Spatial Distribution Analysis of Plaques

Objective

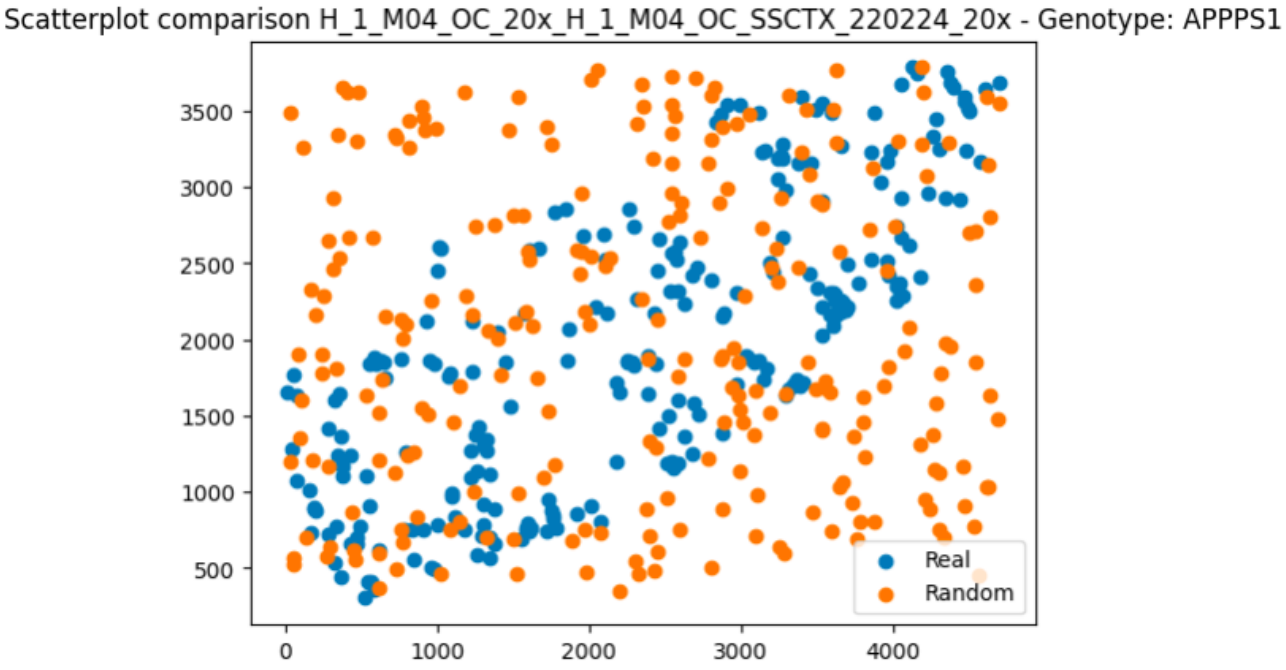
The primary goals of this analysis were to:

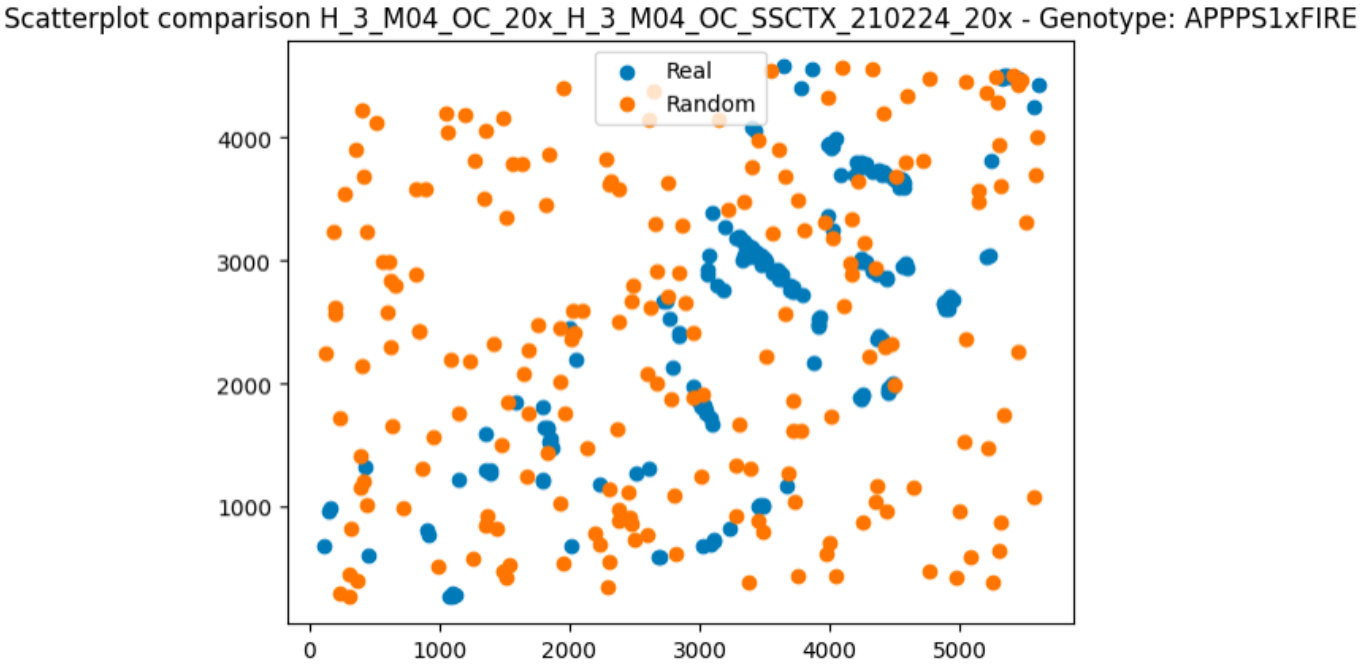
1. Assess if real spatial distributions of objects differ substantially from random distributions of the same size and shape.
2. Identify clustering patterns within these distributions and quantify their characteristics.
3. Examine any differences in spatial distribution patterns between defined regions (Hippocampus (HI) and Somatosensory Cortex (SSCTX)) and genotypes.

Methods

Generation of Random Distributions

For each real dataset composed of objects' centroid coordinates, a corresponding random distribution was generated. This involved sampling new centroid locations uniformly within the original data's minimum and maximum x and y coordinates, thus preserving the size and shape of the distribution area.





Calculation of Spatial Characteristics

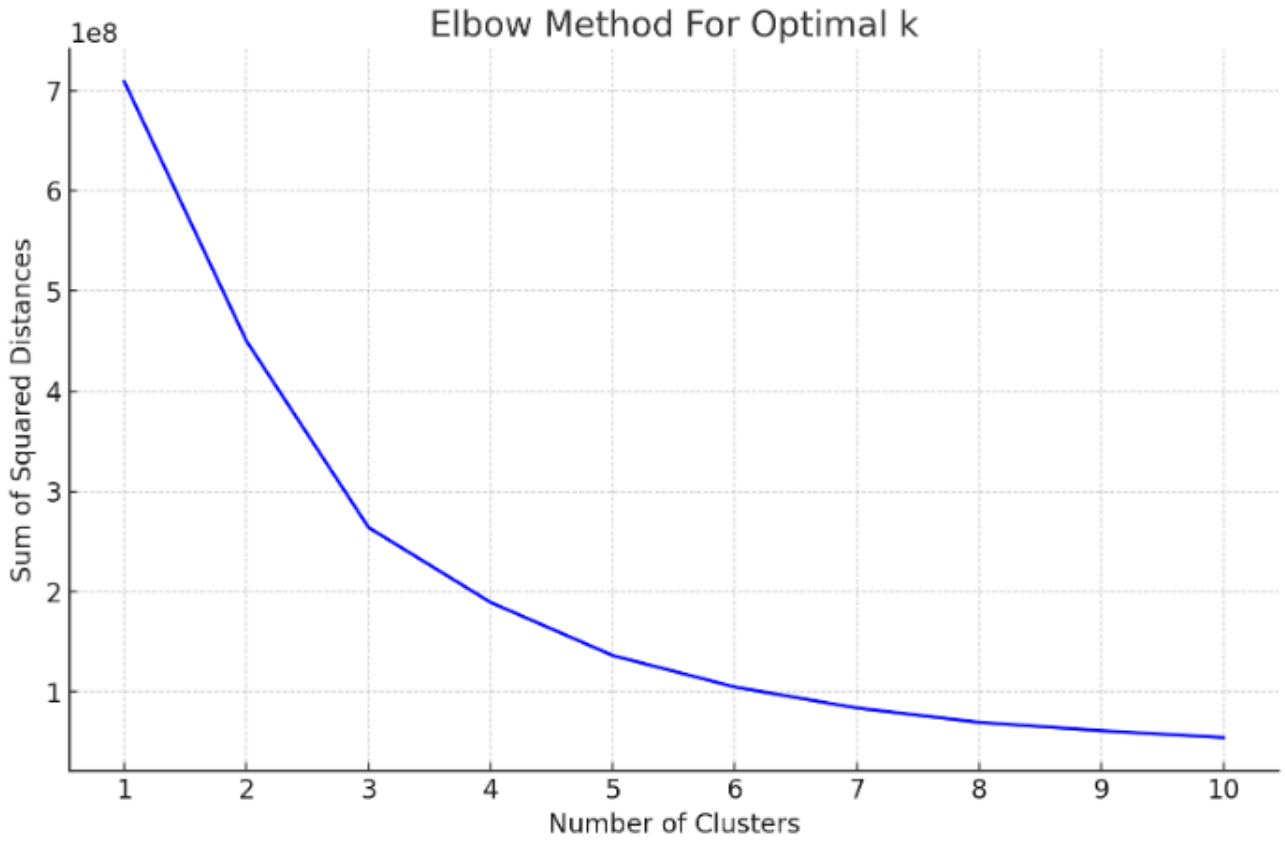
Several spatial characteristics were computed for both real and random distributions:

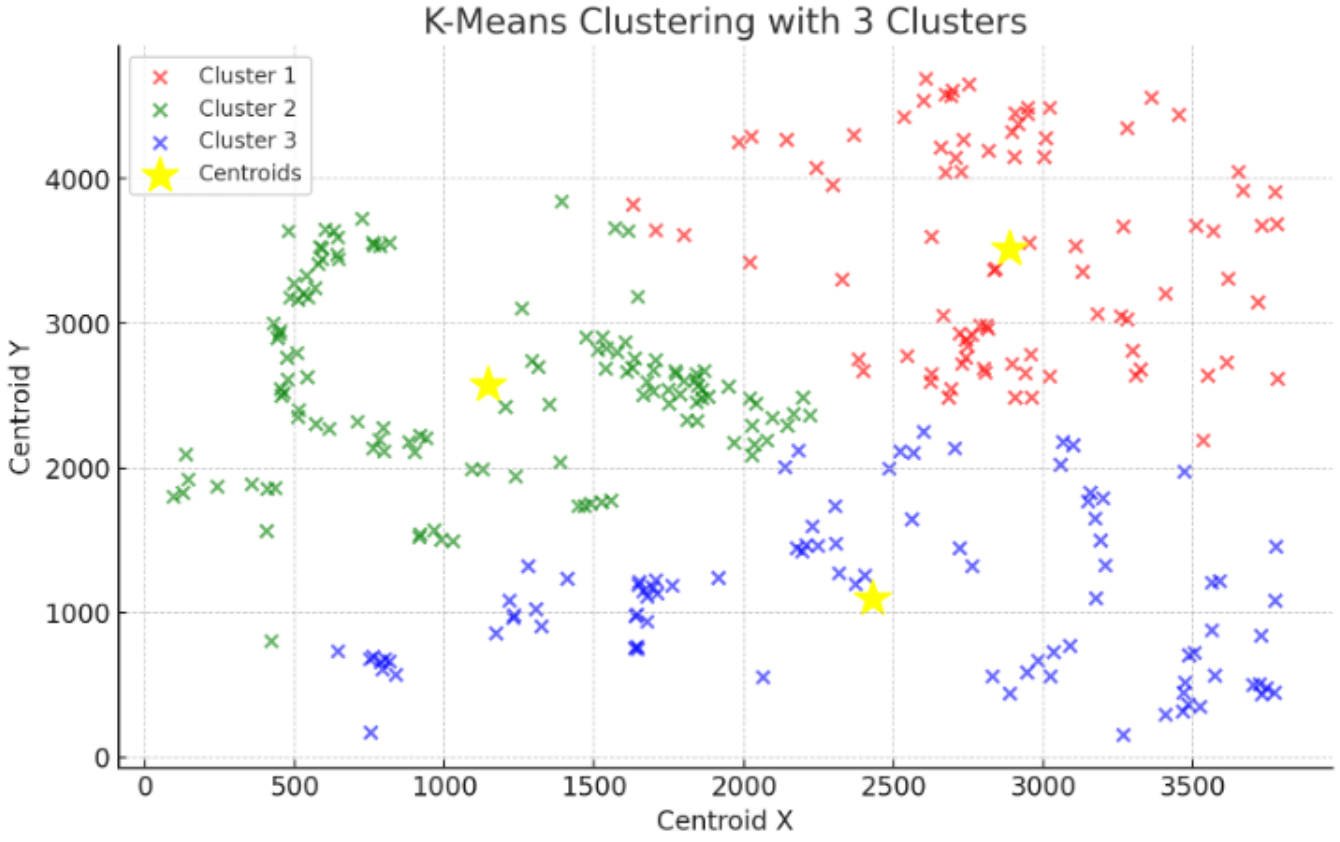
- **Average Distance between Objects**: Calculated as the mean pairwise distance among centroids.
- **Distribution Evenness**: Measured by the variance in distances among objects.
- **Plaque Density**: The number of objects normalized by the area of the distribution.
- **Distance from Image Center and Edge**: The average distances of objects from the center of the image and the nearest edge, respectively.

Clustering Analysis

To explore inherent clustering within the object distributions:

- **Optimal Clusters Determination**: The elbow method determined the optimal number of clusters by identifying the point where the within-cluster sum of squares (WCSS) begins to decrease at a slower rate.
- **K-Means Clustering**: Spatial data was then clustered using the K-Means algorithm based on the optimal cluster number.
- **Silhouette Score**: This metric was calculated to evaluate the coherence and separation of the derived clusters.





Nearest Neighbor Distance

The average nearest neighbor distance was calculated for each object to assess the local density variations within the distributions.

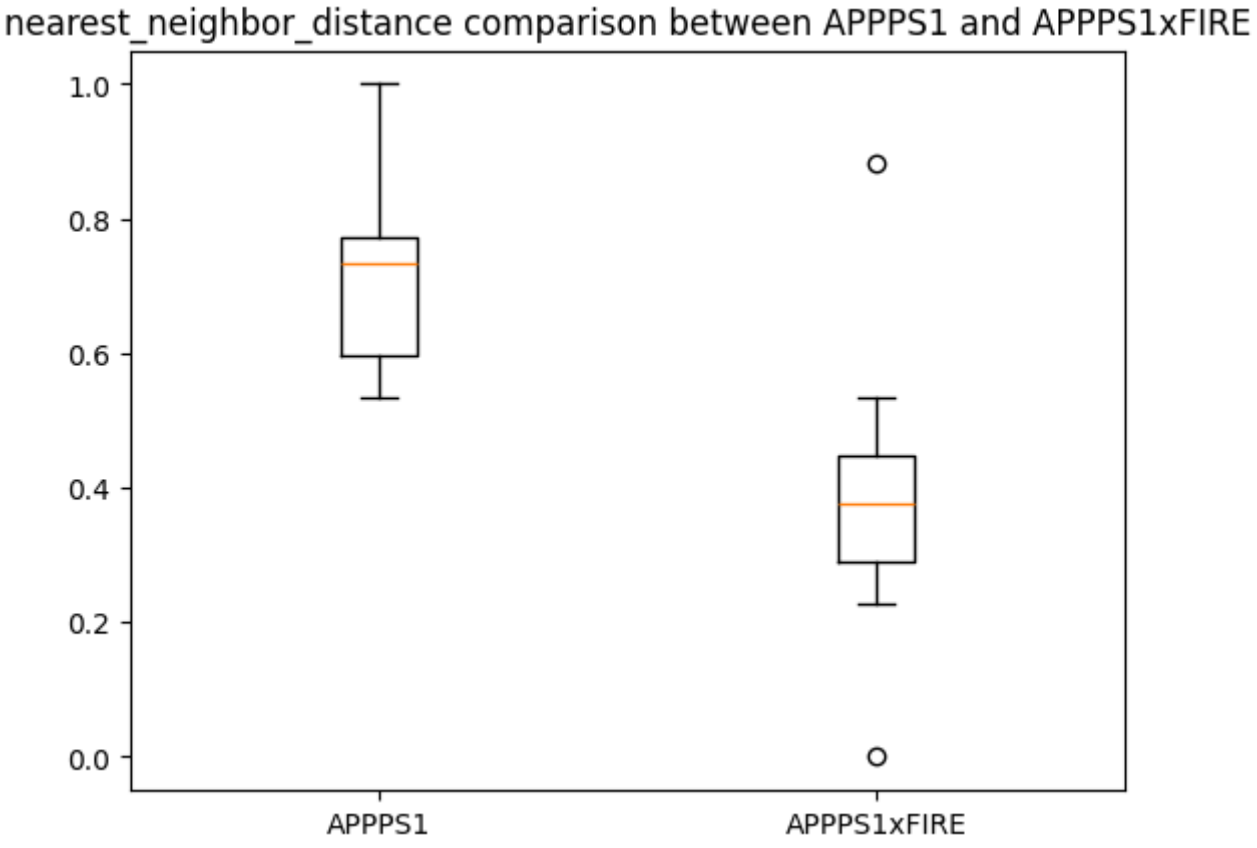
Statistical Comparison

To understand differences between real and generated distributions, as well as across regions and genotypes:

- **Kolmogorov-Smirnov (KS) Test**: Performed to compare the empirical distribution functions of the real and random data samples.
- **Mean Difference Analysis**: The mean differences in spatial characteristics between the real and random distributions were calculated.
- **Variance Analysis**: Variance in the mean differences across genotypes was explored to highlight any genotypic effects.
- **T-Test for Genotypic Differences**: Focused particularly on the nearest neighbor distance to gauge significant differences in local object densities between genotypes.

Results

- **Genotypic Differences**: The T-test results indicated significant differences in the nearest neighbor distances between genotypes. Specifically, APPPS1xFIRE animals exhibited much lower nearest neighbor values compared to random distributions, unlike APPPS1 animals which did not show such divergence. This result was specific to the Somatosensory Cortex.



- **KS Test Outcomes**: The KS test evidenced a lack of equality in variance between real and random distributions for APPPS1xFIRE animals within the Somatosensory Cortex, indicating significant spatial distribution differences.

Significant Findings

- **Nearest Neighbor Distance**: A significant difference was observed in the overall comparison between the genotypes APPPS1xFIRE and APPPS1, with a p-value of 0.004128. This suggests that the spatial distribution of plaques significantly varies between these two genotypes, indicating that the genotypic differences might influence how closely plaques are positioned to each other across the brain.