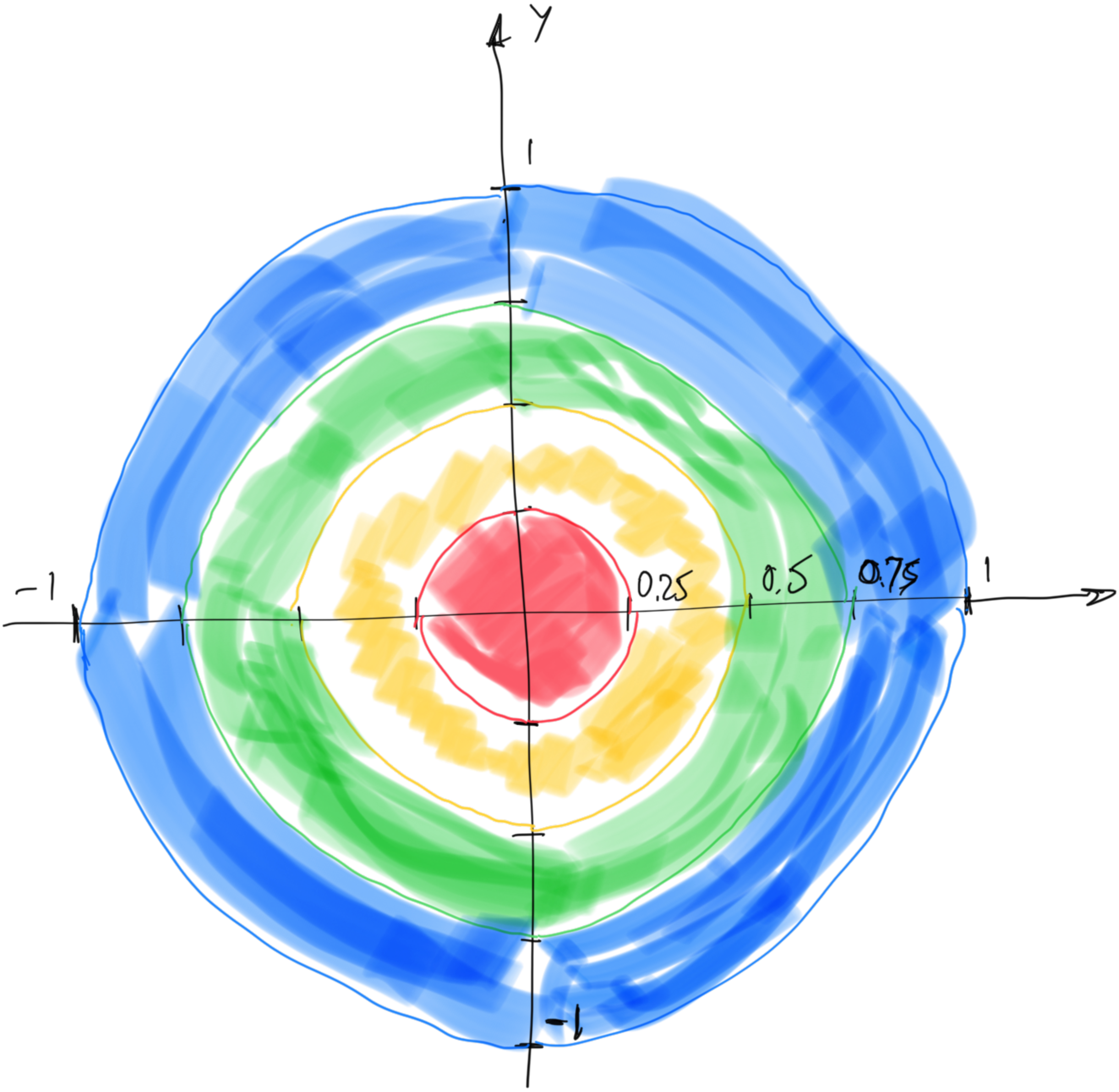
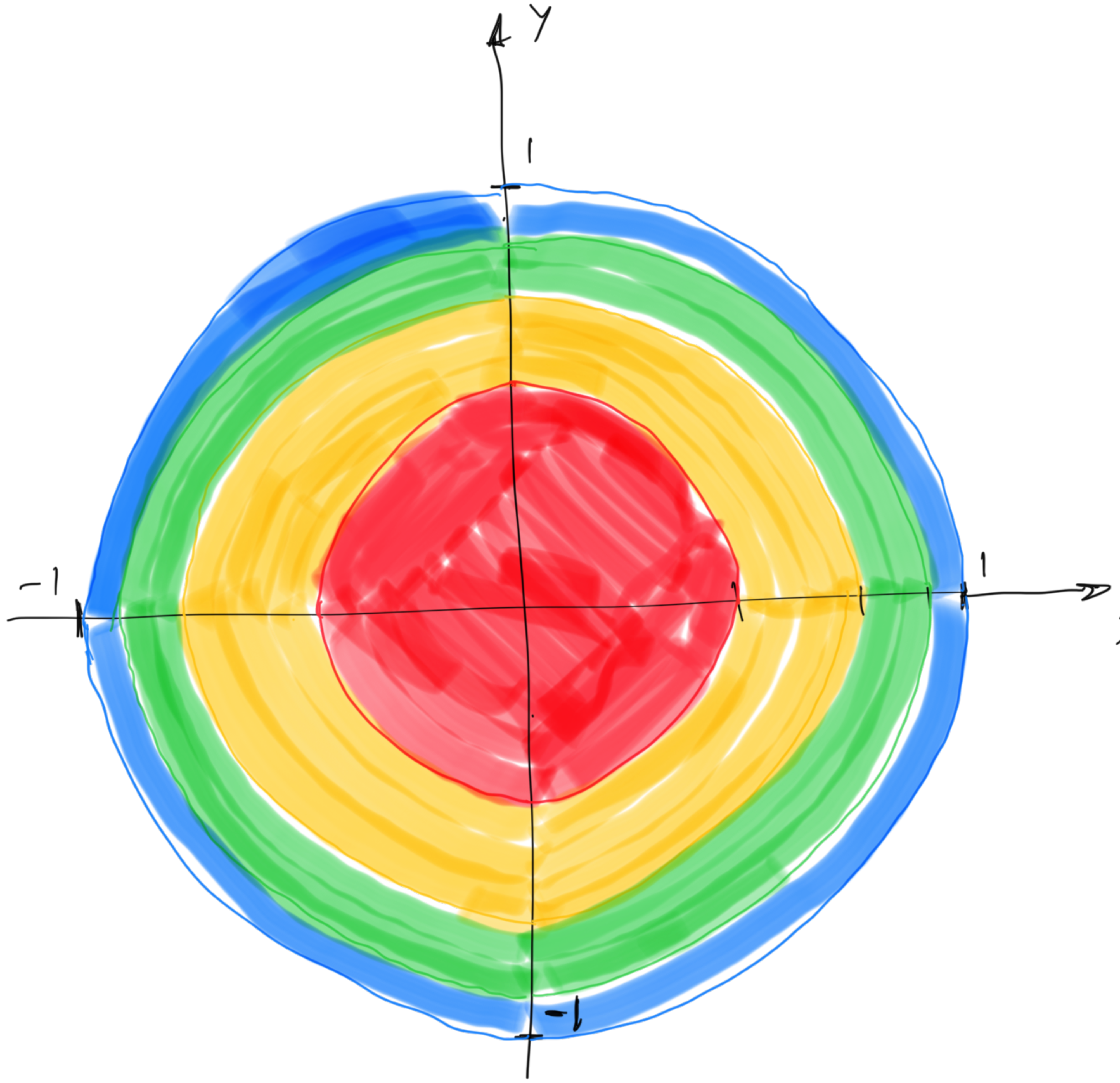
We are sorting points by distance to the origin. That is, we are sorting distances to the origin. Let $r_1, r_2, \dots, r_n$ be those distances, where each r_i is some real number in $[0,1]$. We know that the points are uniformly distributed in a unit circle, but that does not mean that the distances are uniformly distributed in $[0,1]$. For instance, if we have $n=4$ and we divide the radius in 4 equal parts, we get:



blue area > green area > yellow area > red area

Thus we would have more points in blue zone than others.

So, instead of dividing the radius in n parts, we have to divide the area in rings of equal area.



We can compute the corresponding radii, that is, the range of distances for each bucket, as follows.

Total area ~~of~~ of the unit circle $= \pi r^2 = \pi$

Area of each ring corresponding to each bucket $= \pi/n$

Then, it is

$$\cancel{\pi} r_1^2 = \frac{\cancel{\pi}}{n}$$

$$r_1 = \sqrt{\frac{1}{n}}$$

$$\cancel{\pi} r_2^2 - \cancel{\pi} r_1^2 = \cancel{\pi} r_1^2$$

$$r_2^2 = 2r_1^2 = \frac{2}{n}$$

$$r_2 = \sqrt{\frac{2}{n}}$$

$$\cancel{\pi} r_3^2 - \cancel{\pi} r_2^2 = \cancel{\pi} r_2^2 - \cancel{\pi} r_1^2$$

$$r_3^2 = 2r_2^2 - r_1^2 = 3r_1^2$$

$$r_3 = \sqrt{\frac{3}{n}}$$

In general, we have that the upper limit of each bucket is $r_i = \sqrt{\frac{i}{n}}$, for each $i = 1, 2, \dots, n$.

Graphically: