NifTI files are used to store images of brain scans taken with MRI machines.

This livescript will explore what is in a typical NifTI file, as well as demonstrate basic plotting functions in Matlab.

Data is from https://openneuro.org/datasets/ds000228/versions/1.1.1

Warning! You will need the Image Processing Toolbox. If its not already installed, it can be in a few clicks after running the cell below

Firstly, let's examine the header.

```
file = 'sub-pixar023/func/sub-pixar023_task-pixar_bold.nii.gz'; % gz
extraction done automatically
info = niftiinfo(file);

info.raw
```

```
ans = struct with fields:
        sizeof_hdr: 348
          dim_info: '9'
               dim: [4 64 64 32 168 0 0 0]
         intent_p1: 0
         intent_p2: 0
         intent_p3: 0
       intent_code: 0
          datatype: 4
            bitpix: 16
       slice_start: 0
            pixdim: [-1 3 3 3.3000 2 0 0 0]
        vox_offset: 352
         scl_slope: 1
         scl_inter: 0
         slice_end: 0
        slice_code: 2
        xyzt_units: 10
           cal_max: 0
           cal_min: 0
    slice_duration: 0
           toffset: 0
           descrip: 'TE=30;Time=103556.212;phase=1;dwell=0.500'
          aux_file: 'imgComments'
        qform_code: 1
        sform_code: 1
         quatern_b: -0.0373
         quatern_c: 0.9912
         quatern_d: -0.1170
         qoffset_x: 100.5703
         qoffset_y: -60.3081
         qoffset_z: -18.6319
            srow_x: [-2.9773 -0.1877 -0.3482 100.5703]
            srow_y: [-0.2563 2.9096 0.7531 -60.3081]
            srow_z: [-0.2641 -0.7065 3.1940 -18.6319]
       intent_name: ''
             magic: 'n+1 '
```

The most important information is the dim info. This tells us the dimensions of the MRI data.

```
dim: [4 64 64 32 168 0 0 0]
```

The first number reveals the dimensionality of the data, in this case 4. Thus the data is described by the 4 following numbers. The last three fields are ignored.

The next two give the dimensions of the images themselves. Here we see the images are 64 x 64 pixels.

Next we have the number of images in the z direction - here we have 32 slices of the brain.

Lastly there is the temporal variations - we have 168 separate points in time at which images were recorded.

To summarise:

```
dim: [no. dimensions, x_dimension, y_dimension, z_dimension, time_dimension, ...]
```

Accessing Data

The images are stored as an array. To work with the 6th image in the z-direction taken at the first time epoch, do

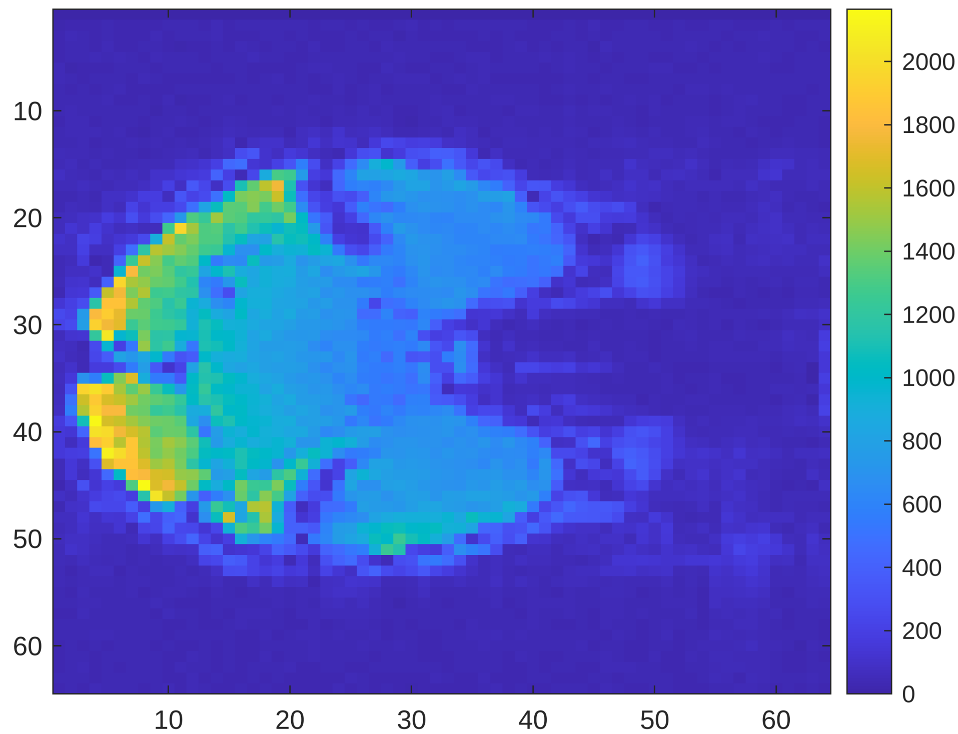
```
V = niftiread(file);
img = V(:,:,6,1);
img
```

```
img = 64×64 int16 matrix
     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0 ...
    23    33    26    28    42    32    31    27    28    34    34    36    31    43    31    39
    32    47    38    30    42    30    32    27    45    26    42    36    34    46    28    27
    30    37    38    30    46    27    30    35    35    32    25    30    32    34    32    47
    32    37    40    44    35    46    34    30    45    37    38    34    30    38    40    38
    49    25    32    31    33    41    38    41    31    36    37    35    36    33    36    35
    46    34    31    35    41    36    33    43    38    31    30    33    30    32    31    34
    35    30    36    28    37    50    31    30    31    29    42    37    36    36    35    39
    39    39    38    39    43    31    31    34    30    44    24    27    33    41    44    28
    35    45    39    38    37    37    36    35    25    38    41    31    40    39    35    36
     ⋮
```

we can see this is a square array of size 64, as expected from the header.

Viewing the image is simple:

```
image(img,'CDataMapping','scaled')
colorbar
```



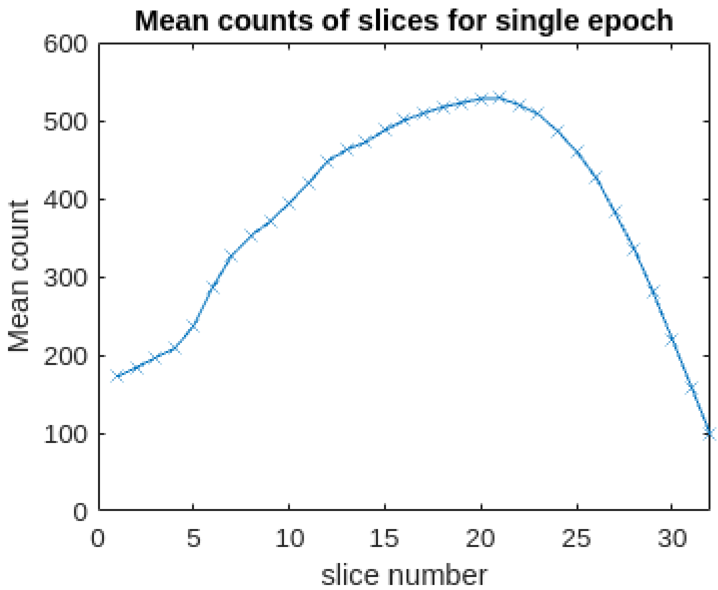
Extracting Statistics

Which slice of the brain is the most active at the first time epoch? Let's average across all 32 images

```
imgs = V(:,:,:,1);
imgs_mean = mean(imgs, [1,2]); % average over 1st and 2nd dimensions. Here x
and y of image plane
imgs_mean = reshape(imgs_mean,1,[]); % reshape to 1D array
```

Now make a plot of the averages

```
h = plot(imgs_mean,"LineStyle","-",...
"Marker","x");

ylabel("Mean count")
xlabel("slice number")
title("Mean counts of slices for single epoch")
```



Is there a point in time at which the brain was most active? Let's now average over time

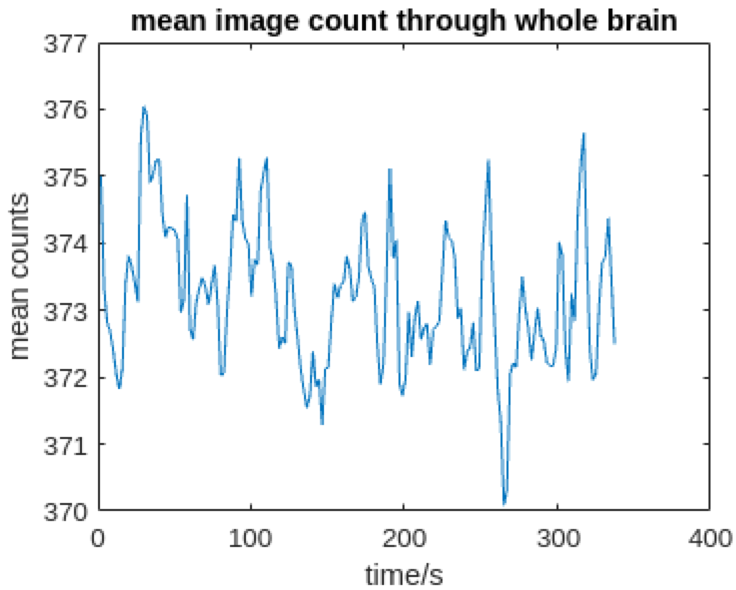
```
time_avg = mean(V, [1,2,3]);
time_avg = reshape(time_avg,1,[]);
```

A plot can also be made using the interactive Create Plot - **SO EASY!**

Time of image acquisition

That's nice but we still don't know anything about the time resolution of the images. This information is stored in a json file.

```
text = fileread("sub-pixar023/func/sub-pixar023_task-pixar_bold.json");
data = jsondecode(text);

times = data.time.samples.CsaImage_TimeAfterStart;

h3 = plot(times,time_avg,"DisplayName","time_avg");

% Add ylabel, title, and legend
ylabel("mean counts")
xlabel("time/s")
title("mean image count through whole brain")
```



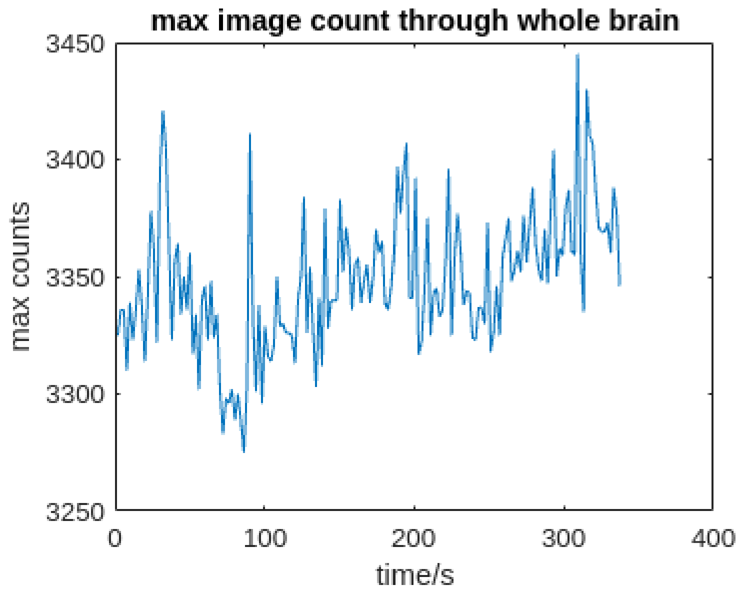
Thoughts

How do you interpret the plot of mean counts vs. time?

Is mean counts the best metric for brain activity?

Let's investigate the maximum count for each time epoch

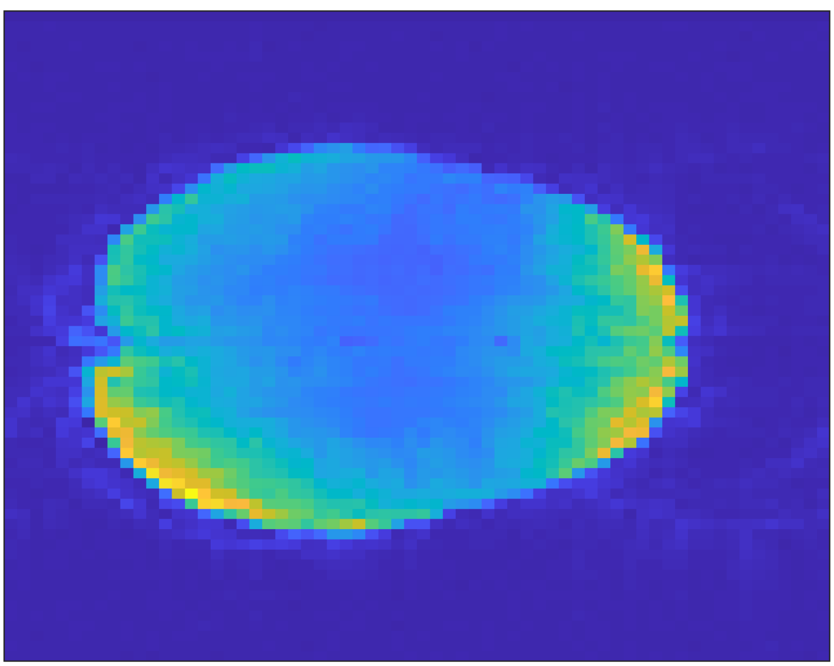
```
res =[];
%should be possible usine max function, but I couldn't do it
for i =1: size(V, 4) % loop over time dim.
    vv = V(:,:,:,i);
    vv_max= max(vv,[],[1,2,3]);
    vv_max = reshape(vv_max,1,[]);
    res = [res; vv_max];
end

plot(times,res);
ylabel("max counts")
xlabel("time/s")
title("max image count through whole brain")
```



Interactive plot with slider

When the two sliders are moved, the plotted data is changed. NB. only works in Matlab live script

```
slice_num = 23;
time_index = 87;
im1 = image(V(:,:,slice_num,time_index),'CDataMapping','scaled');
set(gca,'XTick',[], 'YTick', []) % remove axis tick labels
```



```
help max
```

```
max    Maximum elements of an array.
   M = max(X) is the largest element in the vector X. If X is a matrix, M
   is a row vector containing the maximum element from each column. For
   N-D arrays, max(X) operates along the first non-singleton dimension.

   When X is complex, the maximum is computed using the magnitude
   max(ABS(X)). In the case of equal magnitude elements the phase angle
   max(ANGLE(X)) is used.

   [M,I] = max(X) also returns the indices corresponding to the maximum
   values. The values in I index into the dimension of X that is being
   operated on. If X contains more than one element with the maximum
   value, then the index of the first one is returned.

   C = max(X,Y) returns an array with the largest elements taken from X or
   Y. X and Y must have compatible sizes. In the simplest cases, they can
   be the same size or one can be a scalar. Two inputs have compatible
   sizes if, for every dimension, the dimension sizes of the inputs are
   either the same or one of them is 1.

   M = max(X,[],"all") returns the largest element of X.

   [M,I] = max(X,[],"all") also returns the linear index into X that
   corresponds to the maximum value over all elements in X.

   M = max(X,[],DIM) or [M,I] = max(X,[],DIM) operates along the
   dimension DIM.

   M = max(X,[],VECDIM) operates on the dimensions specified in the vector
   VECDIM. For example, max(X,[],[1 2]) operates on the elements contained
   in the first and second dimensions of X.

   C = max(...,NANFLAG) specifies how NaN values are treated:

   "omitmissing" / "omitnan"       -
                  (default) Ignores all NaN values and returns the maximum
                  of the non-NaN elements.  If all elements are NaN, then
                  the first one is returned.
   "includemissing" / "includenan" -
                  Returns NaN if there is any NaN value. The index points
                  to the first NaN element.

   [M,I] = max(X,[],...,'linear') returns the linear index into X that
   corresponds to the maximum value in X.

   C = max(...,'ComparisonMethod',METHOD) specifies how to compare input
   values. The value of METHOD must be:

       "auto" - (default) Compares real numbers according to "real", and
                complex numbers according to "abs".
       "real" - Compares according to REAL(A). Elements with equal real
                parts are then sorted by IMAG(A).
       "abs"  - Compares according to ABS(A). Elements with equal
                magnitudes are then sorted by ANGLE(A).

   Example:
       X = [2 8 4; 7 3 9]
       max(X,[],1)
       max(X,[],2)
       max(X,5)

   See also min, bounds, cummax, median, mean, sort, maxk, islocalmax.
```

Documentation for max
Other uses of max