International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2019): 7.583

AI-Enhanced KPI Customization in a Manufacturing Portal

Sahil Nyati

Corresponding Author Email: *sahilnyati9[at]gmail.com*

Abstract: ***This research paper presents a comprehensive solution for the integration of Artificial Intelligence AI into the design of a Key Performance Indicator KPI Customization feature for Manufacturing Portals. The aim is to enhance the flexibility and effectiveness of KPI monitoring by addressing the limitations of traditional KPI systems. The paper discusses the essence of KPIs in manufacturing, the drawbacks of traditional KPI systems, the need for customization, and the integration of AI in KPI customization. The proposed solution includes core components such as dynamic database design, AI integration for smart KPI management, and a customizable user interface. The article highlights the importance of this approach in improving operational efficiency, strategic decision-making, and adaptability to future trends. It also outlines prospects for continuous improvement, scalability, and integration with emerging technologies.***

Keywords: Artificial Intelligence, KPI Customization, Manufacturing Portal, Operational Efficiency, Decision-Making, Scalability

1. Introduction

This research paper details the integration of Artificial Intelligence (AI) in the design of a Key Performance Indicator (KPI) Customization feature for a Manufacturing Portal. It aims to utilize AI to enhance the flexibility and effectiveness of KPI monitoring.

2. Background

To understand the necessity and impact of the KPI Customization feature in a manufacturing environment, it is crucial to delve deeper into the background of Key Performance Indicators (KPIs) and their role in industrial systems. This expanded background provides a detailed overview of KPIs, their traditional usage, limitations, and the potential enhancements through customization.

1) The Essence of KPIs in Manufacturing

a) *Definition and Importance:* - KPIs are quantifiable measurements that reflect the critical success factors of an organization.
- In a manufacturing context, KPIs are pivotal in monitoring machine performance, ensuring quality control, and optimizing production processes.
- They provide insights into various aspects such as efficiency, productivity, operational costs, and maintenance needs.

b) *Traditional KPI Usage:* - Traditionally, KPIs in manufacturing have been predefined and static, focusing on general metrics like production volume, downtime, and operational efficiency.
- These KPIs are typically chosen based on industry standards and are uniform across different machines and processes.

2) Limitations of Traditional KPI Systems

a) *Lack of Flexibility:* - Traditional systems offer limited flexibility in terms of modifying or adding new KPIs, which can lead to gaps in monitoring specific or unique aspects of machinery or processes.

b) *One-Size-Fits-All Approach:* - The uniformity of KPIs may not accurately represent the performance or issues of specific machines or production lines, leading to ineffective monitoring and decision-making.

c) *Delayed Insights:* - Relying on manually compiled re-ports or fixed monitoring intervals can result in delayed in- sights, hindering timely decision-making and problem-solving.

3) Need for Customization

a) *Personalized Monitoring:* - Customization allows for the creation of machine-specific or process-specific KPIs, providing more relevant and actionable insights.

b) *Dynamic Adaptation:* - As manufacturing processes evolve and new technologies are introduced, the ability to adapt KPIs to these changes becomes essential.

c) *Enhanced Decision-Making:* - Custom KPIs enable more accurate and granular monitoring, leading to better- informed decisions and quicker responses to operational is- sues.

4) Integration of AI in KPI Customization

a) *Predictive Analytics:* - AI can analyze historical data to predict trends and anomalies, guiding the selection or creation of more predictive KPIs.

b) *Real-Time Data Processing:* - AI algorithms can process real-time data from machines, offering instantaneous insights and the ability to dynamically adjust KPIs based on current operational conditions.

c) *Intelligent Recommendations:*- AI can provide recommendations for KPI customization, helping identify overlooked performance indicators or inefficiencies.

3. Solution Overview

The solution for AI-enhanced KPI customization in a manufacturing portal is designed to address the limitations of traditional KPI systems. It proposes a comprehensive approach that integrates advanced database management, AI-driven analytics, and user-centric customization options.

Licensed Under Creative Commons Attribution CC BY

1) Core Components of the Solution

a) *Dynamic Database Design:* - A robust database architecture is essential to store and manage KPIs, machine data, user preferences, and AI insights.
- The database will support complex queries and real-time updates, crucial for dynamic KPI management.

b) *AI Integration for Smart KPI Management:*- *AI algo*rithms will analyze historical and real-time data to identify patterns, anomalies, and efficiency metrics.
- AI will suggest KPIs that are most indicative of machine performance and operational health, tailored to specific manufacturing contexts.

c) *Customizable User Interface (UI):*- The portal will feature a user-friendly UI, allowing users to easily select, modify, and visualize KPIs.
- Customization options include adding new KPIs, adjusting KPI priorities, and configuring multi-KPI graphs.

2) Detailed Solution Approach

a) *Database Schema Enhancement:* - Implementing a flex-ible schema capable of handling multiple KPI types, custom configurations, and AI-generated insights.
- Tables like 'company_machine_image', 'kpi', 'kpi_customization', and 'ai_insights' will form the backbone of the KPI management system.

b) *Real-Time Data Handling and Analysis:* - The system will continuously process machine data in real-time, feeding into AI models for immediate analysis.
- This capability ensures that KPIs are always relevant and reflective of the current operational state.

c) *AI-Driven Customization and Predictive Insights:* - AI models will generate predictive insights, helping preemptively identify potential issues and optimize operations.
- The system will suggest custom KPIs based on machine learning analysis of historical data trends and real-time conditions.

d) *Interactive and Adaptive UI:* - Users can interact with the system to customize their KPI dashboard according to their specific needs and preferences.
- The UI will adaptively present the most relevant KPIs, aided by AI insights, enhancing the decision-making process.

e) *Seamless Integration with Existing Systems:* - The KPI customization feature will be designed to integrate seamlessly with existing systems in the manufacturing portal.
- This includes compatibility with various machine types, operational databases, and user management systems.

3) User-Centric Customization Features

a) *Drag-and-Drop Interface for KPI Ordering:* - Users can reorder KPIs through a simple drag-and-drop interface, making the customization process intuitive and efficient.

b) *KPI Visibility Toggle:* - Users can choose to hide or display specific KPIs, ensuring that their dashboard only shows the most relevant data.

c) *Custom Multi-KPI Graph Creation:* - The system allows for the creation of custom graphs that can combine up to 10 KPIs, providing comprehensive insights into machine performance.

d) *Personalized AI Recommendations:* - Users receive AI-generated suggestions for KPI customization, which they can choose to adopt or modify according to their needs.

4) Conclusion

The proposed solution for AI-enhanced KPI customization represents a significant advancement in manufacturing data analytics. It brings together the power of AI, the flexibility of a dynamic database, and a user-centric interface to revolutionize how KPIs are managed and utilized in manufacturing settings. This approach not only enhances operational efficiency and decision- making but also aligns with the evolving needs of modern manufacturing environments, where adaptability and precision are key to success.

5) Future Directions

a) Continuous Improvement of AI Models: Regularly update the AI algorithms with new data and feedback for more accurate predictions and insights.

b) Scalability and Expansion: Ensure the system can scale with the growing data needs and can be adapted to different manufacturing scenarios and machinery types.

c) Enhanced User Experience: Continually refine the UI/UX design based on user feedback to make KPI customization even more intuitive and effective.

4. Database Schema

This section provides a detailed explanation of the database schema designed for the AI-enhanced KPI customization feature in a Manufacturing Portal. The schema is structured to support flexibility, efficiency, and the integration of AI-driven insights.

1) Database Schema Breakdown

a) Table: company_machine_image: - Purpose: Differentiates machine images for each customer.
- Fields:
- 'company Machine Image Id' (INT, AUTO INCRE-MENT): A unique identifier for each record.
- 'companyId' (INT): Identifier for the company.
- 'machine ImageId' (INT): Identifier for the machine image.
- This table forms a composite key using 'company Id' and 'machine ImageId'.

b) Table: kpi: - Purpose: Stores all KPIs visible in the portal, including custom KPIs for multi-graphs.
- Fields:
- 'id' (INT, AUTO INCREMENT): Unique identifier for each KPI.
- 'referenced KpiId' (INT): Links to the KPI ID in the machine service or the ID from the 'custom_kpis' table.
- 'company Machine ImageId' (INT): Foreign key to 'company_machine_image'.
- 'type' (ENUM - default, custom): Indicates if the KPI is a default or a custom type.

c) Table: kpi_customization: Purpose: Manages the order

Licensed Under Creative Commons Attribution CC BY

and visibility of KPIs.

- Fields:
- 'kpiId'(INT):Internal KPIID, primary key.
- 'position'(INT): Defines the order of the KPI in the list.
- 'visible' (BOOLEAN): Indicates if the KPI is visible or hidden in the Portal.

d) Table: custom_kpi: Purpose: Stores context for multi- KPI graphs.

- Fields:
- 'id' (INT, AUTO INCREMENT): Unique identifier.
- 'name' (VARCHAR(100)): Name of the multi-KPI graph.
- 'graph Data' (JSON): List of KPI IDs to be plotted on the graph.

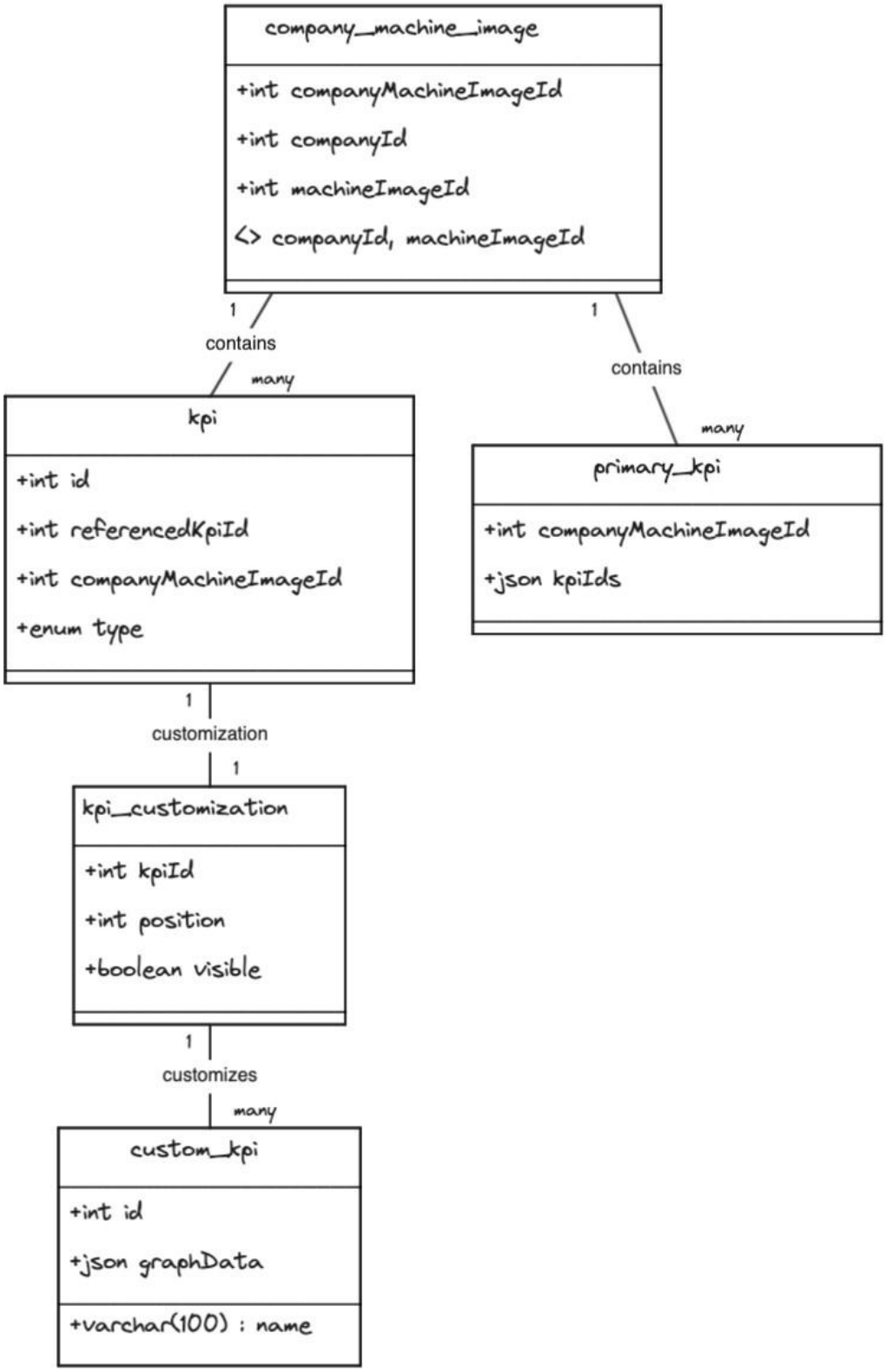

Figure 1

e) Table: primary_kpi: - Purpose: Optionally manages a separate list of primary/top KPIs.

Licensed Under Creative Commons Attribution CC BY

- Fields:
- ‘company Machine Image Id‘ (INT): Foreign key to ‘company_machine_image‘.
- ‘kpiIds‘(JSON):List of top KPIIDs.

f) Denormalized Table:kpi

After combining ‘kpi‘ and ‘kpi_customization‘, the denormalized structure:

- Fields:
- - ‘id‘ (INT, AUTO INCREMENT): Internal KPI ID.
- ‘referenced KpiId‘ (INT): Links to either machine service KPIID or custom KPIID.
- - ‘company Machine Image Id‘ (INT): Foreign key to ‘company_machine_image‘.
- ‘type‘(ENUM-default, custom): Type of the KPI.
- ‘position‘(INT):Order of the KPI.
- ‘visible‘(BOOLEAN):Visibility of the KPI in the portal.

g) Database Relationships and Constraints

- Foreign Key Constraints: Ensure integrity between ‘company Machine ImageId‘ in ‘kpi‘, ‘custom_kpi‘, and ‘pri- mary_kpi‘ tables with the ‘company_machine_image‘table.
- Data Types and Validation: Carefully define data types and constraints for each field to ensure data integrity.
- Indexes: Implement indexes on frequently queried fields like ‘company Id‘, ‘machine ImageId‘, and ‘referenced KpiId‘ for performance optimization.

h) Handling AI Insights

AI Insights Integration: The schema should support the integration of AI-generated insights. This can be achieved through additional fields or tables designed to store AI pre- dictions and recommendations related to KPI configurations.

i) Conclusion

The design of this database schema is foundational for the successful implementation of the KPI Customization feature. It supports efficient data retrieval, manipulation, and the integration of AI-driven insights, providing a robust backbone for the portal’s enhanced functionality.

j) Future Enhancements

- Scalability Considerations: As the user base grows, the schema should be reviewed for scalability, potentially leading to further normalization or the introduction of new tables.
- Advanced Analytics Support: Consider extending the schema to support more advanced analytics and AI features in the future.

5. AI Integration

AI algorithms analyze historical machine data to identify patterns and suggest the most relevant KPIs. These suggestions are stored in the ‘ai_insights‘ table and are accessible to users for customization.

A. Implementation Details

5.1.1. Portal Modifications: This section delves deeper into the specific modifications required in the portal to implement the AI-enhanced KPI Customization feature. Each aspect of the portal modification is detailed below.

a) *Configure Database for the Portal:* - Database Setup

- Initialize a MySQL database.
- Create tables as per the defined schema including ‘company_machine_image‘, ‘kpi‘, ‘kpi_customization‘, ‘cus- tom_kpi‘, and ‘ai_insights‘.
- Data Migration
- Develop scripts to migrate existing KPI data into the new structure.
- Ensure data integrity and consistency during migration.
- Database Management
- Implement regular database maintenance routines.
- Ensure scalability and performance optimization of the database.

b) *AI Integration:* - AI Model Development

- Develop machine learning models to analyze historical data and predict key performance metrics.
- Train models to identify patterns and suggest the most relevant KPIs.
- Data Processing
- Implement data preprocessing steps for AI model inputs.
- Integrate real-time data processing capabilities for up-to-date AI insights.
- Model Deployment
- Deploy AI models within the portal infrastructure.
- Ensure models are updated regularly with new data for continuous learning.

c) *UI Development for KPI Customization:* -Designing the UI

- - Create intuitive and user-friendly interfaces for KPI customization.
- Design interactive elements like drag-and-drop for KPI ordering.
- Integration with Backend
- Connect UI components with backend APIs for data fetching and updating.
- Implement dynamic rendering of KPIs based on user preferences and AI suggestions.
- Testing and UserFeedback
- Conduct thorough UI testing including usability tests.
- Incorporate user feedback for iterative UI improvements.

d) *API Development and Integration:* - APIs for Data Retrieval

- Develop RESTful APIs for fetching KPI data (‘/kpi/company‘, ‘/kpi/custom‘, etc.).
- Implement API endpoints for accessing AI insights (‘/kpi/ai_insights‘).
- APIs for Data Modification
- Create APIs for updating KPI configurations (‘PUT /kpi/configuration‘).
- Implement endpoints for adding new custom KPIs (‘POST /kpi/custom‘).
- API Security and Performance
- Ensure API security with proper authentication and authorization.

Licensed Under Creative Commons Attribution CC BY

- Optimize API performance for handling high-volume requests.

e) ***Redux Integration for State Management:*** **- Redux Store Setup**
- Define the structure of the Redux store to manage state related to KPIs, custom KPIs, and AI insights.
- Ensure the store is modular and scalable for future enhancements.
- State Management
- Implement actions and reducers for managing KPI data within the Redux store.
- Ensure synchronization between the Redux store and UI components.
- Historical Data Integration
- Integrate historical data fetching and management within the Redux architecture.
- Implement state selectors for efficient data retrieval from the store.

f) ***Historical Data Re-fetching:*** **- Data Fetching Strategy**
- Redefine the strategy for historical data retrieval to align with the new KPI customization features.
- Ensure efficient and timely data fetching for real-time analysis.

2. API Development:

a) ***GET/kpi/company:*** **- Purpose: Fetches KPIs for a specific company and machine image.**
- Implementation:
- Endpoint: ‘GET/api/kpi/company‘
- Request Parameters: ‘company Id‘, ‘machine Image Id‘
- Backend Logic:
- Validate request parameters.
- Query the database to retrieve KPIs related to the given ‘company Id‘ and ‘machine Image Id‘.
- Format and return the data.
- Response Structure:
- JSON array of KPI objects, each including ‘id‘, ‘referenced KpiId‘, ‘company Machine Image Id‘, ‘type‘, ‘position‘, ‘visible‘.

b) ***GET/kpi/custom:*** **- Purpose: Retrieves custom KPI configurations.**
- Implementation:
- Endpoint: ‘GET/api/kpi/custom‘
- Request Parameters: Array of‘ids‘.
- Backend Logic:
- Validate the ‘ids‘ array.
- Perform a database lookup for custom KPIs using the provided ‘ids‘.
- Return the details of the custom KPIs.
- Response Structure:
- JSON array containing details of each custom KPI, including ‘id‘, ‘name‘,‘graph Data‘.

c) ***GET /kpi/ai_insights:*** **- Purpose: Accesses AI-generated KPI recommendations.**
- Implementation:
- Endpoint: ‘GET/api/kpi/ai_insights‘
- Request Parameters: ‘company Id‘.
- Backend Logic:
- Validate ‘companyId‘.
- Retrieve AI insights from the ‘ai_insights‘ table for the specifiedcompany.
- Format and return the insights.
- Response Structure: JSON object containing AI-generated KPI insights.

d) ***PUT/kpi/configuration:*** **- Purpose: Updates KPI configuration.**
- Implementation:
- Endpoint: ‘PUT/api/kpi/configuration‘
- Request Body: Array of objects, each containing ‘kpiId‘, ‘position‘,‘visible‘.
- BackendLogic:
- Validate and sanitize inputdata.
- Update the ‘kpi_customization‘ table based on the provided configurations.
- Handle any exceptions or errors.
- Response Structure:
- Status message indicating success or error.

e) ***POST /kpi/custom:*** **- Purpose: Creates a new custom KPI.**
- Implementation:
- Endpoint: ‘POST/api/kpi/custom‘
- Request Body: Object containing ‘name‘, ‘graph Data‘ (array of KPIIDs).
- Backend Logic:
- Validate input data.
- Insert a new record into the ‘custom_kpi‘ table.
- Return the ID of the newly created custom KPI.
- Response Structure:
- JSON object with the new custom KPI’s ‘id‘.

Code Snippets for API Implementation GET /kpi/company

```
“‘javascript
app.get(’/api/kpi/company’, (req, res) => {
const { companyId, machineImageId } = req.query;
// Database query and response logic
}); “‘
```

GET /kpi/custom

```
“‘javascript
app.get(’/api/kpi/custom’, (req, res) => { const { ids } = req.query;
// Database query and response logic
}); “‘
```

GET /kpi/ai_insights

```
“‘javascript
app.get(’/api/kpi/ai_insights’, (req, res) => { const { companyId } = req.query;
// AI insights retrieval and response logic
}); “‘
```

PUT /kpi/configuration

```
“‘javascript
app.put(’/api/kpi/configuration’, (req, res) => {
```


Licensed Under Creative Commons Attribution CC BY

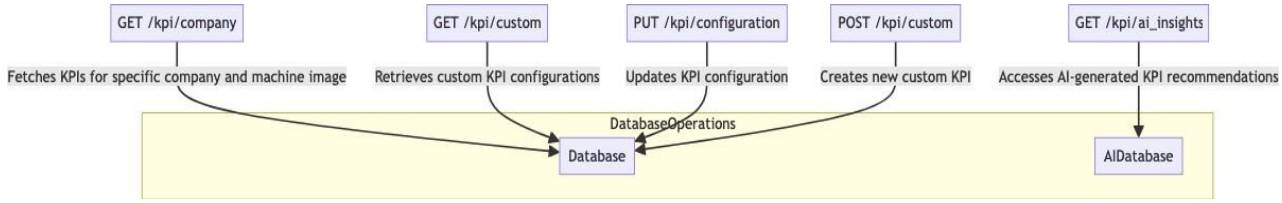

Figure 2

```
const configurations = req.body;
// Update configuration logic
}); “‘
```

POST /kpi/custom

```
“‘javascript
app.post(’/api/kpi/custom’, (req, res) => { const { name, graphData } = req.body;
// Custom KPI creation logic
}); “‘
```

Testing and Validation

- **API Testing:** Each API endpoint should undergo thorough testing to ensure it handles requests correctly and securely. This includes testing for various scenarios, error handling, and edge cases.
- **Input Validation:** Implement robust input validation to prevent in valid data entry and potential security vulnerabilities.
- **Performance Testing:** Test the APIs under load to ensure they can handle high numbers of requests without significant performance degradation.

6. Conclusion

The development and implementation of an AI-enhanced KPI customization feature within a manufacturing portal mark a significant stride in industrial operational management. This conclusion reiterates the key points of the research, its implications, and prospects.

1) Key Takeaways

a) *Enhanced Flexibility and Efficiency:* - The proposed solution overcomes the rigidity of traditional KPI systems, introducing a level of flexibility and efficiency that aligns with the dynamic nature of modern manufacturing processes.
   - Users gain the ability to tailor KPIs to their specific needs, leading to more relevant and actionable insights.

b) *Integration of AI:* - AI plays a crucial role in transforming KPI management from a static to a dynamic process. By leveraging historical and real-time data, AI algorithms provide predictive insights and intelligent KPI recommendations.
   - This integration elevates the system’s capability to not just report but also predict and advise, thereby enhancing decision- making processes.

c) *User-Centric Approach:* - The focus on a customizable and interactive user interface ensures that the system is accessible and valuable to users with varying levels of technical expertise.
   - The empowerment of users to modify, add, and visualize KPIs according to their preferences fosters a more user- engaged approach to data analytics.

2) Implications and Impact

a) *Operational Excellence:* - The implementation of this system is expected to lead to significant improvements in operational efficiency, accuracy in performance monitoring, and proactive maintenance.
   - It allows for quicker responses to changing conditions and potential issues, thereby minimizing downtime, and optimizing resource allocation.

b) *Strategic Decision-Making:* - With more relevant and timely data at their fingertips, managers and operators can make more informed, strategic decisions that positively impact overall productivity and profitability.

c) *Adaptability to Future Trends:* - The solution is designed to be adaptable, ensuring that it remains relevant and effective as new technologies and methodologies emerge in manufacturing.

3) Prospects

a) *Continuous Improvement and Learning:* - The AI models will continually learn and improve, offering increasingly accurate predictions and insights.
   - Regular updates and feedback cycles will ensure the sys- tem evolves to meet the changing needs of the manufacturing sector.

b) *Scalability and Broader Application:* - The system’s architecture will be assessed for scalability to accommodate larger datasets and more complex operational environments.
   - Potential applications in other industrial sectors will be explored, widening the impact of this innovative approach to KPI management.

c) *Integration with Emerging Technologies:* - Future enhancements may include the integration of the Internet of Things (IoT), augmented reality (AR), and other emerging technologies to further enrich data collection and visualization. In summary, the AI-enhanced KPI customization feature represents a significant technological advancement in manufacturing operations. By aligning AI capabilities with user-centric design and dynamic data management, this solution sets a new standard in industrial KPI analytics, paving the way for smarter, more efficient, and responsive manufacturing practices.

References

[1] R. Chen, Artificial Intelligence in Industrial Applications. New York: Springer, 2020.

Licensed Under Creative Commons Attribution CC BY