Report – Brain Mapping Steps

Inputs:

- electrode locations ($Elec(x_e, y_e, z_e)$ which have been registered on scalp mesh) and corresponding labels and a vector of values $Values_{(x_e, y_e, z_e)}$ for electrodes
- scalp mesh locations (vertices) $(Vertices\ (x_v, y_v, z_v))$

purpose:

- find a vector of values for mesh nodes from vector of values of electrodes by interpolation (semi bicubic method)

Procedure to achieve a value for each scalp mesh vertex by bicubic interpolation

1. find neighbouring electrodes for each EEG electrode
   method: by triangulation connections neigbouring electrodes are detected

2. Find at least 4 neighbouring electrodes locations
   $(Elec1(x_{e1}, y_{e1}, z_{e1}), Elec2(x_{e2}, y_{e2}, z_{e2}), Elec3(x_{e3}, y_{e3}, z_{e3}), Elec4(x_{e4}, y_{e4}, z_{e4}))$
   for each scalp mesh vertex location $(Vertices\ (x_{vi}, y_{vi}, z_{vi}))$
   method:
   1. find nearest electrode to each scalp mesh vertex by finding minimum distance

   2. allocating the selected nearest electrode and its neighbours as the vertex neigbours

   3. find first 4 nearest neigbouring electrodes from the defined neigbours for each vertex

   4. Sort four neigbouring electrodes and their values in counterclockwise order positioning

      ([0,0]-->[10]-->[11]-->[01]) corresponding to
      $(Elec1(x_{e1}, y_{e1}, z_{e1}), Elec2(x_{e2}, y_{e2}, z_{e2}), Elec3(x_{e3}, y_{e3}, z_{e3}), Elec4(x_{e4}, y_{e4}, z_{e4}))$
      neighbouring electrode locations
      And
      $(Values1_{(x_{e1}, y_{e1}, z_{e1})}, Values2_{(x_{e2}, y_{e2}, z_{e2})}, Values3_{(x_{e3}, y_{e3}, z_{e3})}, Values4_{(x_{e4}, y_{e4}, z_{e4})})$
      corresponding values for neighbouring electrodes.
      Bicubic method need input neigbouring electrodoes in counter clock wise order. For this step first electrode locations are mapped from 3D to 2D and then easily sorted by comparing their x and y locations.

3. Allocate value 0 to scalp vertices with no neighbouring electrodes and for other vertices bicubic interpolation is applied to their neigbouring electrodes in the following way:
   For each scalp mesh vertex location $(Vertices\ (x_{vi}, y_{vi}, z_{vi}))$ whith 4 neighbouring electrode locations

$(Elec1(x_{e1}, y_{e1}, z_{e1}), Elec2(x_{e2}, y_{e2}, z_{e2}), Elec3(x_{e3}, y_{e3}, z_{e3}), Elec4(x_{e4}, y_{e4}, z_{e4}))$
a coefficient value $(BLI(x, y) = [\, BLI1\, , BLI2])$ is achieved in x and y, 2 dimensional directions. BLI is in fact the vertex point mapped location between 4 electrodes (which is normalized between 0 and 1)
So, inputs for degree 3/Semi-Bicubic Interpolation (1st & 2nd dr = 0) are:

- $\left(Values1_{(x_{e1}, y_{e1}, z_{e1})}, Values2_{(x_{e2}, y_{e2}, z_{e2})}, Values3_{(x_{e3}, y_{e3}, z_{e3})}, Values4_{(x_{e4}, y_{e4}, z_{e4})}\right)$
- $(BLI(x, y) = [\, BLI1\, , BLI2])$

$Value_{(x_v, y_v, z_v)}$ with Semi-Bicubic Interpolation for $Vertices\ (x_{vi}, y_{vi}, z_{vi})$is calculated as:

$$
\begin{aligned}
a = \{&Values1, 0, -3 * Values1 + 3 * Values2, 2 * Values1 - 2 * Values2, \dots \\
&0\, , 0, 0, 0, -3 * Values1 + 3 * Values4, 0, \dots \\
&9 * Values1 - 9 * Values2 - 9 * Values4 + 9 * Values3, \dots \\
&-6 * Values1 + 6 * Values2 + 6 * Values4 - 6 * Values3, \dots \\
&2 * Values1 - 2 * Values4, 0, \dots \\
&-6 * Values1 + 6 * Values2 + 6 * Values4 - 6 * Values3, \dots \\
&4 * Values1 - 4 * Values2 - 4 * Values4 + 4 * Values3\};
\end{aligned}
$$

$Value_{(x_v, y_v, z_v)} = 0;$

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for i = 0:3
  for j = 0:3
    Value_(x_v,y_v,z_v) = Value_(x_v,y_v,z_v) + a{i * 4 + j + 1}.* (BLI2^i).* (BLI1^j);
  end
end
```

The total time of program for 800 and 5000 scalp mesh points was 5 s and 34 s, respectively.