vice versa. As a result the activation map looks like the difference of the two stimulation patterns. The sign of the activation reflects the signs given to the two patterns.