Peer Consulting Report

Project Title: Swiss Post Sorting Centers Package Sorting Performance Analysis and Prediction

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1) Project Description

The goal of the project is to analyze the postal sorting center's performance by identifying the most influential factors contributing to sorting issues, including shipment attributes (e.g. dimensions, weight, coding stations, and timestamps) as well as chute congestion which are assumed to have a major impact on overall performance of the center and finally using a model to determine whether overburdened chutes or certain features create bottlenecks that reduce overall system efficiency.

The sorting process consists of three key stages:

1. Shipments arrive and are delivered to the sorting center, using designated units.
2. Shipments are scanned and transferred to the conveyor belts, where automatic and manual sorting machines determine their route and send them to the appropriate chute based on the destination.
3. The chute serves as the output of the sorting machine, directing the parcels to different destinations depending on the ZIP code, one chute can serve several ZIP codes.

The center's performance is measured by the number of parcels processed per time frame. Some centers have shown up to a 15% increase in processing efficiency compared to others with similar setups. Further investigation revealed that traffic bottlenecks at certain chutes, which handle significantly higher package volumes, cause an imbalance. This results in a non-normal distribution of packages across the chutes, leading to a noticeable reduction in overall performance.

More specifically, the goal of the project is to achieve a balanced, normally distributed flow of packages across all available chutes, which should enhance the sorting rate and improve overall center performance. The specific objectives of the project are the following:

1. *Determine Feature Importance:* Rank the shipment features by their importance and identify which shipment attributes (e.g., dimensions, weight, coding station) are most influential in causing sorting issues at postal centers. As well correlation between the features and the impact on performance.

2. *Determine chute congestion impact:* Determine whether chutes are handling disproportionately large volumes of packages can create bottlenecks that reduce overall system efficiency.

3. *Predict Sorting Performance and Issues:* Develop a predictive model capable of forecasting sorting issues based on historical shipment data.

4. *Generate Actionable Insights:* Provide data-driven recommendations for improving chute utilization and enhance overall performance.

2) Good Solutions

The already conducted analyses, which entailed some descriptive analyses and applying a random forest model, brought out some revealing insights. It focused on understanding which features mostly affect sorting issues and therefore provides insights that can be used to improve sorting operations at Swiss Post. The key findings of the already conducted analyses were:

1. *Chute Congestion:* Certain chutes were identified as potential bottlenecks, handling significantly more packages than others and showing longer processing times. Managing chute congestion is critical to improve the overall efficiency.

2. *Processing Time Variability:* There was a substantial variability in processing times across shipments. Factors such as shipment dimensions, weight, and chute assignment contributed to this variability.

3. *Data Quality Issues:* Several data quality issues, such as missing or inconsistent timestamps, were identified. These issues were addressed to ensure accurate analysis, but continued data quality monitoring is recommended.

4. *Model Insights:* The Random Forest model provided insights into the factors most influencing sorting performance, with shipment weight and chute utilization being significant contributors. However, additional factors not captured in the dataset may also play a role in performance variations.

These findings already show some promising solutions for reaching the project objectives. However, there are some possible improvements about which we will talk about in the following section.

3) Possible Improvements

The following points could be considered as possible improvements for the project and achieving its objectives:

1. *Refine Feature Selection Methods:* Incorporate advanced feature selection techniques such as SHAP values and mutual information to better identify influential factors affecting sorting performance.

2. *Improve Predictive Modeling:* Evaluate additional machine learning algorithms, such as XGBoost and ensemble methods, to enhance predictive accuracy for sorting issues.

3. *Optimize Chute Allocation Strategies:* Investigate dynamic chute allocation strategies, including reinforcement learning approaches, to balance package volumes effectively and reduce bottlenecks.

4. *Implement Real-time Monitoring Tools:* Develop a dashboard for real-time performance monitoring and anomaly detection to quickly address performance issues as they arise.

5. *Enhance Data Quality Monitoring:* Deploy automated systems for continuous data validation and cleaning to maintain data consistency and reliability.

6. *Test Scalability of Solutions:* Assess the scalability of the proposed solutions to ensure their effectiveness in larger sorting centers with higher package volumes.

By pursuing these improvements, the project would further enhance the operational efficiency of postal sorting centers and achieve a balanced, normally distributed flow of packages across chutes.