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Laboratory Performance Optimization:

Achieving performance improvement in the laboratory through AI-enabled optimization initiatives.

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Executive Summary

With growing complexities in research methods, evolving market demands, and changes to regulations, laboratories are required to do more and in less time. It is becoming evident that the companies that will survive are those that use their data assets and artificial intelligence (AI) techniques to move faster and be more effective. Until now, the lab operator's relationship to his or her data was usually prescribed by predefined LIMS dashboards and reports. The data itself, often unstructured and siloed from other enterprise systems, was not always accessible without an expensive and tactical data modeling exercise. It was difficult to leverage AI across the laboratory and to include data assets from around the enterprise for a 360° view of the organization's processes. This reality is fast changing as AI and machine learning (ML) are being deployed in the laboratory.

This white paper attempts to discuss the need for optimization in the laboratories and the target areas where optimization techniques can contribute significantly to the improvement of performance. The focus of this paper is to explore the myriad applications of Artificial Intelligence and Machine Learning techniques in the field of performance optimization for laboratories and emphasize the importance of adopting such techniques in the laboratory to stay competitive in the market and be ahead of the competition.

Optimization in the context of laboratories

Optimization can be defined as the process of arriving at the best possible design outcome relative to a set of prioritized constraints. Such constraints can span across increasing productivity, efficiency, utilization, and reliability to decreasing operating costs, procedural errors, and regulatory non-compliances. In the context of laboratories, operational optimization is attempted to maximize the key performance indicators (KPI) around which the productivity and efficiency of a laboratory are usually measured.

Depending upon the exact industry and the mode of the operation of a laboratory, KPIs for performance measurement can be numerous and varied. Some of the commonly used KPI dimensions for measuring the performance of a laboratory are:

Turn-around time – Regardless of the nature of the laboratory, TAT is always a key performance indicator as it is a direct reflection of the laboratory throughput. Monitoring TAT per analysis allows laboratories to effectively pinpoint problems around resource availability and allocation and procedural efficiency.

Asset utilization – Utilization of the assets through monitoring their idle time and allocation schedules of the equipment and machinery in the laboratory

Equipment downtime – Reduction of unscheduled equipment downtime and maintenance duration

Consumable usage – Monitoring the total usage of consumables on a weekly/monthly basis and the average quantity of consumables used per analysis helps in the reduction of material wastage and better management of the inventory

Measurement accuracy/precision – Tracking average accuracy and precision of the measurements taken in repeated experiments and measuring overall equipment effectiveness (OEE).

Energy consumption – Reduction of energy consumption aligned with the organization's sustainability goals

Revenue management – Tracking budget expenditure, cost per analysis/experiment, periodic revenue, and profitability, etc.

Each KPI is always defined with specific and quantifiable goals. KPI goals are usually set using the SMART framework meaning that goals are Specific (S), Measurable (M), Attainable (A), Relevant (R), and Time-bound (T). With the growing adoption of process automation and integrated digital assets in the laboratory, it has now become possible to define KPIs across almost all dimensions of laboratory operations and measure them continuously and accurately. However, the correlation among such KPI dimensions is often quite complex and as the number of KPIs increases, it becomes overwhelming for manual operators to simultaneously optimize all the KPIs and maximize the operational performance. This is where machine learning-enabled optimization tools come in handy.

Optimization through adoption of machine learning and AI tools

As more and more laboratories are embracing the importance of centralized data management and implementing robust data lakes and warehouses which consolidate data generated by the software and instruments in the laboratory, it is becoming easier to adopt AI tools and train machine learning models on the past data to uncover trends, hidden to the lab operator and automatically apply optimization measures to improve KPIs.

Some of the areas where AI-enabled optimization techniques are already creating disruptions are discussed below:

Demand forecasting – Predictive analysis of historical laboratory data can help in estimating and effectively predicting the demand for raw materials and consumables in the lab for the immediate future. This helps in the dynamic and optimum requisition of raw materials and can reduce procurement cycles and costs.

Inventory management – Efficient inventory management is a direct benefit resulting from efficient demand forecasting. Furthermore, with the help of ML algorithms, it is possible to track consumable wastage and accurately determine the factors contributing to excessive wastage and subsequently take corrective actions. This eventually helps in much better utilization of the inventory and reduces procurement and inventory management costs.

Predictive maintenance – Machine learning on operational data of the instruments in the laboratory can help identify anomalies in the expected performance and can help identify potential downtime or probability of failure in the near future, which can help laboratories plan for pre-emptive instrument maintenance and avoid operational outage due to unplanned instrument downtime.

Predictive formulation – The design of experiments in the research laboratory can be made more efficient by applying statistical methods on past experiment data to predict the optimum formulations and ingredients that will be required to achieve the target specifications of the output compound. This use case has become highly relevant in the pharmaceutical sector for producing viable drug products by significantly reducing the duration of the discovery phase.

Optimization of energy consumption – IoT-based sensors, coupled with optimization algorithms, can dynamically control power consumption within the laboratory by monitoring floor space occupancy, current environmental conditions, instrument schedules, etc, and reduce energy costs manifold.

Conclusion

A 2019 survey of Pharma Lab Leaders by Agilent reveal that the primary focus of 55% of the survey respondents is achieving quicker results and 65% are of the opinion that the most important type of innovation in the laboratory are the ones which increase efficiency. **Overall, 83% of the respondents readily agree that their current workflow is in need of optimization.**

With the growing permeance of data centricity and data analytics tools in laboratories, the applications and adoption of performance optimization are steadily on the rise. AI-enabled performance optimization techniques assist laboratories to balance their workloads by dynamically deploying resources (manpower and equipment) from areas of low utilization to high utilization. Proactive planning for service delivery and maintenance schedules allows laboratories to optimize their investments and reduce expenditure. With the aid of predictive tools, laboratories can start making better strategic decisions around investment, procurement, and disposition.

References

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2 *Pharma Lab Leaders Survey 2019 by Agilent*

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