**COMSATS UNIVERSITY ISLAMABAD**

**Pattern Recognition**

**ASSIGNMENT # 04**

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**For a use case you are running a factory, producing some sort of widget that requires steel as a raw material. Your costs are predominantly human labor, which is $20$20dollar sign, 20 per hour for your workers, and the steel itself, which runs for $170$170dollar sign, 170 per ton.**

**Evaluate the impact of using Lagrange Optimization and present your hypothesis. [ 5 Marks]**

Lagrange Optimization, also known as Lagrange multipliers, is a mathematical technique used to optimize a function subject to equality constraints. In the context of the factory scenario described, where the costs are predominantly labor and steel, Lagrange Optimization can be applied to optimize the production process and minimize costs.

To evaluate the impact of using Lagrange Optimization, we can formulate the problem as an optimization task. Let's define the objective function and the constraints:

**Objective function:**

Minimize the total cost (C) = labor cost + steel cost

**Constraints:**

Total labor hours (L) should not exceed a certain limit.

Total steel used (S) should not exceed a certain limit.

Using Lagrange Optimization, we can solve this optimization problem by introducing Lagrange multipliers for each constraint. The Lagrangian function will be formulated as:

L(L, S, λ1, λ2) = C + λ1(L - L\_limit) + λ2(S - S\_limit)

where λ1 and λ2 are the Lagrange multipliers, and L\_limit and S\_limit are the limits for labor hours and steel usage, respectively.

By taking partial derivatives of the Lagrangian function with respect to L, S, λ1, and λ2, and setting them to zero, we can find the optimal values for L and S that minimize the total cost.

The impact of using Lagrange Optimization in this factory setting can be evaluated by comparing the total cost and resource utilization before and after applying Lagrange Optimization. It is expected that Lagrange Optimization will result in an optimal allocation of labor and steel, leading to reduced costs while satisfying the given constraints.

Hypothesis: By using Lagrange Optimization in the factory production process, the total cost can be minimized while effectively managing the allocation of labor and steel resources.

To evaluate the hypothesis and quantify the impact, the factory can collect data on labor hours, steel usage, and costs before implementing Lagrange Optimization. After implementing the optimization technique, the factory can compare the costs and resource utilization metrics, such as labor hours and steel usage, to assess the effectiveness of Lagrange Optimization in reducing costs and optimizing resource allocation**.**

**For a classic game problem like Tic Tac Toe evaluate how Principal component analysis be used for dimensionality reduction and does it offer better performance. Show your justification with reasoning and references. [ 5 Marks]**

Principal Component Analysis (PCA) is a dimensionality reduction technique used to transform high-dimensional data into a lower-dimensional space while retaining the most important information. In the case of Tic Tac Toe, PCA can be used to reduce the dimensionality of the game's state space and evaluate its impact on performance.

**Justification and Reasoning:**

Dimensionality Reduction: Tic Tac Toe is a game with a relatively small state space, consisting of 9 positions on the board. However, as the game progresses, the number of possible board configurations increases, resulting in a larger state space. By applying PCA, it is possible to reduce the dimensionality of the state space and capture the most relevant features that contribute to the game's outcome. This can simplify the analysis and improve computational efficiency.

Feature Extraction: PCA can also be used to extract important features from the game's state space. By identifying the principal components, which are linear combinations of the original features, PCA can provide insights into the most influential factors in determining the game's outcome. These extracted features can potentially enhance the performance of game-playing algorithms by focusing on the most informative aspects of the game.

Performance Evaluation: To assess whether PCA offers better performance in Tic Tac Toe, a comparison can be made between different approaches. One approach could involve using the original state space (9 positions) as input for a game-playing algorithm, and another approach could involve using the reduced-dimensional space obtained through PCA. The performance metrics, such as win rate or average number of moves, can be compared to determine if PCA improves the algorithm's performance.

**References:**

*Hastie, T., Tibshirani, R., & Friedman, J. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction (2nd ed.). Springer.*

*Shlens, J. (2014). A Tutorial on Principal Component Analysis. arXiv preprint arXiv:1404.1100.*

By applying PCA to Tic Tac Toe, it is expected that the reduced-dimensional space will capture the essential information for making game-playing decisions. However, the actual impact on performance can vary depending on the specific algorithm and the complexity of the game.