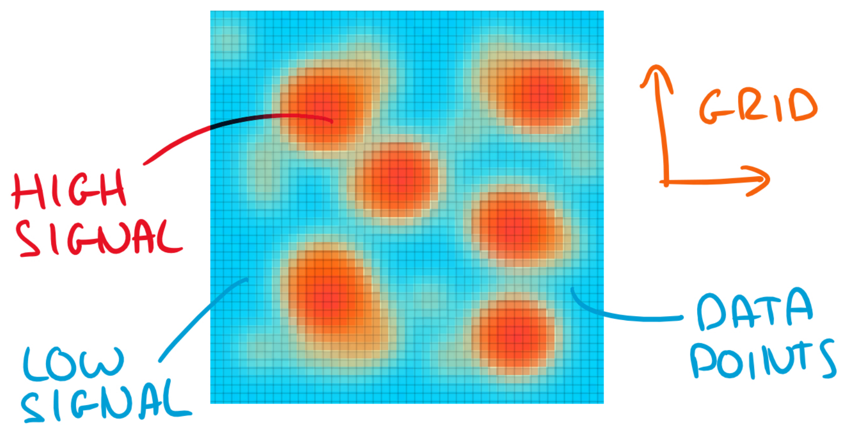
sensing & data processing

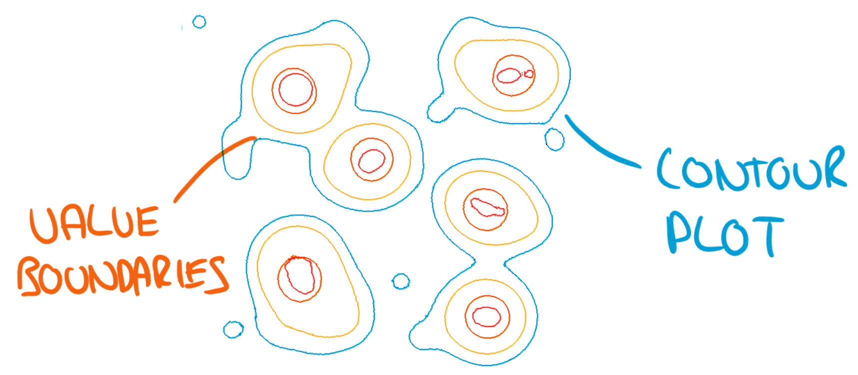
sensing overview

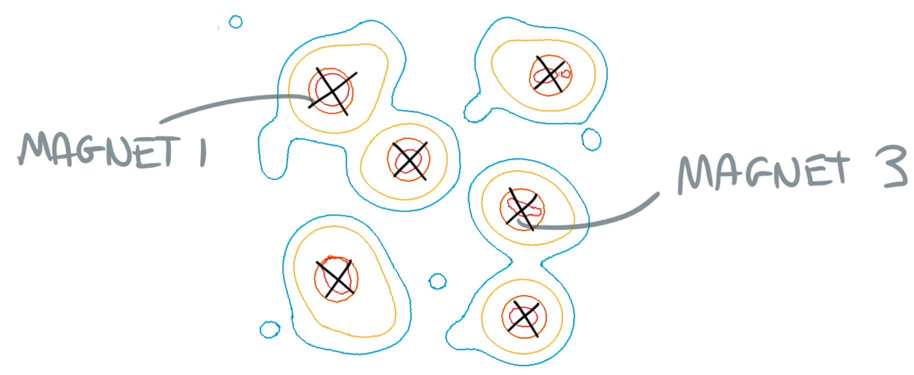
1. Scanning run produces magnetic 'heat-map'

2. Data is processed into more usable form

3. Algorithms determine centre points of magnets

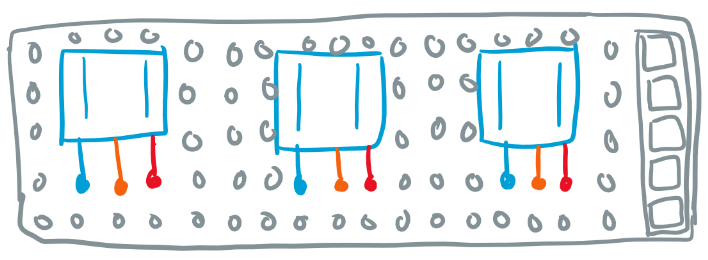




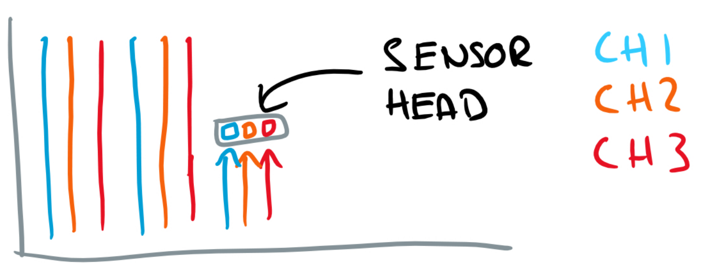


sensor head

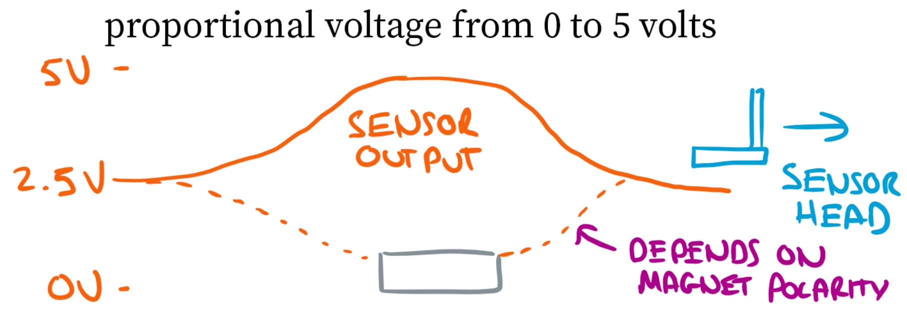
Made from three hall effect sensors in a line



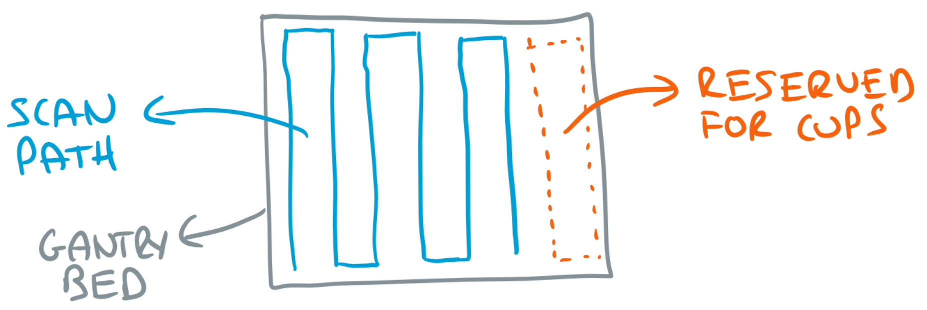
This allows three columns of data to be gathered in a single sweep



As the magnetic field changes, the sensors output a proportional voltage from 0 to 5 volts

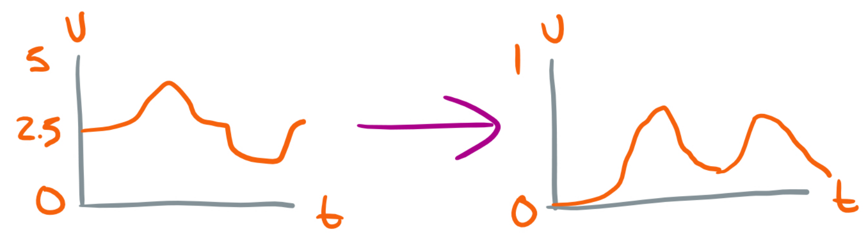


Square wave sweep pattern covers the whole board

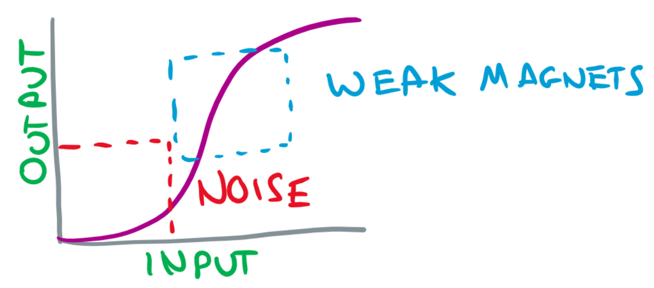


processing steps

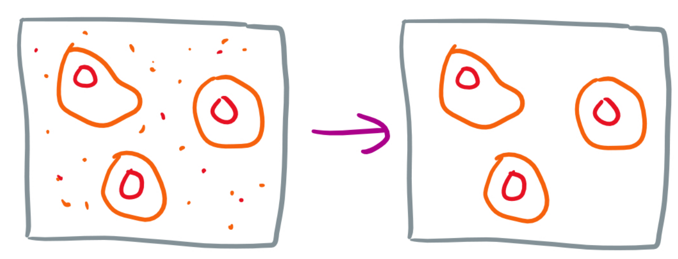
Sensor input is normalised at 0 volts



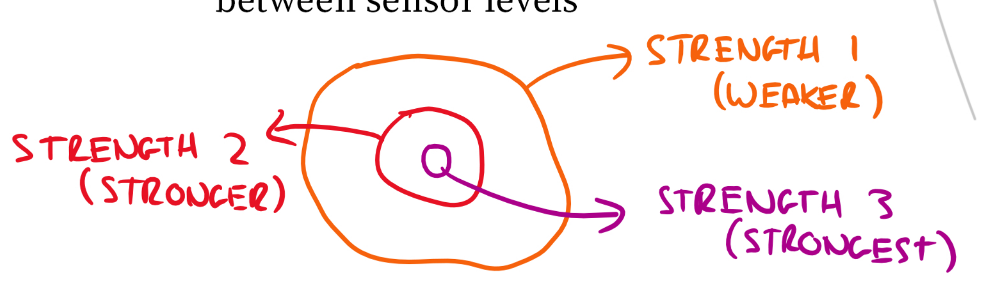
An S curve filter removes weak signals and boosts strong signals, without clipping



Wiener filter removes any remaining noise



Contour plot of data values shows boundaries between sensor levels



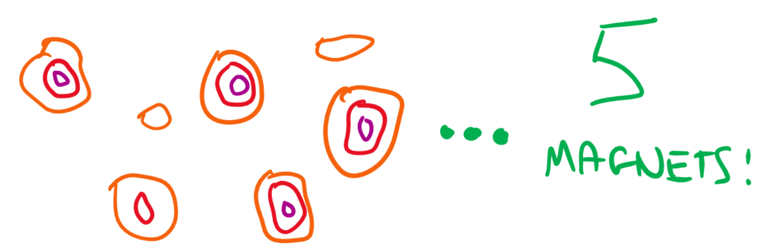
centre point detection

For each contour outline, the centre point is found by averaging x and averaging y points

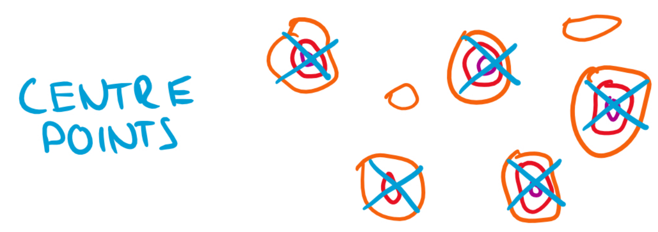
Points are weighted based on their signal strength

WEAK ⇒ LOW WEIGHT
MEDIUM ⇒ MEDIUM WEIGHT
STRONG ⇒ HIGH WEIGHT

Davies-Boildin Criterion estimates the number of magnets present, N



k-means clustering groups data points into N collections, and outputs their centroids



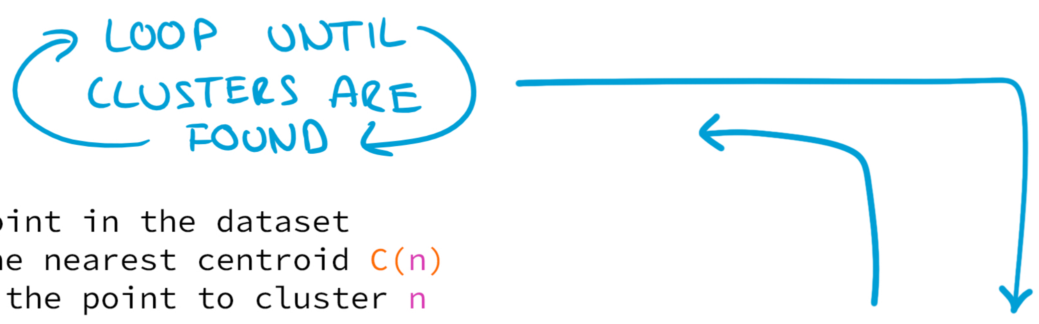
k-means algorithm

```
function[centroids] = kmeans(npoints, datapoints)
```

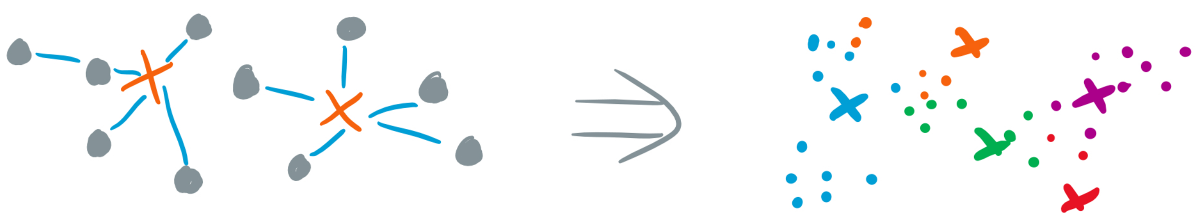
CENTRES OF MAGNETS — HOW MANY MAGNETS — CONTOUR CENTRE POINTS

```
place initial centroids C(1:npoints) at random locations
```


```
while convergence is not reached
```




```
for each point in the dataset
    find the nearest centroid C(n)
    assign the point to cluster n
```



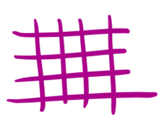
```
for each cluster n
    average the positions of all data points in cluster n
    move centroid C(n) to this average position
```

```
%% Convergence is reached when no points change clusters between
   iterations; the system is steady state.
```

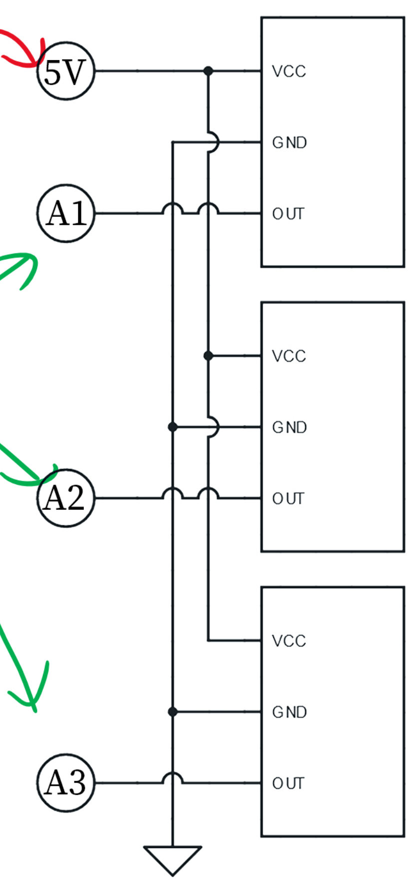
sensor head layout

Common VCC & ground to minimise wiring

Output pins feed straight to Arduino

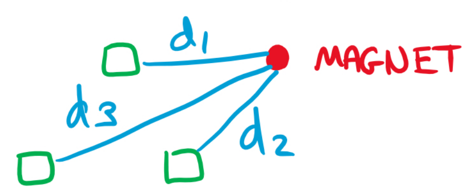


Sensors spaced 10mm apart, resulting in 10mm grid spacing



design evolution

Original concepts included triangulation of three sensor values to determine location of maximum magnetic field



Movement of the sensor head could also be used to determine magnet centres

algorithm selection process

A general process was followed in algorithm selection for signal processing and centre point detection:

1. Research to determine if there is an existing popular algorithm ?
2. Determine if any of these algorithms are available in MATLAB / addons
3. Test the algorithms using generated data and varying parameters, and compare results → A || B