Improving ELSA and adding a theoretical framework

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- **Idea:** Adding theoretical background to *Efficient Latent Search Algorithm (ELSA)* and making improvements to its search components.
- **Relevant Papers:**

1. *Bardes, A., Ponce, J., & LeCun, Y. (2021). VICReg: Variance-Invariance-Covariance Regularization for Self-Supervised Learning (Version 3). arXiv.*
2. *Shwartz-Ziv, R., Balestriero, R., Kawaguchi, K., Rudner, T. G. J., & LeCun, Y. (2023). An Information-Theoretic Perspective on Variance-Invariance-Covariance Regularization (Version 2). arXiv.*
3. *Li, J., Zhou, J., Xiong, Y., Chen, X., & Chakrabarti, C. (2022). An Adjustable Farthest Point Sampling Method for Approximately-sorted Point Cloud Data (Version 1). arXiv.*

GreedyS

Greedy Sampler

- The proposed modification to the Random Sampler of ELSA aims to enhance point selection efficiency by introducing the Greedy Sampler (GreedyS) approach. Instead of selecting points collectively, GreedyS suggests choosing points individually based on confidence levels determined by the linear head. Subsequently, the selected point is labeled by an Oracle, followed by an exhaustive Nearest Neighbor search to identify all points within its cluster.
- This method prioritizes confident point selection to prevent distant point selections, thereby optimizing sampler performance as the algorithm progresses. The concept of Farthest Point Sampling (FPS) aligns with this approach, as it involves iteratively selecting a point followed by Nearest Neighbor Search.
- So the new point on the next iteration would not belong to any cluster of previously visited points. By leveraging FPS principles, it is possible to enhance point selection strategies within ELSA while minimizing computational complexity and improving sampling performance.

FarS

Farthest Point Sampler :

- The Farthest Point Sampler (FarS) method enhances point sampling by incorporating farthest point sampling and the linear head. It aims to maximize a function $g : \mathbb{D}^n \rightarrow \mathbb{R}$ defined as the sum of pairwise distances between points and the confidence values output by the linear head.

$$g(x_1, x_2, \ldots, x_n) = \sum_{i=1}^{n} \sum_{j=1}^{n} ||x_i - x_j|| + \sum_{i=1}^{n} f_c(x_i)$$

  where f_c is the output of the linear head.
- By maximizing both confidence values and inter-point distances, FarS identifies points of interest that are crucial for the algorithm. These selected points are then labeled by an Oracle and subjected to a nearest neighbor search if identified as positive. FarS leverages Farthest Point Sampling principles to streamline the process of finding positive samples efficiently, reducing the number of iterations required. This approach optimizes sampling by emphasizing both point confidence and spatial distribution, enhancing the effectiveness of point selection within ELSA.

GridS

Grid Sampler :

- The Grid Sampler (GridS) method enhances point sampling by transforming the latent space into a lower-dimensional space using Principal Component Analysis (PCA). This transformation facilitates the division of the space into rectangular grids using hyperplanes.
- Subsequently, GridS identifies the most confident point within each grid and selects the maximum confident points among them. By employing this approach, GridS ensures that all samples are positioned at a distance from each other, promoting spatial diversity. Moreover, by reducing the dimensionality through grid-based search, GridS effectively manages computational complexity as the number of search grids grows exponentially with increasing dimensions.
- This method optimizes point selection within ELSA by leveraging PCA for dimension reduction and grid-based sampling to enhance spatial distribution and sampling efficiency.

Thank you

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