Coverage of Point Clouds

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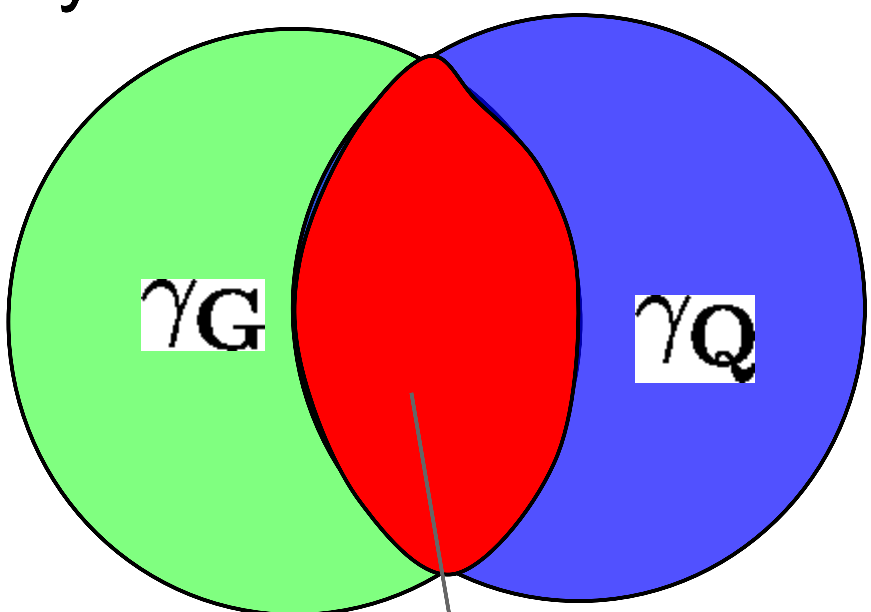
Definition

2 clouds : **Cloud G** and **Cloud Q**

$\gamma_{\mathbf{G}}$ = fraction of total region covered by cloud G ONLY

$$< \gamma_{\mathbf{G}}, \gamma_{\mathbf{Q}} >$$



$$\gamma_{\mathbf{G}\cap\mathbf{Q}} = 1 - \gamma_{\mathbf{G}} - \gamma_{\mathbf{Q}}$$

Examples

- Cloud G and Cloud Q are completely similar.
  - Cover each other completely

$$\implies \gamma_G = 0; \quad \gamma_Q = 0$$

- Cloud G has occluded portions

Cloud Q covers parts that are occluded by G

  - Cloud Q covers γ_Q fraction not covered by G

$$\implies \gamma_G = 0; \quad \gamma_Q = \alpha$$

Approach
Step 1

Partition the points into regions which are covered by

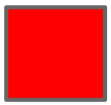
- **Only Cloud G**
- **Both Gloud G and Cloud Q**
- **Only Cloud Q**

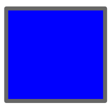
How?

Partitioning points into sets
(parameter : R_{mcd})

For each point p_q in Cloud Q,

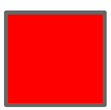
If $\exists$ p_g in Cloud G such that $\mathbf{dist(p_q,p_g) < R_{mcd}}$

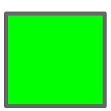
then p_q $\in$ 

Else p_q $\in$ 

|||y for each p'_g in Cloud G,

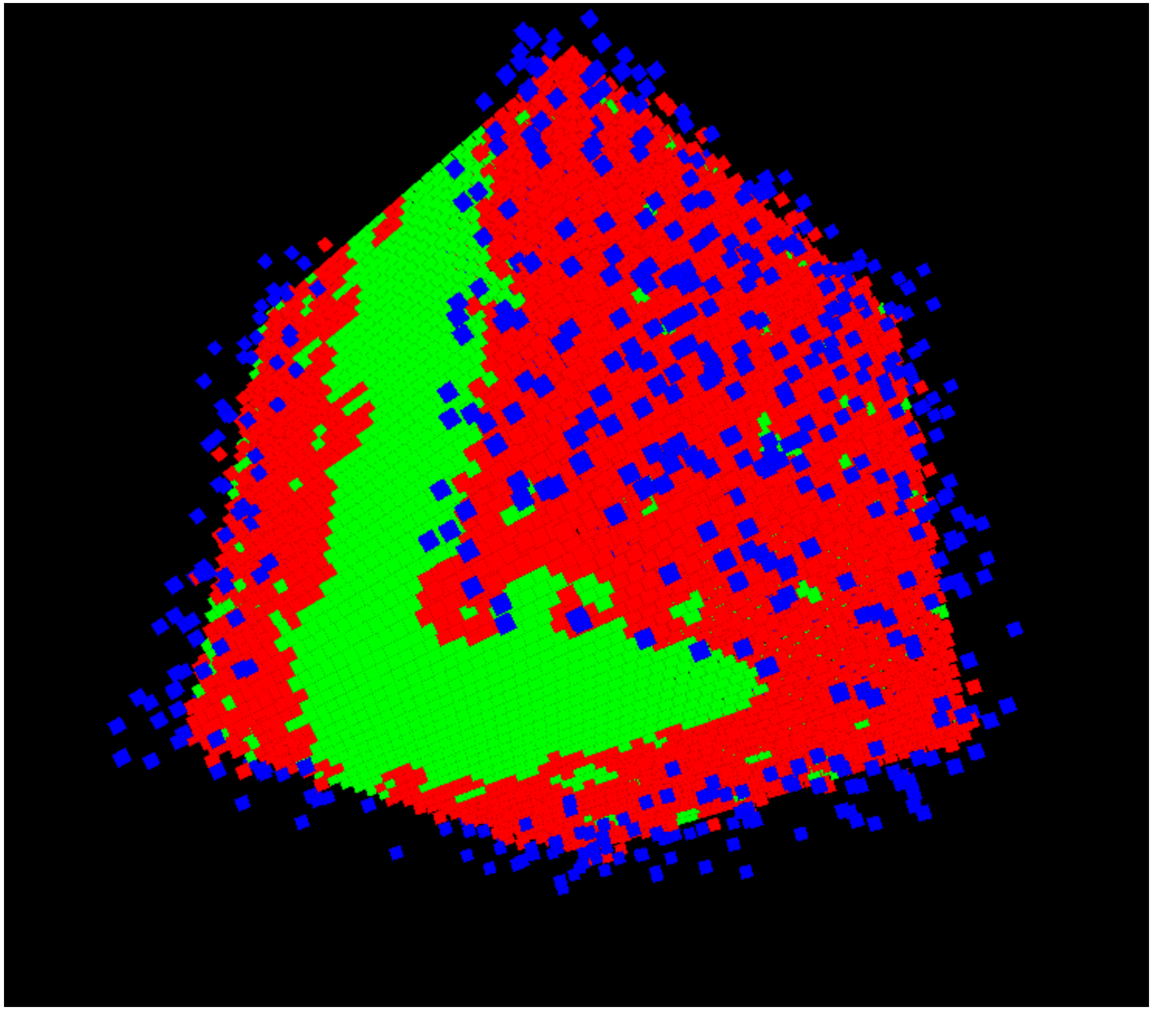
If $\exists$ p'_q in Cloud Q such that $\mathbf{dist(p'_q,p'_g) < R_{mcd}}$

then p'_g $\in$ 

Else p'_g $\in$ 

Example : Occluded Cube

Classify points as belonging to G_cloud, Q_cloud or both acc to nearest neighbor correspondence distance



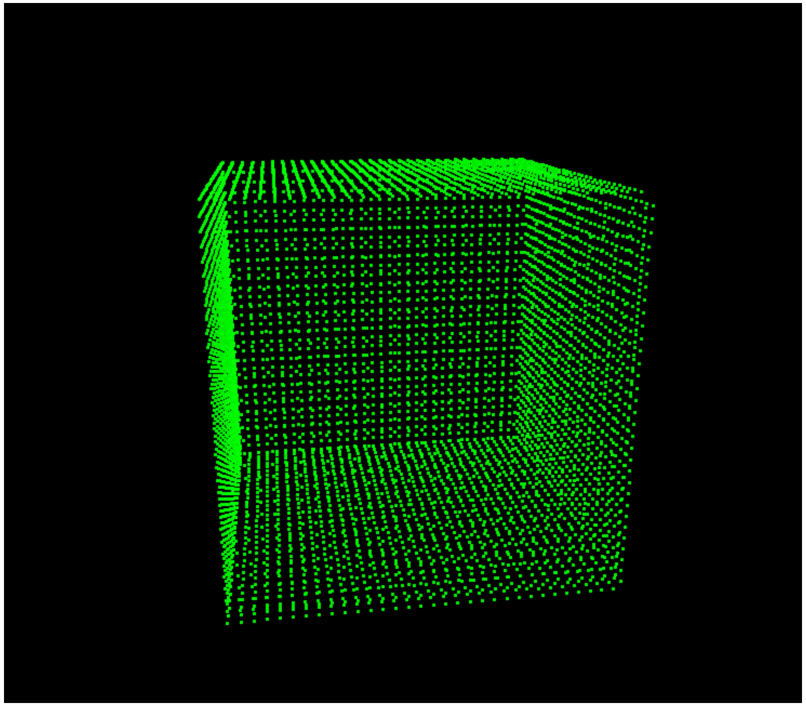
Green => GCloud
Blue => QCloud
Red => Both

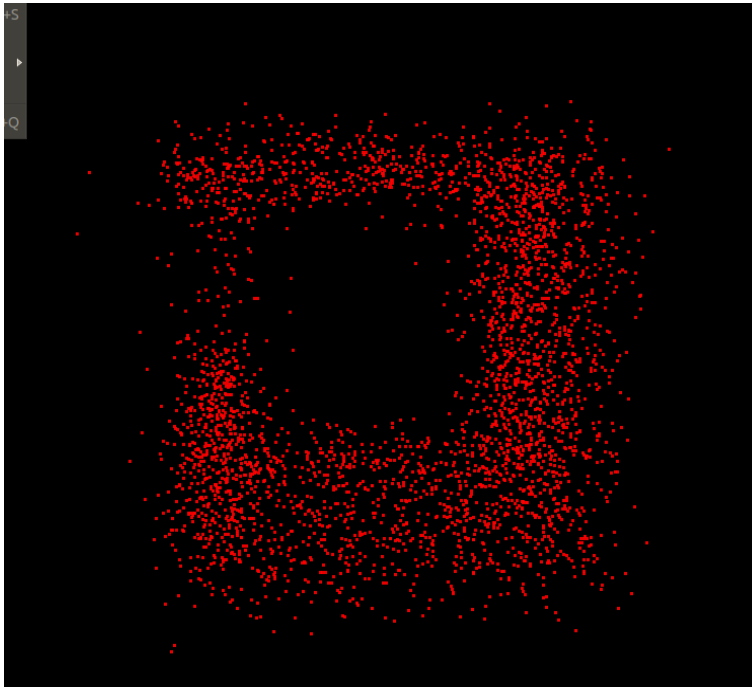
Case Study

Randomly delete parts from the surfaces of cube:

Occlusion Fractions: 0.476096 *0.0206466* 0.413397 *0.130399* 0.842922 0.787669

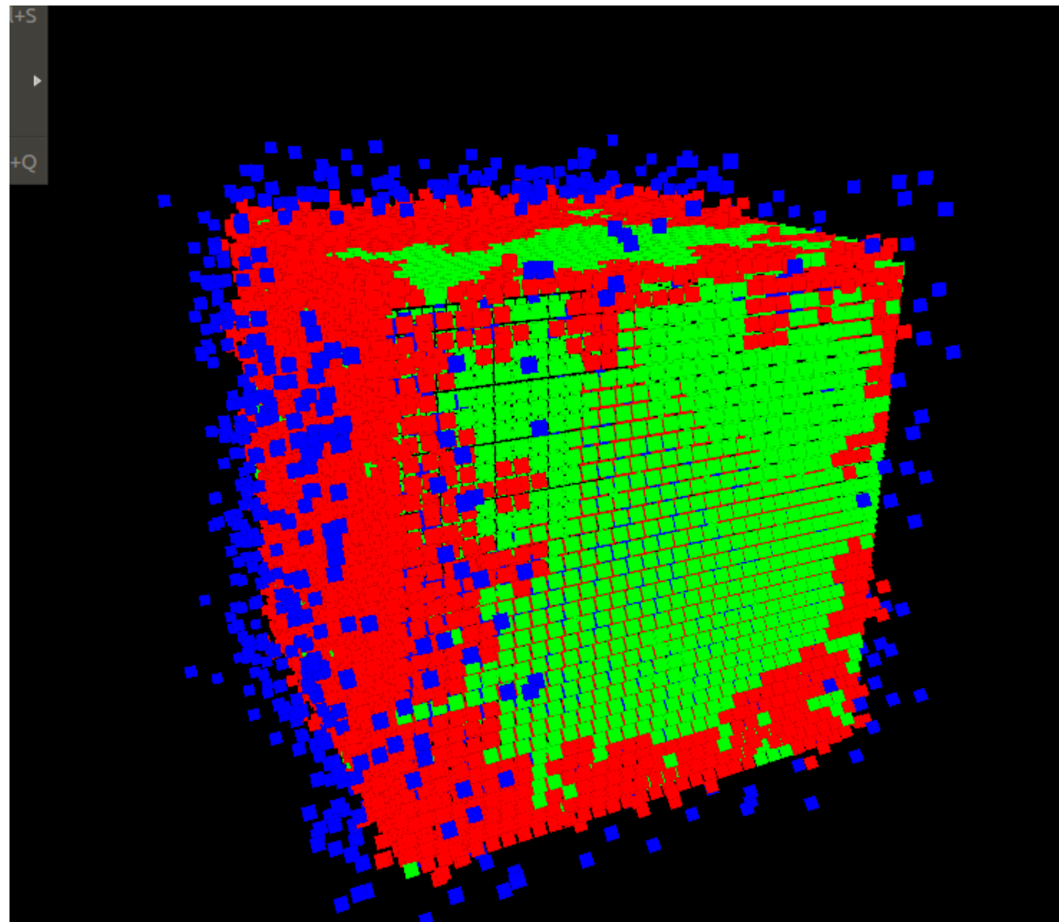
Total occluded fraction : 0.445188





Coverage Cloud : Correspondences

Find correspondences for each point (using R_{mcd}=0.05)



G: 6144

Q: 3417

Both: 6123

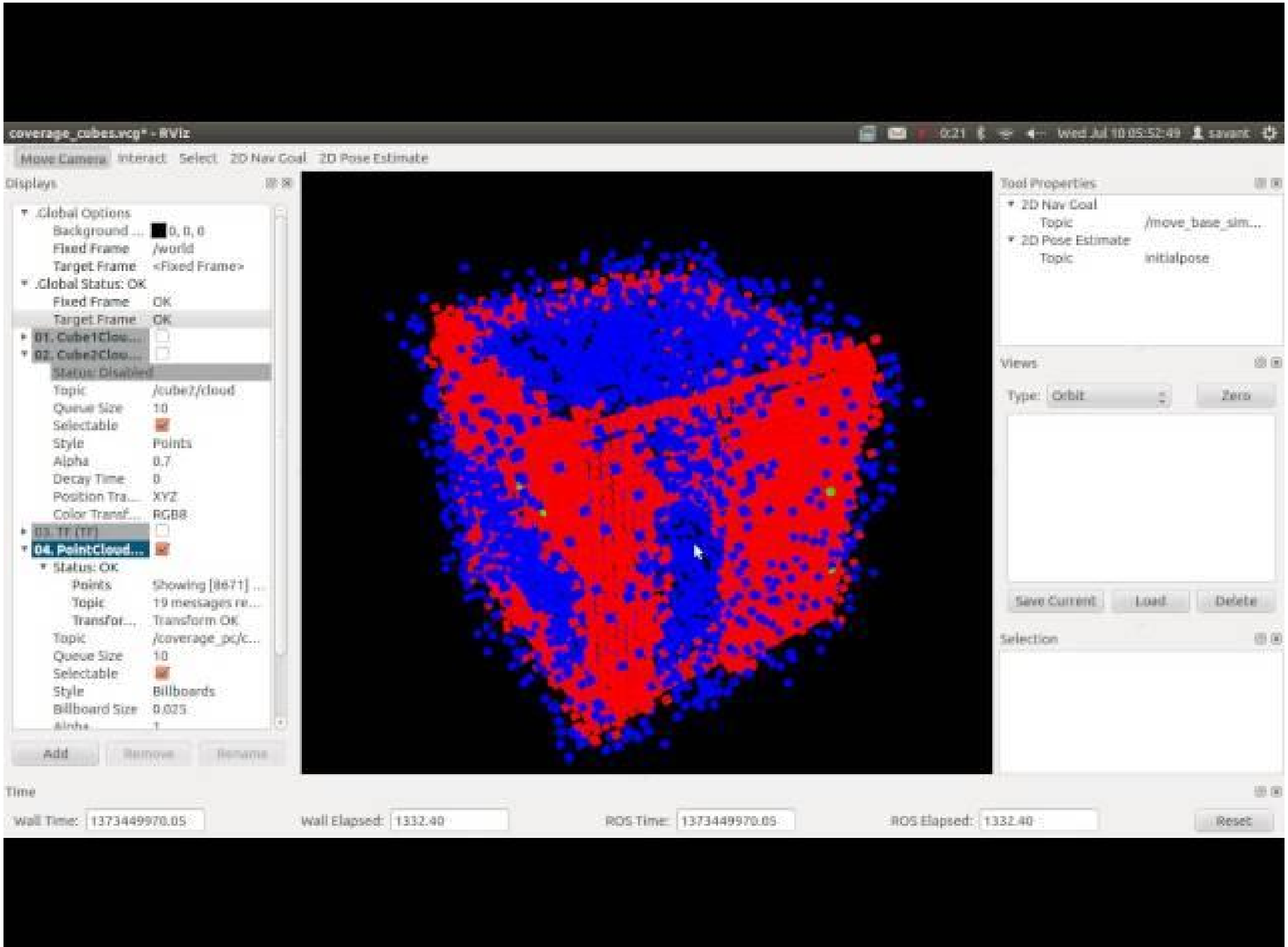
Gcl: 2019

Qcl: 1419

Effect of parameter

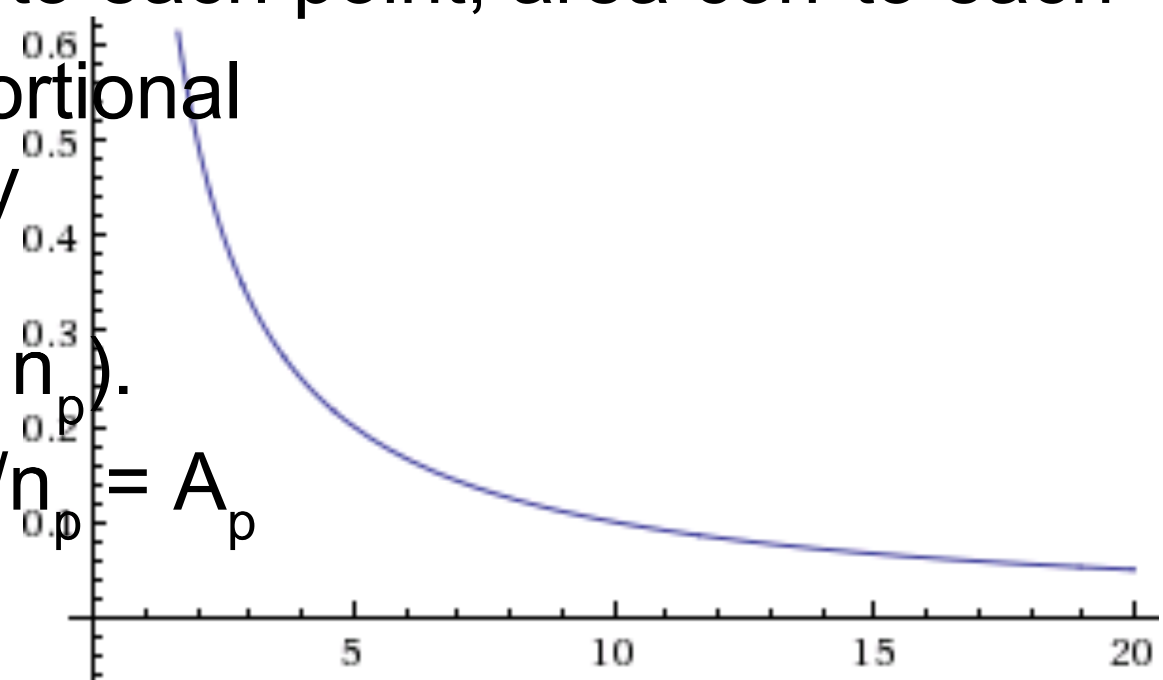
- R_{mcd} affects partitioning
- Very low R_{mcd} => both clouds will be treated as different from each other even if overlapping regions
- Very high R_{mcd} => regions not belonging to both clouds will be wrongly set as belonging to both.

Variation of classification with MCD



Approach
Step 2

- Find the no. of nearest neighbours of point **p** in radius $\mathbf{R_{mcd}}$. Let it be $\mathbf{n_p}$
- Dividing a cross section area of NN sphere pi*R_{mcd}*R_{mcd} to each point, area corr to each point is proportional to the density of points (inv. prop. to n_p).
- pi*R_{mcd}*R_{mcd}/n_p = A_p

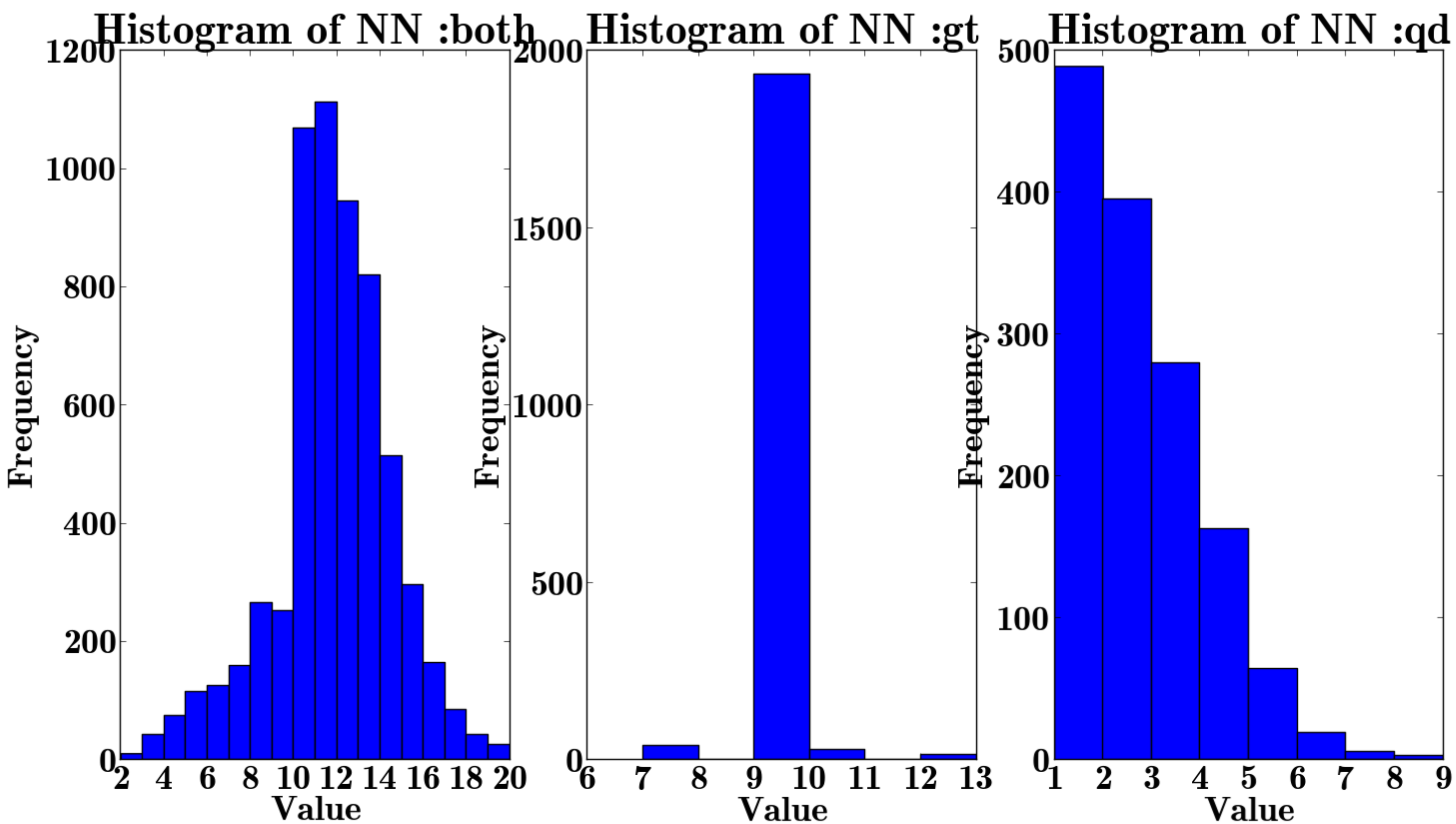


Histogram of NN

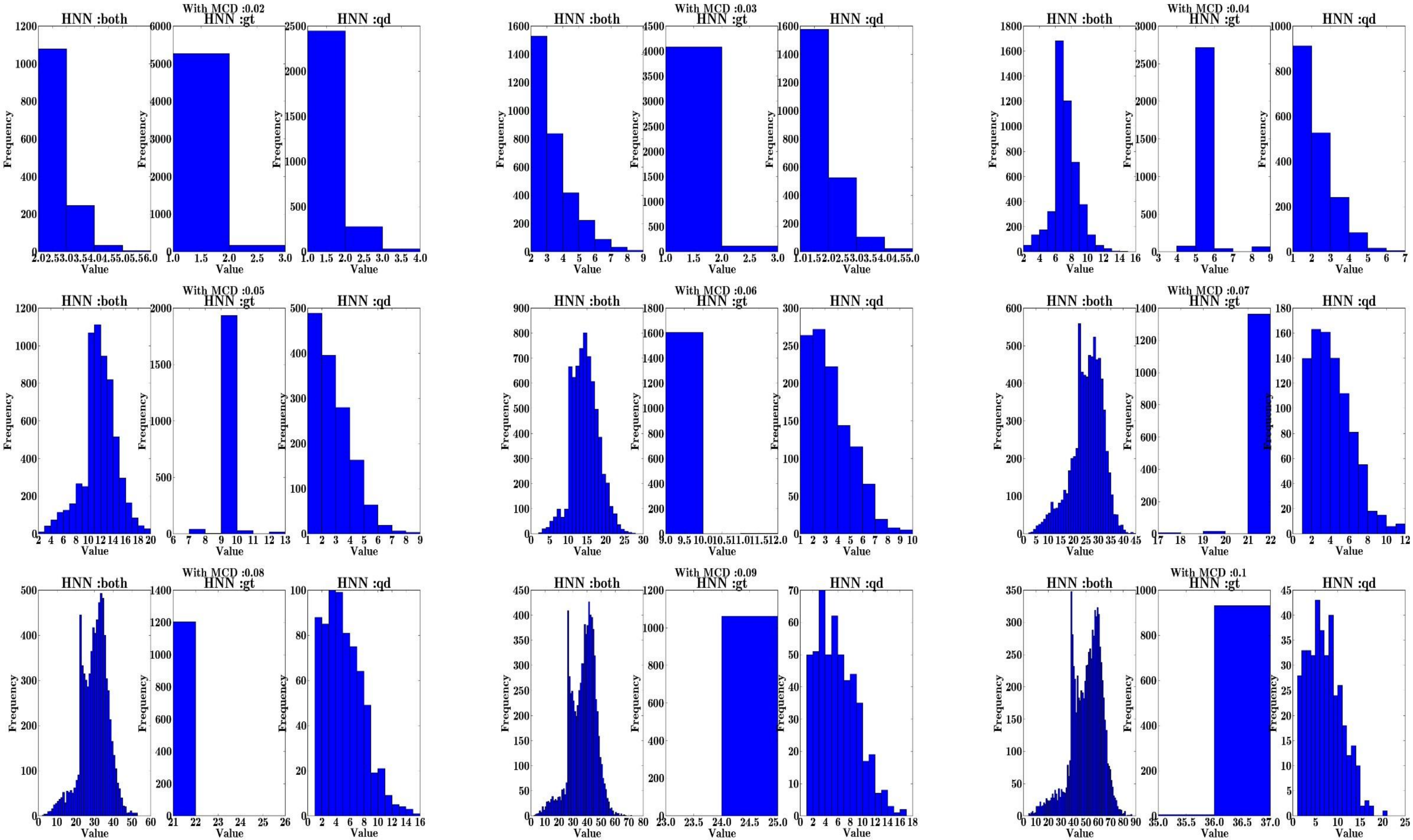
In above case: **1*1*1**

max_correspondence_distance = **0.05**

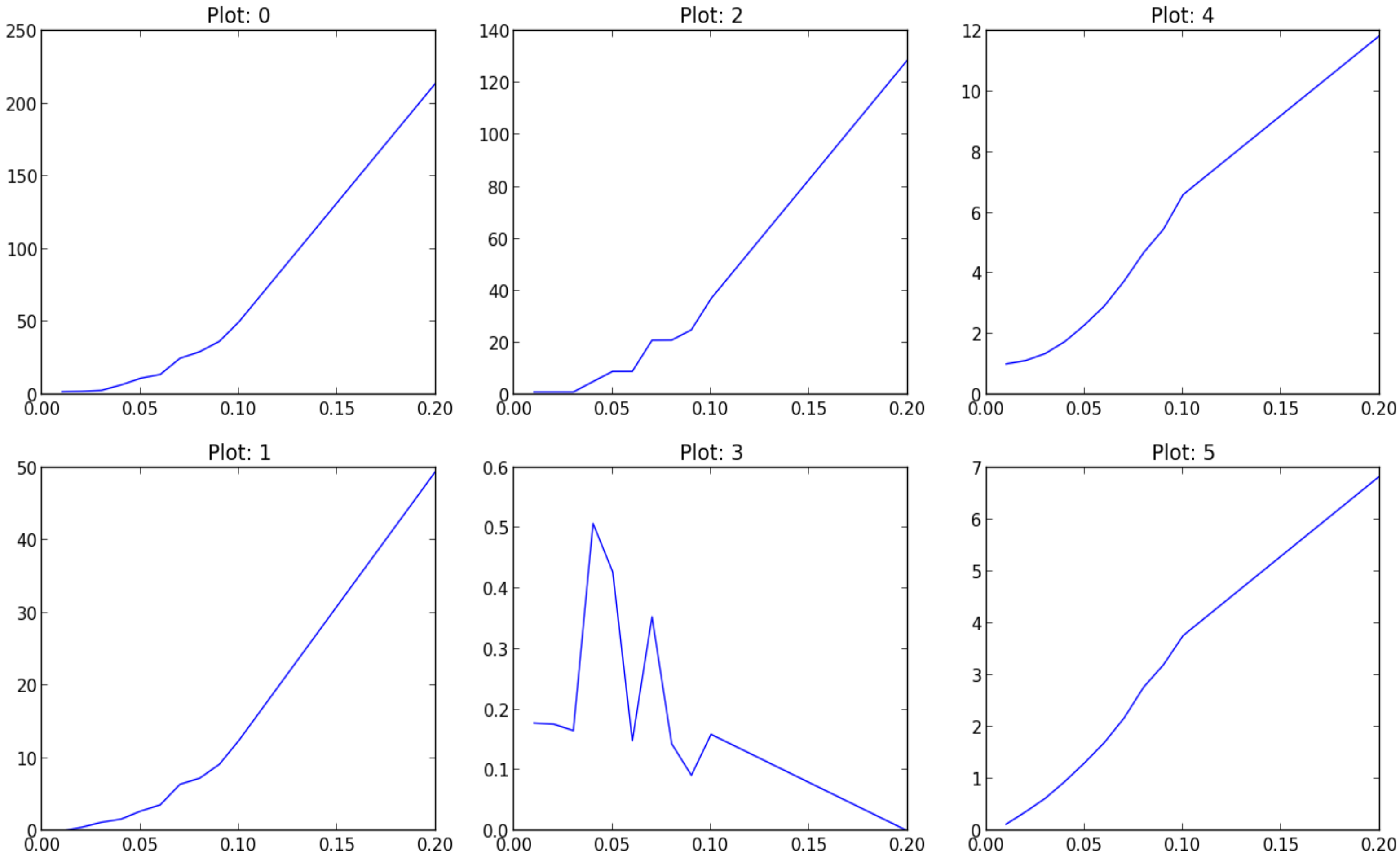
11.31; 2.73 **8.99; 0.43** **2.31; 1.31**



Variation of NN Hist. with MCD



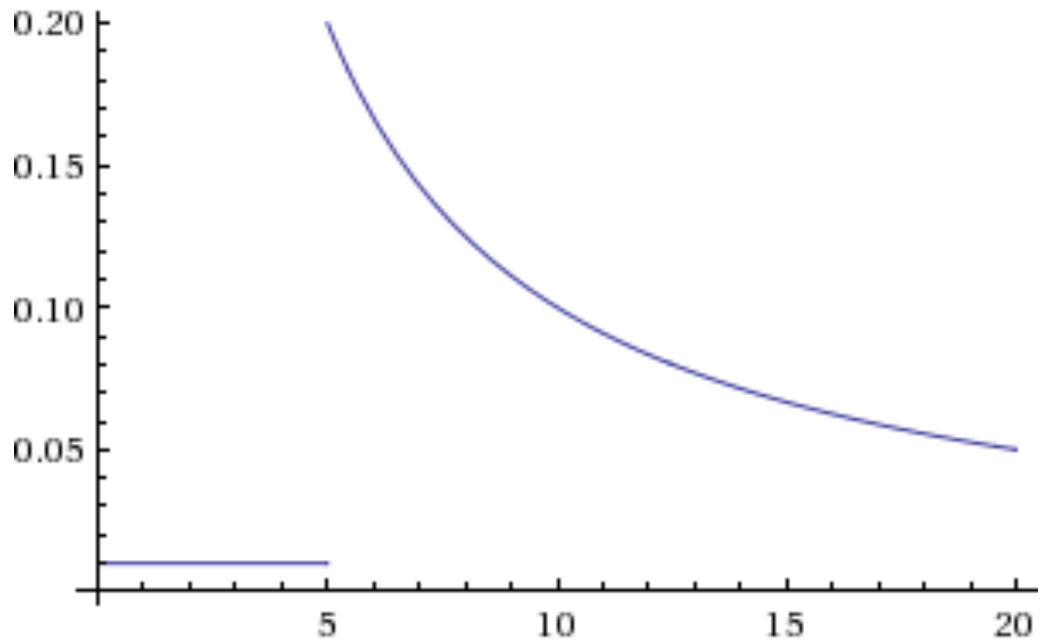
Mean and SD of NN with MCD



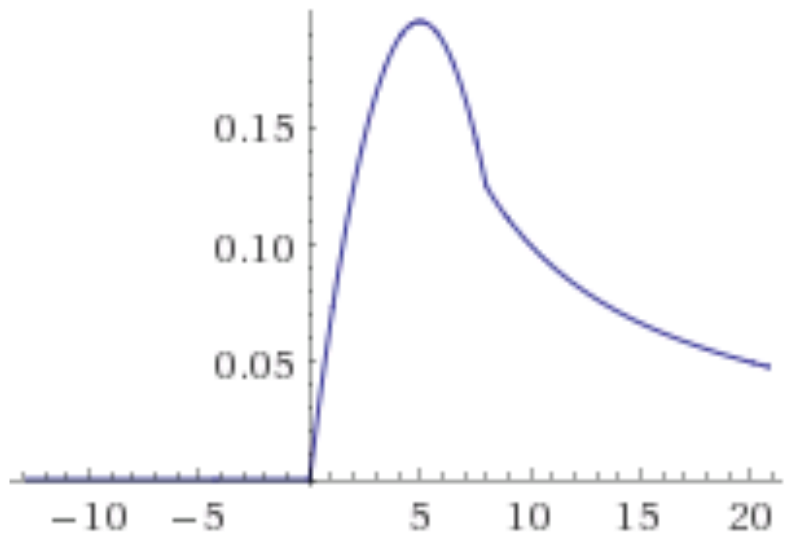
Thresholding area factor

$A_p \quad = 1/n_p \quad \text{if } n_p > n_{threshold}$

$\quad\quad = 0 \quad\quad \text{else}$



Another variation of area weightage

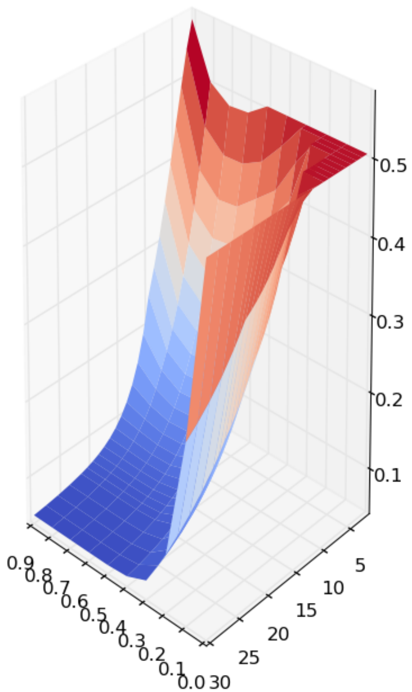


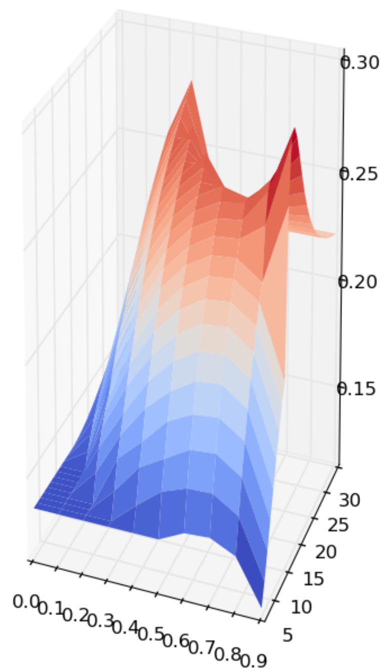
$\eta = 0.8$

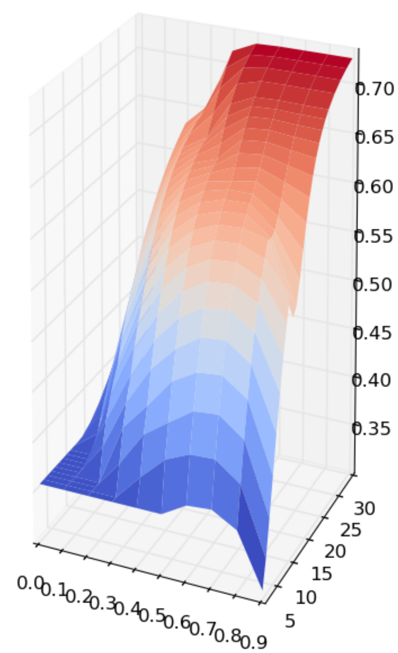
$T = 10$

$$A(x) = \begin{cases} x(T-x)/K, & x \leq \eta T \\ 1/x, & x > \eta T \end{cases}$$

Variation in fraction wrt \eta and T



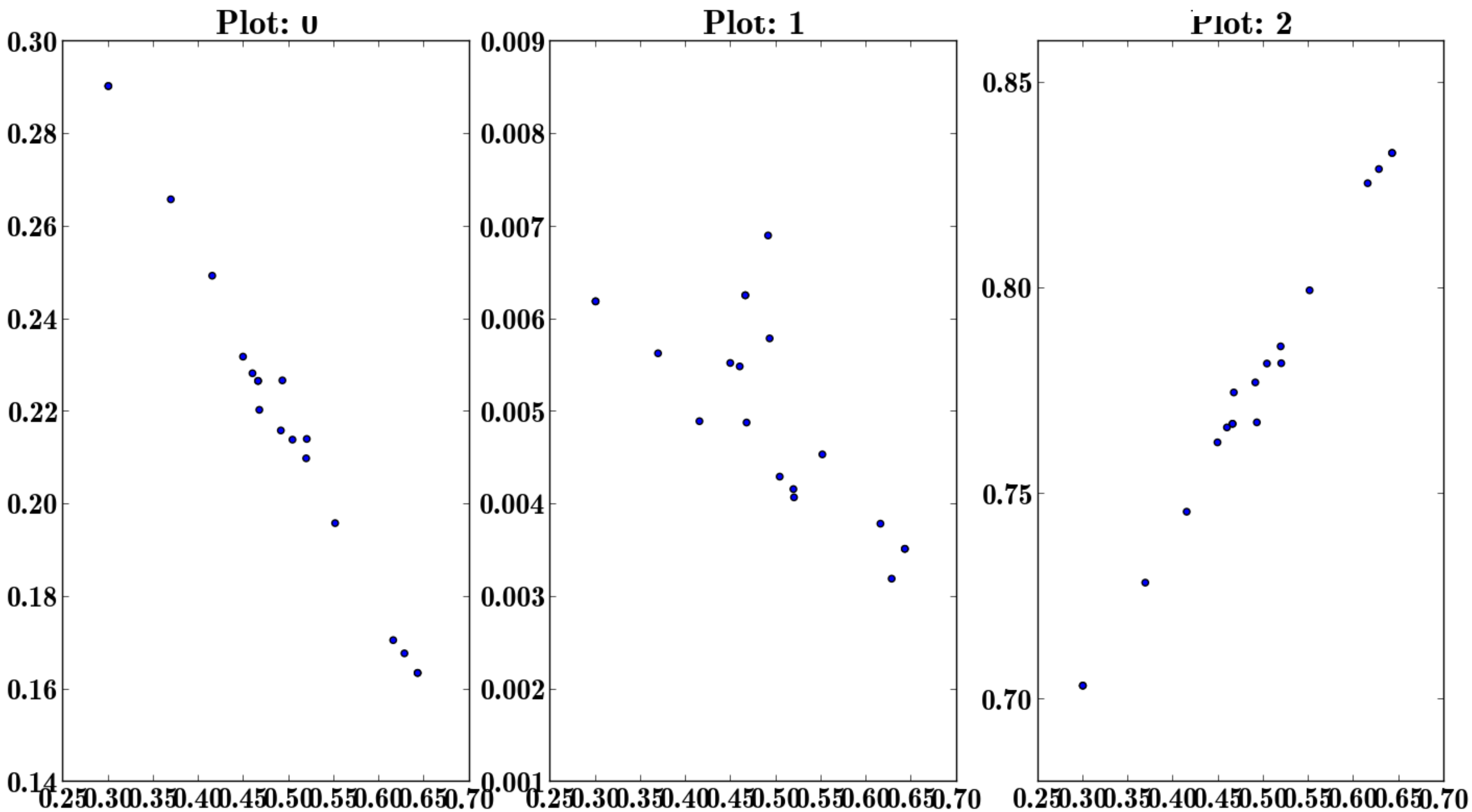




Some Results
(No thresholding) R_{mcd}=0.05

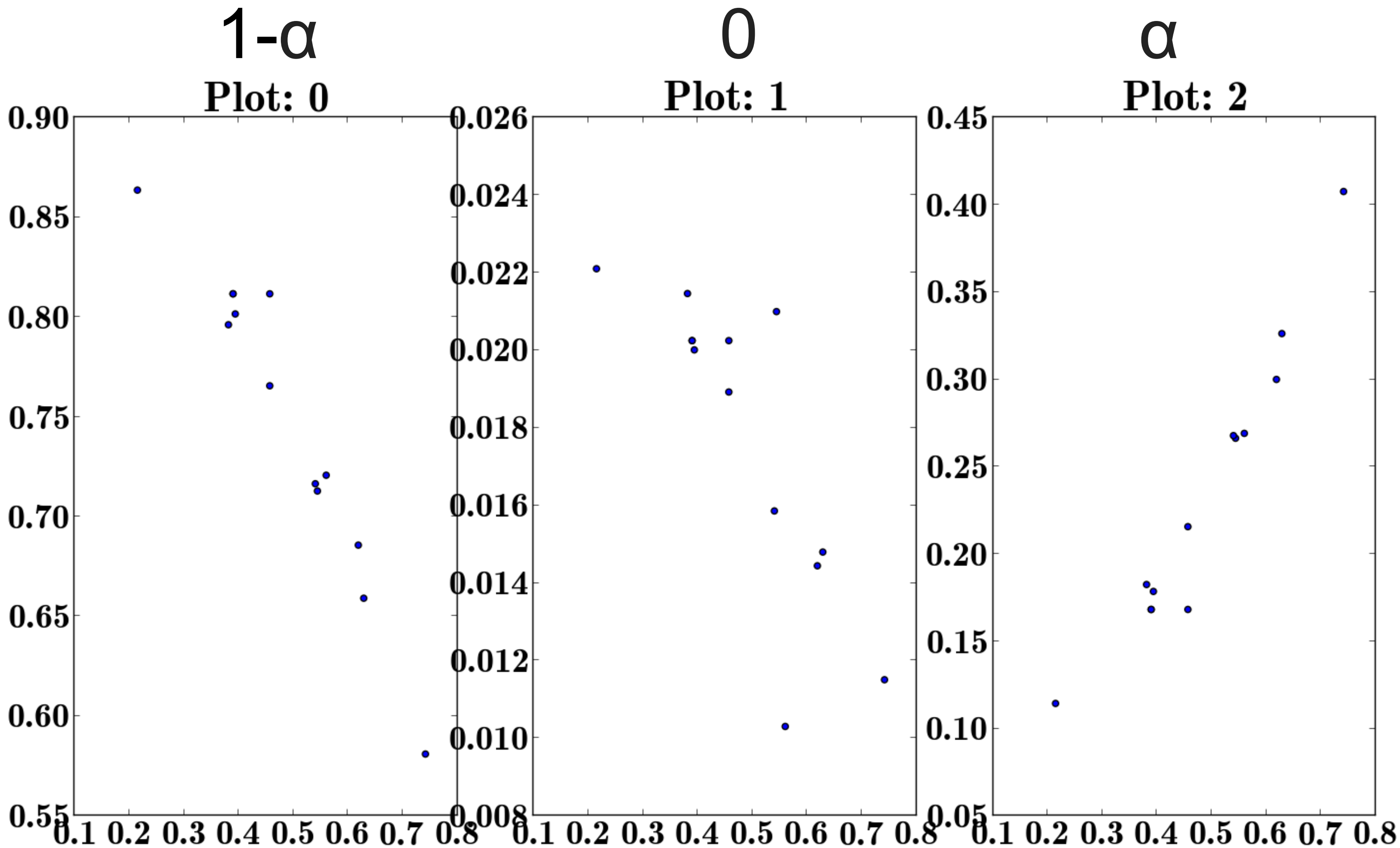
Target = <0,α>

1-α 0 α

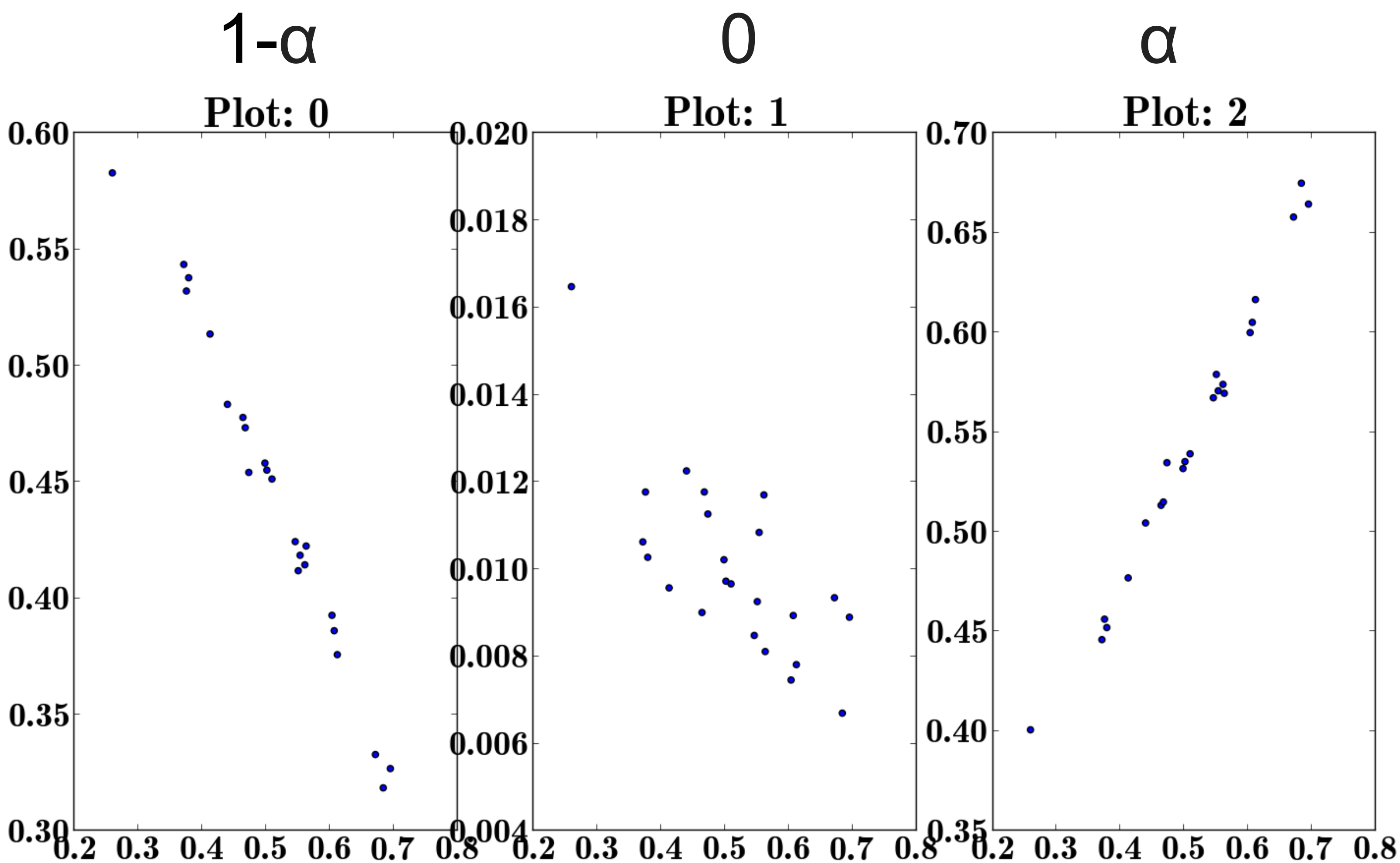


Some Results
(WITH thresholding) R_{mcd}=0.05

Target = <0,α>



Some Results
(fancy function, η=0.8, T=10) R_{mcd}=0.05



Bridge models + Laser simulation
(Credit : Daniel, Sankalp)