1. Theoretical Tasks

In this exercise we will focus on visualizing and understanding what the Convolutional Neural Networks we have discussed in the previous weeks are doing under the hood. Watch the following presentation on t-SNE, and answer the questions below:

- https://www.youtube.com/watch?v=RJVL80Gg3lA

1) What are the advantages of t-SNE over PCA?

Advantages of t-SNE over PCA:

Preservation of local structures: t-SNE is specifically designed to preserve the local structures in high-dimensional data, while PCA primarily focuses on preserving global structures. This makes t-SNE more suitable for visualizing complex datasets where the relationships between data points are crucial to understanding the underlying patterns.

Non-linear dimensionality reduction: PCA is a linear technique, which means it might not be able to capture the non-linear relationships present in the data. t-SNE, on the other hand, is a non-linear technique that can better represent non-linear structures in the data.

Clustering: t-SNE has the ability to reveal natural clusters within the data, which can be useful for identifying patterns and relationships among data points. PCA, being a linear technique, might not be as effective at separating clusters in high-dimensional data.

Robustness to the crowding problem: The crowding problem refers to the difficulty of representing high-dimensional data points in a lower-dimensional space without them becoming too densely packed. t-SNE addresses this issue by using a t-distribution to model the pairwise similarities in the low-dimensional space.

2) **Consider three points *a*, *b* and *c* in the high-dimensional space. Let us assume that *a* and *b* are very close to each other, and that *c* is very far away from both of them. How would the loss behave if the following is true for the low-dimensional space? Feel free to use dummy numbers to support your answer.**

- ***a*, *b* and *c* are all close to each other.**
    - High loss: In the high-dimensional space, a and b are close, while c is far from both. In this case, the pairwise similarities between a-b and a-c would be misrepresented in the low-dimensional space, resulting in a high loss.
- ***a* and *b* are close to each other, and *c* is far away from them.**
    - Low loss: This configuration closely matches the relationships in the high-dimensional space, and the loss would be low.
- ***a*, *b* and *c* are all far away from each other.**
    - High loss: In this case, the pairwise similarity between a and b is not well-represented, resulting in a higher loss.
- ***a* is far away from both *b* and *c*, that are close to each other.**
    - Intermediate loss: Here, the pairwise similarity between a and b is misrepresented, while the pairwise similarities between a-c and b-c are well-represented. This configuration would result in an intermediate loss.