INTELLEGENT INVETORY MANAGEMENT SOFTWARE (IIMS)

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ILGC Sem 4

End-semester Project Report.

1. **Title of the project and Project summary**:

The project titled "Intelligent Inventory Management System for Small and Medium-Sized Enterprises (SMEs)" endeavours to revolutionise inventory control processes by integrating advanced machine learning techniques. Currently, many businesses, especially SMEs, grapple with inefficient stock management practices, resulting in financial losses due to overstocking or understocking of goods. To tackle this challenge, our project proposes a holistic approach that combines historical data analysis, market trends assessment, and machine learning algorithms to offer guidance on optimal product quantities. It involves developing a comprehensive inventory management system with essential features such as user authentication, invoice generation, and efficient data handling.

Through extensive secondary research, we uncovered a critical gap in existing systems: the lack of robust error-proofing mechanisms. Our findings, validated by industry experts, highlighted the urgent need for systems that prioritise accurate data entry to mitigate risks and enhance decision-making. In response, our project focuses on implementing error-proofing measures alongside predictive analytics to empower SMEs with precise inventory management and informed decision-making capabilities, ultimately fostering growth and competitiveness in the market.

The highlight of the project lies in the integration of machine learning for demand prediction, enabling businesses to anticipate future demand patterns accurately. By leveraging predictive analytics, the system empowers SMEs to make informed decisions regarding optimal purchasing quantities, thereby minimising risks and maximising profitability. Furthermore, through extensive secondary research, we identified a significant gap in existing systems: the lack of robust error-proofing mechanisms. Our findings, validated by industry experts, highlighted the urgent need for systems that prioritise accurate data entry to mitigate risks and enhance decision-making. In response, our project prioritises error-proofing measures alongside predictive analytics to empower SMEs with precise inventory management and informed decision-making capabilities, ultimately fostering growth and competitiveness in the market.

2. **Existing state of art**:

The market for inventory management globally is growing rapidly, with the Inventory Management Software Market projected to reach USD 4.05 billion by 2030, exhibiting a CAGR of 9.6% during the forecast period. The key components of inventory management include-

Software management: Inventory management software helps end-users in various industries automate their inventory processes, optimise stock levels, and manage orders more efficiently.

Hardware: Hardware inventory management software is designed to provide detailed information about all hardware assets within an organisation, helping to ensure the system and business are always equipped with the necessary hardware.

SaaS companies: Many businesses are adopting Software as a Service (SaaS) solutions for inventory management, which offer cloud-based platforms for managing inventory, automating processes, and integrating with other systems.

The latest trends in inventory management globally include:

- Internet of Things (IoT), RFID, and Robotics
- Cloud-based systems for remote access
- Distributed inventory management
- Data analytics
- Predictive inventory
- Outsourcing

We also researched the literature on spreadsheet anomaly detection. The following are the most impactful papers we found-

- https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=07578f12f0e8601d4bc302173b647e2e3530e5d4 A paper by scientists from Microsoft Research, on their technique called MELFORD that uses neural networks to detect copy-pasted errors. Also details on some error prevention/detection methods already used in Excel.
- https://www.sciencedirect.com/science/article/abs/pii/S0164121216300103 Overall techniques used for anomaly detection in spreadsheets- broadly, preventing errors, detecting errors, and fixing errors. The 3 methods empirically studied are AmCheck, UCheck, and Dimension. All have citations, along with more techniques used. Some spreadsheet corpora are also mentioned for testing- EUSES Spreadsheet Corpus, Enron Spreadsheet Corpus, and Hawaii Kooker Corpus.
- https://www.sciencedirect.com/science/article/pii/S026840122031481X The algorithm requires “a few minutes” to retrain itself on user data, while for real life use we might need it to update within a fraction of a second. This is the only reason we cannot use this for our project :-(

3. **Significance of proposed project**:

The proposed project for an Intelligent Inventory Management System holds significant promise in addressing the limitations of existing inventory management solutions, especially when compared to the current status of the market. Existing solutions primarily focus on automating processes and optimising stock levels without fully leveraging advanced technologies like AI and machine learning.

The significance of the proposed project lies in its innovative approach to integrating machine learning algorithms for demand prediction, a feature not extensively explored in many existing inventory management systems. By harnessing AI capabilities, the proposed system can accurately forecast demand, optimise inventory levels, and automate decision-making processes. This contrasts with traditional inventory management software, which often relies on historical data and manual inputs, leading to inefficiencies and errors in forecasting and decision-making.

Furthermore, this holistic approach enables real-time tracking, instant identification of inventory, and remote access to inventory data, promoting flexibility, collaboration, and efficiency across different locations—a feature not fully realised in many existing systems.
Additionally, the proposed project addresses the issue of human error in data entry, which is a significant challenge in current inventory management practices. By implementing error-proof data entry mechanisms, the proposed system enhances data accuracy and reliability, mitigating the risks associated with inaccurate inventory data.
Overall, the proposed project represents a significant advancement in inventory management technology, offering SMEs a sophisticated yet user-friendly solution that leverages cutting-edge AI, machine learning, and IoT technologies to optimise operations, increase efficiency, and reduce costs. Its innovative features and comprehensive approach set it apart from existing solutions, making it a valuable intervention in the evolving landscape of inventory management systems.

4. **Objectives:**

- **Identification of the need for the product** through techniques like mom's test and surveys, of the end user (customers rather than clients.)
- **Define the customer archetype or scale of business** that is most likely to benefit from the proposed product. To classify the segment (business, as ours is a B2B model) of the market that can reap most of the benefits from our product that we want to create.
- I**dentification of time slabs or time intervals** (week, month) where quantity prediction and inventory management are most effective.

- **Find existing gaps:** Find the existing gap in the market through primary and secondary research which has to be bridged by the product.
- **Investigate Anomaly Detection Algorithms:** We explored various algorithms used for anomaly detection, evaluating their effectiveness in identifying errors within inventory management systems.
- **Identify the Best-Suited Algorithm:** Through rigorous testing, we sought to identify the algorithm that delivers the most accurate and reliable performance in detecting anomalies specific to inventory data.
- **Design an algorithm**: Most of the algorithms are not suited to our use case. So we designed an algorithm for our use case.

5. Major Findings:

These are the important conclusions that we could find in the case of small retailers.:

- Demand-based inventory: Small retailers avoid traditional inventory management and instead, base their stock on real-time customer demand. They closely monitor buying trends and adjust inventory levels accordingly. This minimises storage costs and unsold goods.
- Loyal customer base: Small retailers focus on building strong relationships with their customers through personalised service and consistent quality. This loyalty translates to repeat business and positive word-of-mouth promotion.

As an example of a customer who would use such an inventory management system, we interviewed stakeholders in Plaksha's mess management.

These are the insights we gained from talking to the Plaksha Mess coordinator and the food service provider:

- Demand forecasting: Plaksha estimates the number of students on campus and predicts how many will have each meal. They factor in holidays and buffer in a safety margin to avoid shortages.
- Menu planning: The mess committee prepares a weekly menu which is used to determine ingredient requirements.
- Inventory procurement: An external food service provider (FFS) receives ingredient requests and procures them from vendors based on pre-negotiated fixed rates.
- Inventory management: The mess uses a FIFO (First In, First Out) system to ensure fresh ingredients are used.
- Wastage management: Plaksha anticipates food waste and factors it into their planning. They also have a system to collect leftover food for piggery.

- Billing and cost tracking: Plaksha pays FFS a base cost for a set number of meals with additional charges for exceeding that amount

Major Threats to Inventory Management Accuracy:

Effective inventory management hinges on precise data. Unfortunately, several factors can introduce errors into the system, with significant consequences:

1. **Manual Entry Errors:** Both intentional and unintentional mistakes during manual data entry can have serious repercussions. These errors can lead to financial discrepancies, potentially resulting in fraud or legal issues for the company.
2. **Fraction values:** All the current systems store fractions as floating value.

   For example-

   In our mess's inventory management system, fractions are stored as floating-point numbers. When the person responsible for managing stocks inputs menu items into an Excel sheet, these fractional values are stored in floating-point format. Due to the inherent nature of floating-point representation, a small portion of the fraction may be lost during conversion or storage.Once the Excel sheet from the mess is sent to the central center in Chandigarh, similar lists from various other messes are also collected. Each of these lists contains fractional values stored in floating-point format, potentially leading to further loss of precision during data aggregation.

   As the lists are forwarded to higher authorities at the national level, the errors in the aggregated data become more pronounced. With each additional list received, the cumulative effect of these small errors grows, potentially leading to significant discrepancies in the final inventory calculations.

   Finally, when the national-level authority places the order with the food provider based on the aggregated data, the inaccuracies introduced at each stage of the process can lead to suboptimal ordering decisions. This, in turn, can impact the availability of raw materials required for meal preparation in the mess

3. **Inconsistent Accounting Practices:** Maintaining consistent accounting methods across all departments is crucial. Failure to do so creates inconsistencies that can snowball into major

errors during audits.

4. **Estimation Errors:** Missing data points can tempt employees to estimate values, particularly for miscellaneous expenses. While acceptable in limited cases, these estimations can introduce errors that distort data and impact overall accuracy.

Consequences of Inventory Management Errors:

- **Tax Miscalculations:** Inaccurate entries can lead to discrepancies in GST or other tax calculations. Underpaying taxes can result in penalties, while overpaying reduces profitability unnecessarily.
- **Inefficient Operations:** Inaccurate data within the system creates a ripple effect. Inaccurate inventory levels lead to inefficient order management and poor decision-making, hindering overall operational efficiency.
- **Reduced Costs:** Errors can result in wasted resources, unnecessary rework, and potential fines. Error-proofing helps prevent these issues, leading to overall cost savings.
- **Improved Brand Reputation:** Consistent accuracy builds trust with customers, suppliers, and partners. Error-proofing demonstrates a commitment to quality and professionalism, enhancing your brand image.

There are two main approaches to tackling anomaly detection problems:

1. **Modelling the Anomaly Distribution:** This approach attempts to understand the underlying patterns of anomalies within the data. By building a model that effectively captures these characteristics, we can identify data points that deviate significantly from the expected behaviour and flag them as anomalies.

2. **Outlier Detection:** This approach focuses on pinpointing individual data points that fall outside the normal range. It's particularly useful when the nature of anomalies is diverse and defies easy categorization by a single model.

The parameter **alpha** determines the fraction of training or test points considered anomalies. If alpha is sufficiently large, a model can be fitted to the anomaly distribution.However, for small values of alpha, the problem is treated as outlier detection.

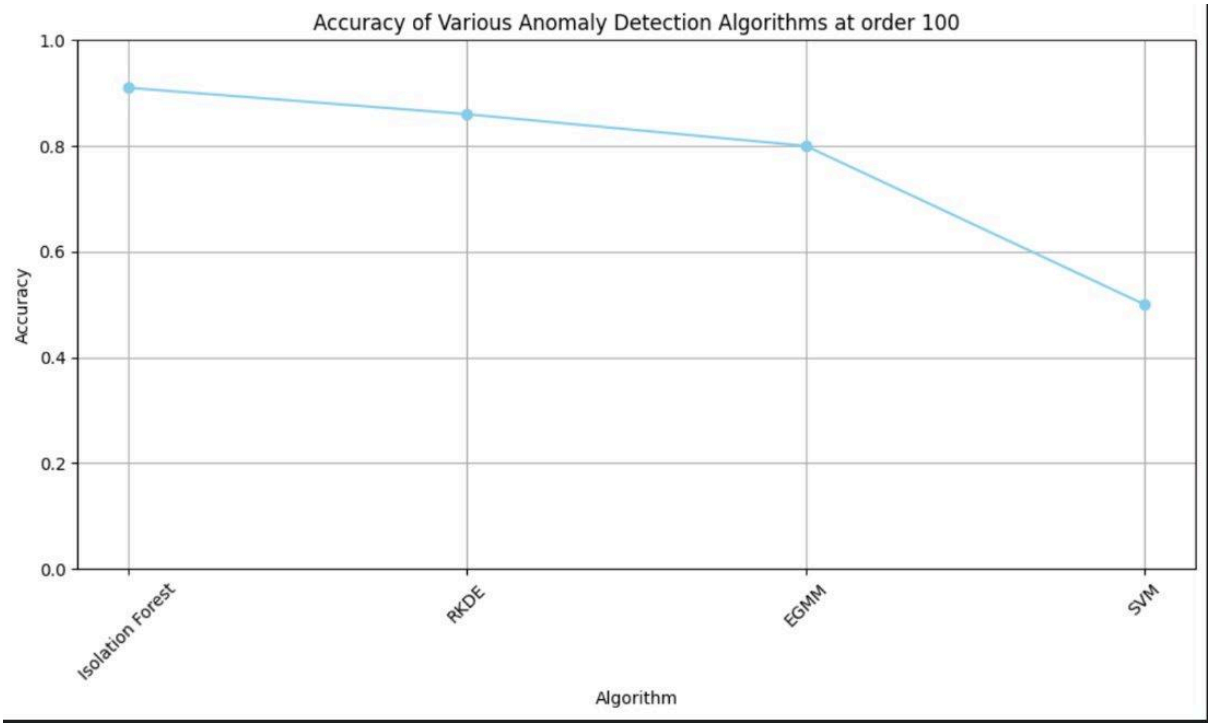
In our case, with a small alpha value, our focus is on outlier detection. Specifically, our goal is to develop a system that promptly alerts users when erroneous data is detected, prompting them to review and correct the input**.**

The Search for the Perfect Solution: Why Existing Algorithms Fall Short

We embarked on a comprehensive exploration of existing anomaly detection algorithms. These tools offer valuable functionality, but after thorough testing, we identified limitations that hinder their effectiveness in real-world applications:

- **Speed:** Training these algorithms often requires significant processing power and time. This is a major drawback for real-time scenarios where immediate analysis is critical.
- **Scalability:** As data volumes inevitably grow with business expansion, existing algorithms may struggle to maintain performance. This can lead to missed anomalies and potential problems slipping through the cracks.
- **Usability:** Implementing and maintaining complex algorithms often necessitates specialized expertise. This creates a barrier for businesses seeking user-friendly solutions that can be readily integrated into existing workflows.

While we experimented with combining these algorithms to address these shortcomings, the resulting approach unfortunately sacrificed accuracy. **This revelation fueled our determination to develop a superior solution – one that prioritises speed, scalability, and user-friendliness without sacrificing accuracy.**



"Anomaly Detection: Algorithms, Explanations, Applications"- Talk by Dr. Thomas Dietterich at Microsoft Research, 2018 (available on YouTube)

5. **Development Methodology:**

Evaluation of Algorithms:

An algorithm is evaluated based on the under written process.

1. Randomly Introduce Errors: First, I randomly select 10% of the data and introduce errors into them by multiplying the transaction values with a specified error order. I mark these data points as errors by creating a new column to indicate error status.
2. Divide the Dataset: I divide the dataset into two parts: a training set and a test set. Typically, I'd use around 70-80% of the data for training and the remaining for testing. However, since I'm interested in evaluating how well the algorithm classifies errors, I might want to ensure that both sets contain a similar proportion of errors.
3. Training the Algorithm: I train the different algorithms using the training set. This involves fitting the model to the training data, so it learns the patterns in the data.
4. Classification: For each data point in the test set, I use the trained model to predict whether the transaction value is classified as an error or not. Different algorithms use different criteria to do so.
5. Evaluation: I compare the predicted error status (error or not) with the actual error status. If the introduced error is classified as an error, it's a correct classification; otherwise, it's an incorrect classification. I calculate the accuracy as the proportion of correctly identified errors to the total number of data points identified as errors.
6. Calculate Evaluation Metrics: Besides accuracy, I can also calculate other evaluation metrics like precision, recall, F1 score, and specificity to get a comprehensive understanding of the model's performance.

Different evaluation Parameters:

- Accuracy: The proportion of correctly classified instances out of all instances.

- Balanced Accuracy: Accuracy that considers the class distribution, ensuring fair evaluation across different classes.

- Precision: The proportion of correctly identified positive cases out of all cases identified as positive.

- Recall: The proportion of correctly identified positive cases out of all actual positive cases.

- F1 Score: A combined measure of precision and recall, indicating the balance between the two metrics.

- Specificity: The proportion of correctly identified negative cases out of all actual negative cases.

The algorithms which we tested are:

1)Isolation forest

2)MEMTO **(**Memory-guided Transformer for Multivariate Time Series Anomaly Detection.)

3)EGMM (Ensemble Gaussian mixture model)

4)RKDE (Robust Kernel Density estimation)

5)One class SVM

6)LSTM

1) Isolation Forest

Amongst the explored algorithms, Isolation Forest achieved good results (accuracy: 0.8-0.92, recall: high across data sizes). However, for our needs, both high accuracy and recall are crucial.

Here is a brief description of how isolation forests work:

Isolation Forest is a machine learning algorithm tailored for anomaly detection, particularly adept at spotting outliers in vast datasets with efficiency. It operates on a few key principles:

1. Random Partitioning: The algorithm partitions the dataset recursively, selecting features and split points randomly until all data points are isolated or a stopping criterion is met.
2. Isolation: Anomalies are typically isolated in fewer steps compared to normal data points during the partitioning process, making them easier to identify.
3. Path Length Calculation: Each data point's average path length to isolation across multiple trees in the forest is computed. Anomalies are expected to have shorter average path lengths.
4. Anomaly Score: Data points receive anomaly scores based on their average path lengths. Lower scores indicate a higher likelihood of being anomalies, while higher scores suggest normalcy.
5. Decision Threshold: Anomalies are classified based on a predefined decision threshold for the anomaly scores.

Output :

```
Evaluation Metrics:
Accuracy: 0.929163472594864
Balanced Accuracy: 0.9557537720721923
Precision: 0.5875017712909169
Recall: 0.9890267175572519
F1 Score: 0.737132189527958
Specificity: 0.9224808265871325
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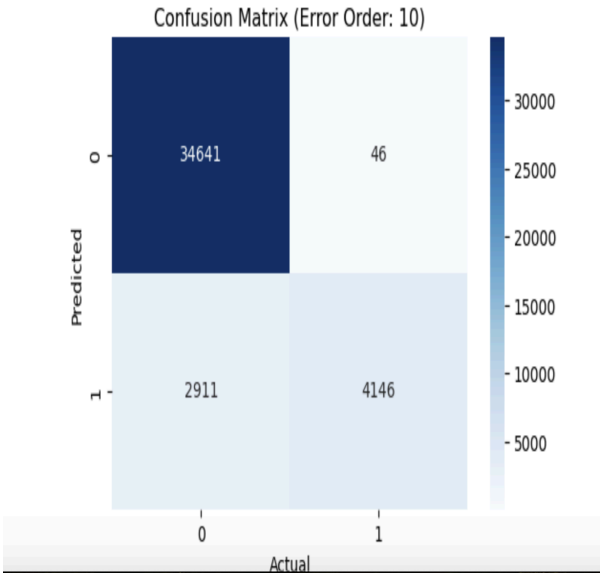


```
Evaluation Metrics:
Accuracy: 0.9083461096205443
Balanced Accuracy: 0.9489354076869227
Precision: 0.523542600896861
Recall: 0.9997621313035204
F1 Score: 0.6872138652714191
Specificity: 0.898108684070325
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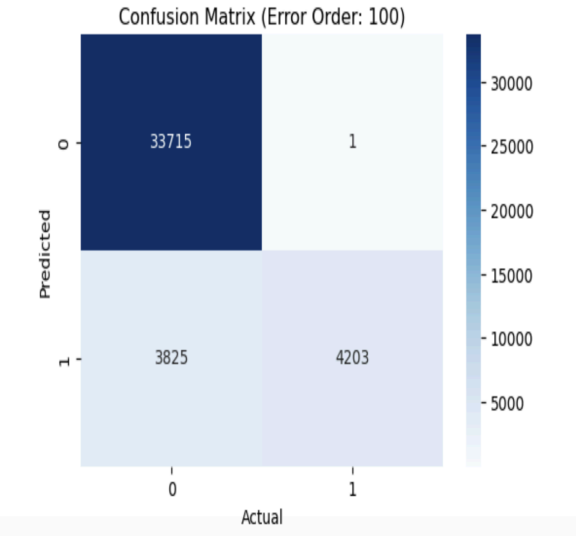

```
Evaluation Metrics:
Accuracy: 0.9581017631276351
Balanced Accuracy: 0.9766010084204453
Precision: 0.7061197041022192
Recall: 0.9997619614377529
F1 Score: 0.8276677505172922
Specificity: 0.9534400554031377
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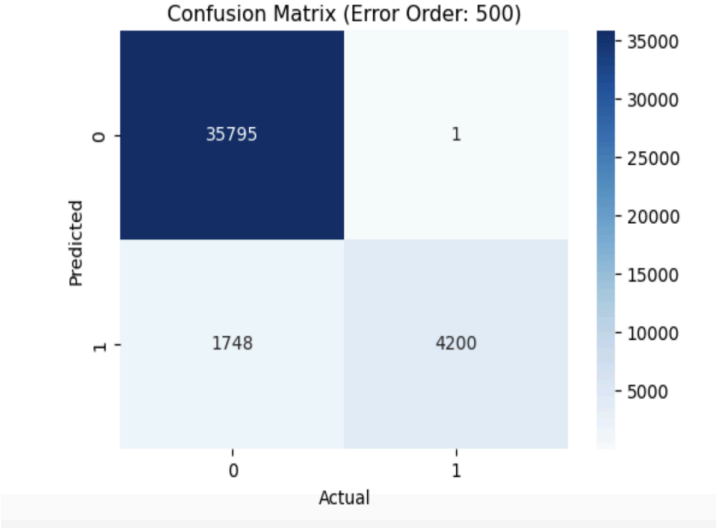
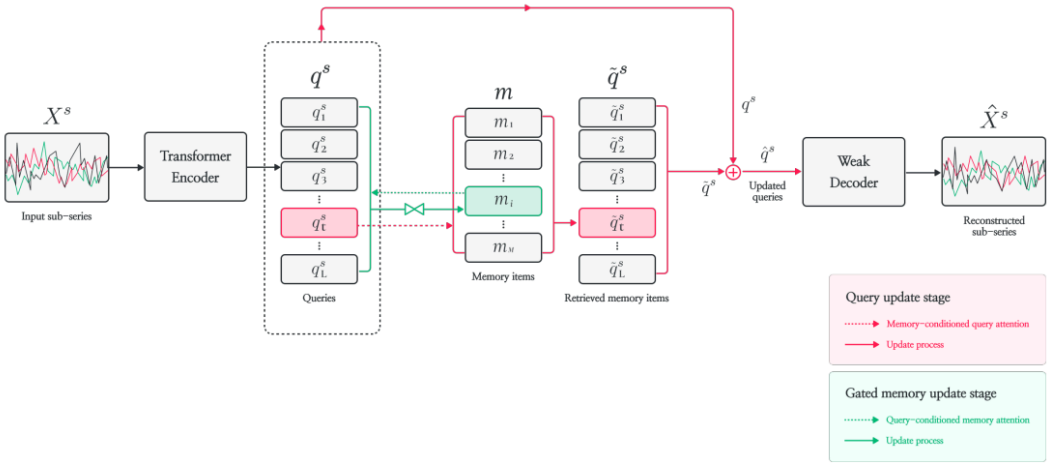


Result:

Isolation forest has shown variable result on all order as accuracy fluctuates between 0.8 to 0.92 for order of 10, 100 , 500. But recall continues to be very high (approx 1) in all cases.

2) MEMTO: Memory-guided Transformer for Multivariate Time Series Anomaly Detection.

MEMTO is a cutting-edge anomaly detection model designed for multivariate time series data. By leveraging a memory-guided Transformer framework, MEMTO effectively adapts to diverse normal patterns within the data through a data-driven approach. This innovative model introduces a novel memory module that dynamically learns how each memory item should be updated in response to input data. To ensure robust training, MEMTO employs a two-phase training paradigm that includes K-means clustering for initialising memory items. Additionally, MEMTO introduces a bi-dimensional deviation-based detection criterion that calculates anomaly scores by considering both input space and latent space. Through extensive experiments on real-world datasets, MEMTO has demonstrated superior performance, surpassing previous state-of-the-art methods in anomaly detection tasks.



MEMTO outperforms traditional anomaly detection methods by incorporating a memory-guided Transformer model with a reconstruction-based approach. Its adaptive memory module learns diverse normal patterns, enhancing anomaly detection efficiency. The two-phase training paradigm, including K-means clustering, boosts model stability. The bi-dimensional deviation-based criterion considers input and latent space, improving anomaly score accuracy. These unique features make MEMTO more effective in detecting anomalies in multivariate time series data compared to existing methods.

MEMTO achieves an average anomaly detection F1-score of 95.74%, significantly outperforming previous state-of-the-art methods .

Result: MEMTO, designed for multivariate time series anomaly detection in applications like computer vision, may not suit the context of inventory management. Inventory data primarily comprises univariate time series, centred on transactional information. Consequently, MEMTO's Transformer encoder might struggle to effectively leverage features or pinpoint pertinent queries in such univariate datasets. Moreover, its decoder tends to simply map inputs to the highest transaction value, lacking the nuanced understanding necessary for accurate anomaly detection in inventory management. Overall, MEMTO's architecture and functionality are ill-suited for the specific objectives of error-proofing and precisely detecting anomalies in inventory management systems.

3) RKDE

Results:

```
Evaluation Metrics:
Accuracy: 0.826849367573783
Balanced Accuracy: 0.5136540448352688
Precision: 0.12143712574850299
Recall: 0.12466191295795427
F1 Score: 0.12302839116719243
Specificity: 0.9026461767125833
```

```
Evaluation Metrics:
Accuracy: 0.8242382138750479
Balanced Accuracy: 0.5111741882322176
Precision: 0.11976047904191617
Recall: 0.12013455069678039
F1 Score: 0.11994722322178242
Specificity: 0.9022138257676547
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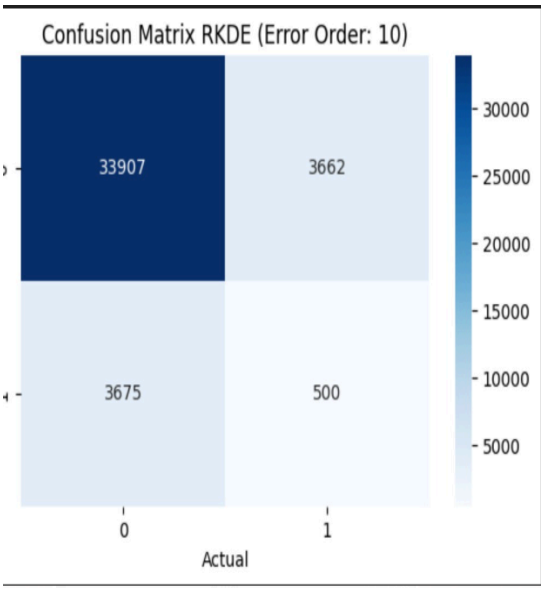

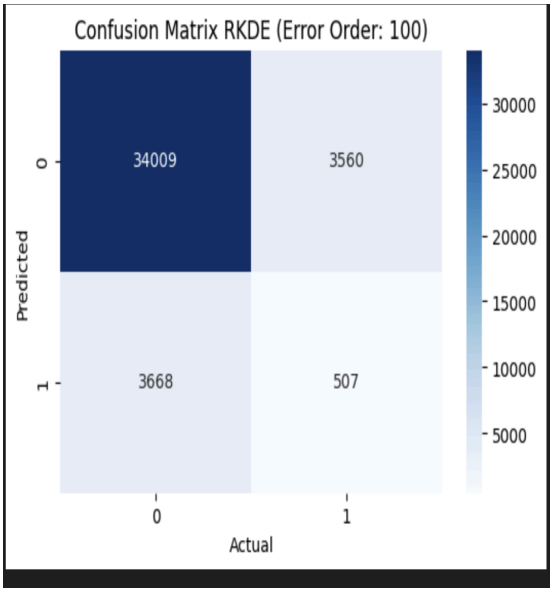


```
Evaluation Metrics:
Accuracy: 0.8237591031046378
Balanced Accuracy: 0.5095317803083182
Precision: 0.11664670658682635
Recall: 0.11717998075072185
F1 Score: 0.11691273556595846
Specificity: 0.9018835798659146
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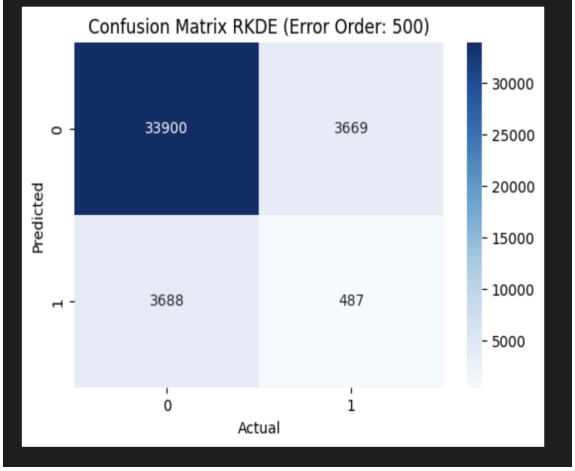

4)EGMM

Results

```
Evaluation Metrics:
Accuracy: 0.8138654656956689
Balanced Accuracy: 0.48494422707650736
Precision: 0.07353293413173653
Recall: 0.07293894036588264
F1 Score: 0.07323473282442748
Specificity: 0.8969495137871321
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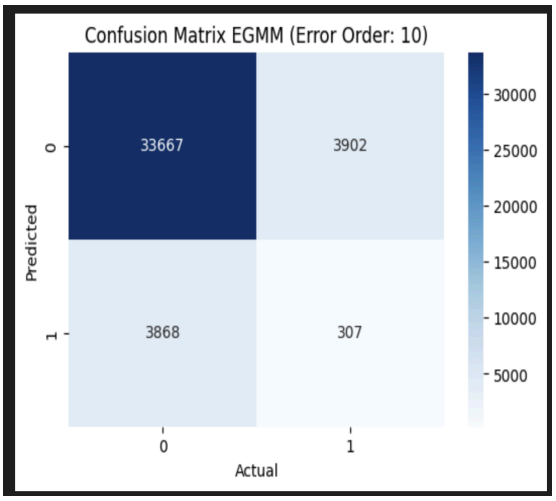


```
Evaluation Metrics:
Accuracy: 0.8054331161364507
Balanced Accuracy: 0.46254255482
Precision: 0.03305389221556886
Recall: 0.0326781908595785
F1 Score: 0.032864967849487975
Specificity: 0.8924069187921431
```

```
Evaluation Metrics:
Accuracy: 0.9503401686469912
Balanced Accuracy: 0.8629179006036464
Precision: 0.7475449101796408
Recall: 0.753864734299517
F1 Score: 0.7506915213469633
Specificity: 0.9719710669077758
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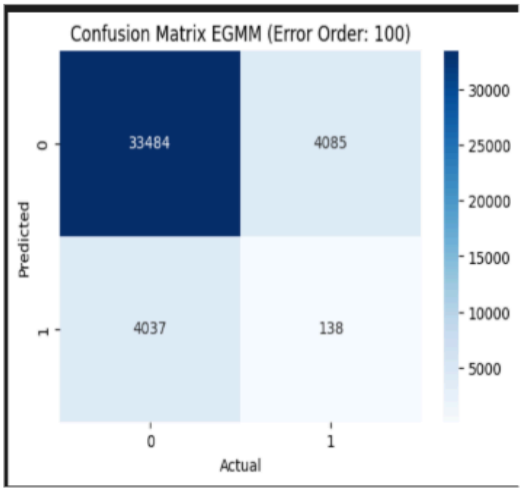

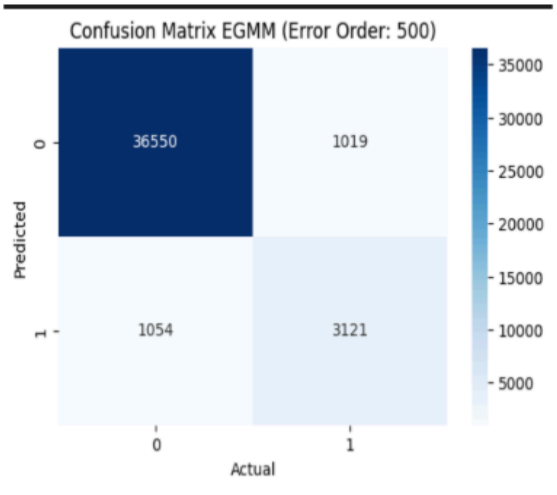

KNN based heuristic:

The heuristic used in this algorithm aims to address the speed and scalability and accuracy issues commonly encountered in existing algorithms, particularly in the context of processing large datasets as we explained in the major finding section of this report. Let's delve into how this heuristic solves these challenges:-
Steps:
Find K nearest neighbour.
Calculate the mean of the nearest neighbours.
Calculate variance of the dataset.
Calculate the range which is mean of neighbours -standard deviation to mean of neighbours +standard deviation.
Classify
Heuristic Approach:

1. Nearest Neighbours Simplification: Instead of exhaustively comparing each data point with every other point in the dataset, the algorithm employs the k-nearest neighbours (KNN) approach. This method significantly reduces the computational complexity by focusing only on a subset of the data that is most relevant to the input.
2. Localised Computation: By utilising KNN with a limited number of neighbours (parameter k), the algorithm confines its computations to a local neighbourhood around each data point. This localised approach reduces the computational burden compared to global methods while still providing meaningful insights.
3. Mean-based Prediction: Rather than individually processing each data point in isolation, the algorithm leverages the collective information from the nearest neighbours. By computing the mean of the transactions of the nearest neighbours, it generates a prediction that reflects the local data distribution. This simplification reduces the algorithm's reliance on intricate calculations while preserving predictive accuracy.
4. Range-based Validation: Instead of evaluating each prediction against the entire dataset's distribution, the algorithm employs a range-based validation strategy. It compares the predicted transaction value against a range defined by the mean and standard deviation of the nearest neighbours' transactions. This range-based validation enables a rapid assessment of whether the prediction falls within an acceptable deviation from the local data distribution.
5. Range Calculation:The range calculation in the algorithm is based on the mean and standard deviation of the nearest neighbours' transactions, where the acceptable range is defined as the mean transaction value plus or minus one standard deviation. **This choice stems from the intuition that in a normal distribution, approximately 68% of the data falls within one standard deviation of the mean, capturing the typical variability in transaction values**. Through experimentation with various range calculation methods, including wider ranges like ±2 or ±3 standard deviations, it was found that ±1 standard deviation consistently yielded the best results. **This narrower range strikes a balance between capturing the majority of normal transaction values and minimising false positives and false negatives in error detection, optimising the algorithm's accuracy and performance** within the inventory management system.

Impact:

- Speed Enhancement: By adopting a localised approach and simplifying computations, the algorithm achieves significant speed improvements compared to traditional methods. The reduction in computational overhead allows for faster processing of large datasets, enhancing overall efficiency and responsiveness.
- Scalability Improvement: The heuristic's reliance on localised information and simplified calculations enhances the algorithm's scalability. It can effectively handle larger datasets without exponential increases in processing time or resource utilisation, making it well-suited for applications requiring scalability.
- Real-time Capabilities: The streamlined processing enabled by the heuristic facilitates real-time or near-real-time applications. By minimising computational delays and resource requirements, the algorithm can deliver timely insights and responses, enhancing its suitability for dynamic environments.

In summary, the heuristic employed in the algorithm addresses the speed and scalability challenges inherent in existing approaches by adopting a localised, simplified, and range-based methodology. This approach not only improves computational efficiency and scalability but also enables real-time processing, making it a valuable solution for various data-intensive applications.

```
Evaluation Metrics:
Accuracy: 0.9622700268302031
Balanced Accuracy: 0.9241856098927306
Precision: 0.7696110036535568
Recall: 0.8768364348677767
F1 Score: 0.8197321735149364
Specificity: 0.9715347849176845
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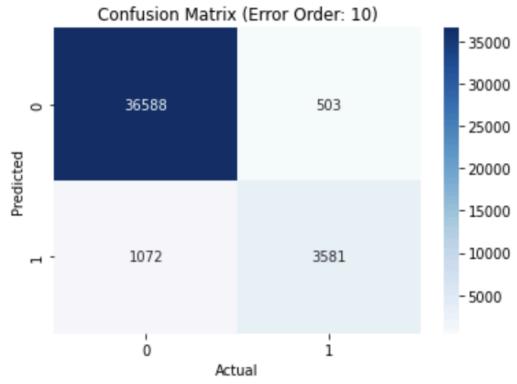
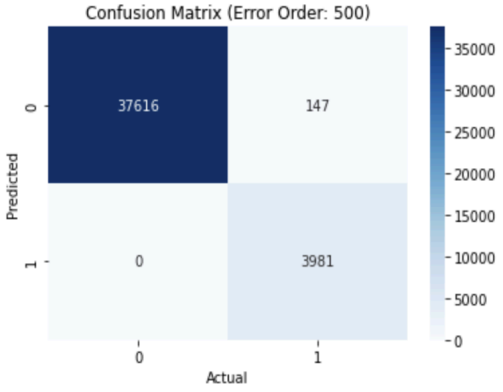



```
Evaluation Metrics:
Accuracy: 0.9964785358374856
Balanced Accuracy: 0.9821947674418605
Precision: 1.0
Recall: 0.9643895348837209
F1 Score: 0.9818719940806511
Specificity: 1.0
```



```
Evaluation Metrics:
Accuracy: 0.9962629359908011
Balanced Accuracy: 0.9819067501739736
Precision: 1.0
Recall: 0.9638135003479471
F1 Score: 0.9815733522324592
Specificity: 1.0
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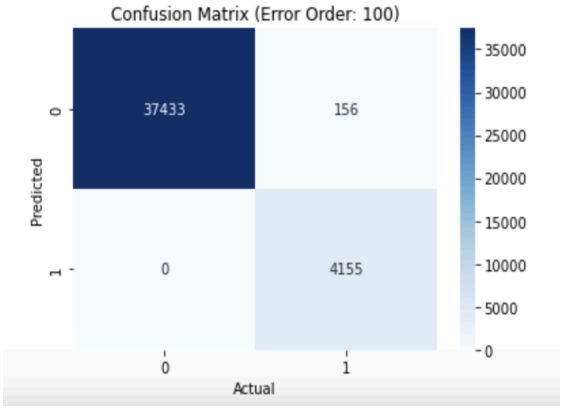
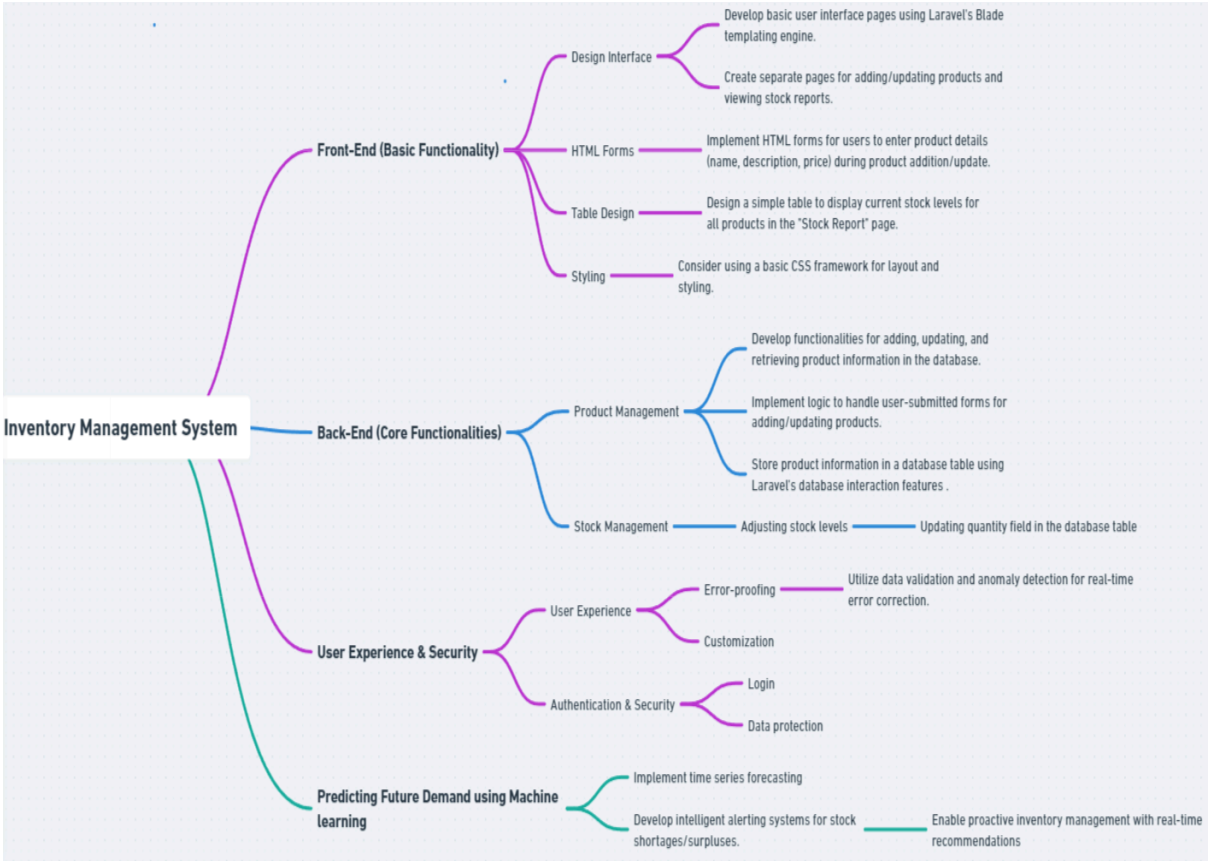


6. **Work Plan and timeline:**

Sl. No.	*Component/Work Elements or Milestones/Targets*	*Expected Start (Date/ Month)*	*Expected Completion (Date/Month)*
1.	Primary Research(Mom's Test, Identify Customer Archetype,IVM theory and others)	20 Jan	10 Feb
2.	Secondary Research(Major market players, Customer Journey etc)	10 Feb	15 March

3.	We assessed top anomaly detection algorithms and analysed if those meet our error-proofing objectives into our inventory management system.	27 March	15 April
4.	Following rigorous testing, we developed a customised anomaly detection method for our (IIMS) using (KNN). Additionally, we evaluated the Isolation Forest algorithm, both of which exhibited the highest accuracy in anomaly detection.	20 April	1 May

7. Flow Chart:


Inventory Management System
Front-End (Basic Functionality)
Design Interface
Develop basic user interface pages using Laravel's Blade templating engine.
Create separate pages for adding/updating products and viewing stock reports.
HTML Forms
Implement HTML forms for users to enter product details (name, description, price) during product addition/update.
Table Design
Design a simple table to display current stock levels for all products in the "Stock Report" page.
Styling
Consider using a basic CSS framework for layout and styling.
Back-End (Core Functionalities)
Product Management
Develop functionalities for adding, updating, and retrieving product information in the database.
Implement logic to handle user-submitted forms for adding/updating products.
Store product information in a database table using Laravel's database interaction features .
Stock Management
Adjusting stock levels
Updating quantity field in the database table
User Experience & Security
User Experience
Error-proofing
Utilize data validation and anomaly detection for real-time error correction.
Customization
Authentication & Security
Login
Data protection
Predicting Future Demand using Machine learning
Implement time series forecasting
Develop intelligent alerting systems for stock shortages/surpluses.
Enable proactive inventory management with real-time recommendations

CUSTOMER JOURNEY

Formerly Forbes Facility Services

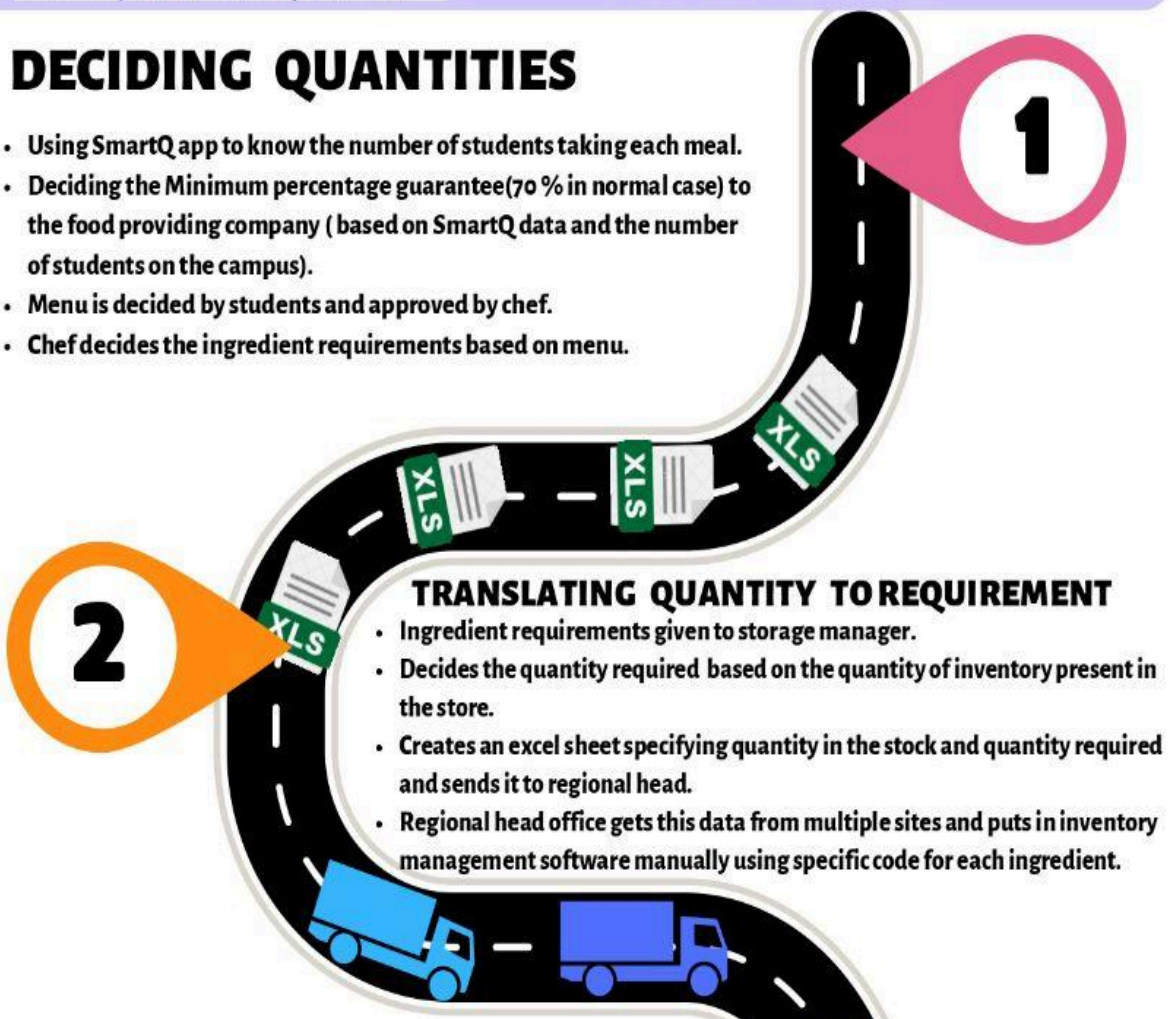
Forbes Facility Services

(Plaksha Mess)

DECIDING QUANTITIES

1

- Using SmartQ app to know the number of students taking each meal.
- Deciding the Minimum percentage guarantee(70 % in normal case) to the food providing company (based on SmartQ data and the number of students on the campus).
- Menu is decided by students and approved by chef.
- Chef decides the ingredient requirements based on menu.



TRANSLATING QUANTITY TO REQUIREMENT

2

- Ingredient requirements given to storage manager.
- Decides the quantity required based on the quantity of inventory present in the store.
- Creates an excel sheet specifying quantity in the stock and quantity required and sends it to regional head.
- Regional head office gets this data from multiple sites and puts in inventory management software manually using specific code for each ingredient.

REQUIREMENT TO PROCUREMENT

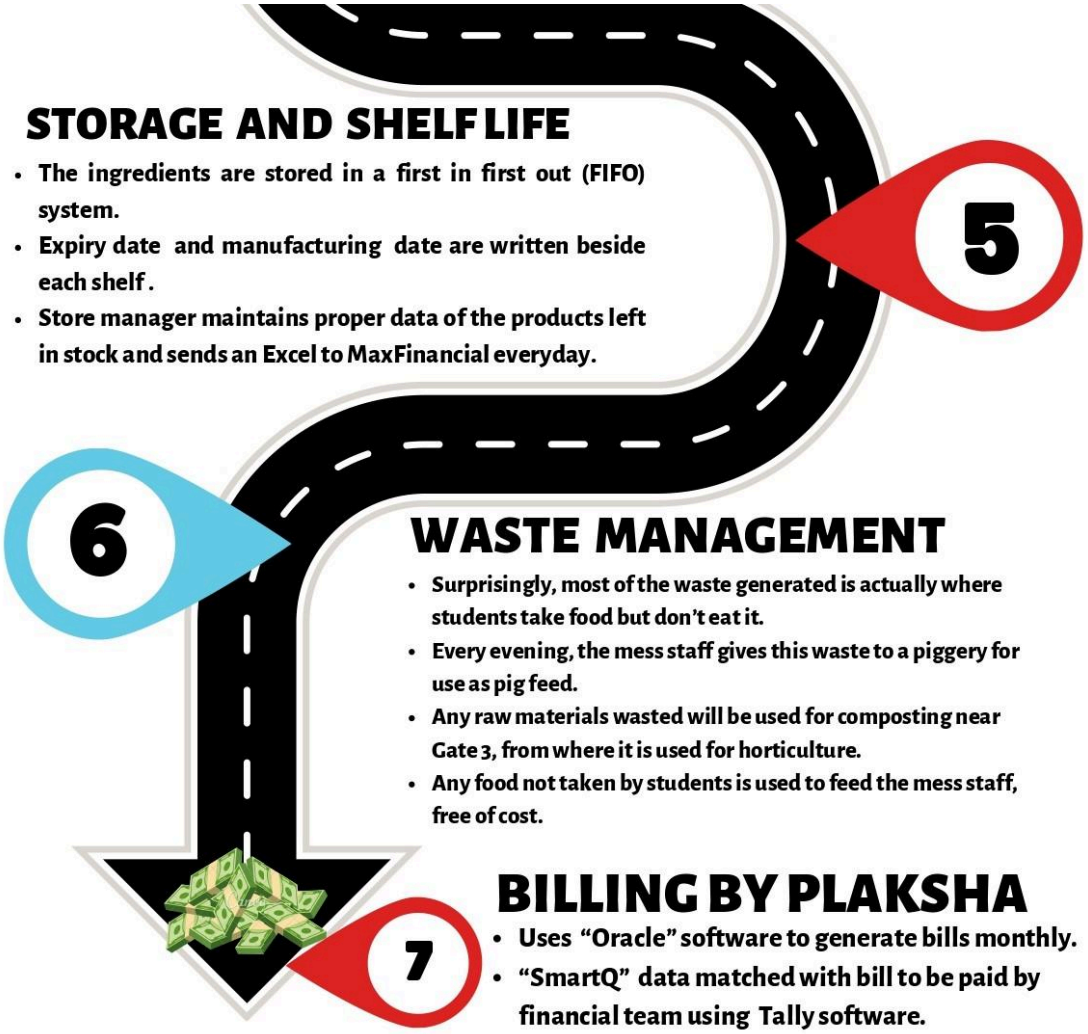
3

- This whole process is done using "MaxFinancial", a software made by Maxus Technologies Pvt. Ltd.
- They keep track of the daily inventory transaction
- And the inventory order is placed manually with the Standardized vendor (eg Catch, HP gas, Verka (local))
- It also keeps track of the billing and accounting of the vendors.

RECEIVING THE RAW MATERIALS.

4

- Things like vegetables which are used on regular basis are brought everyday.
- Things which have long shelf life like rice are brought in every 15 days.



9. **Next Steps:**

Develop an Inventory Management software

- **Front-End Design (Basic Functionality):**
    - Develop user interfaces using Laravel's Blade templating engine for:
        - Adding/updating products
        - Viewing stock reports
    - Implement HTML forms for product details (name, description, price) during product addition/update.
    - Design a table displaying current stock levels for all products.

    - Consider using Bootstrap (optional) for layout and styling.
- **Back-End Development (Core Functionalities):**
    - **Product Management:**
        - Develop functionalities for adding, updating, and retrieving product information in the database.
        - Implement logic to handle user-submitted forms for product actions.
        - Store product information (name, description, price) using Laravel's Eloquent ORM
        - Develop functionalities to retrieve all product information for stock reports.
    - **Inventory Management:**
        - Implement logic to adjust stock levels based on user interaction (e.g., adding/removing items).
        - Update a dedicated quantity field in the database table for stock adjustments.
- **User Design (Prototype Focus):**
    - Prioritize user-friendly interfaces for core functionalities.
    - Ensure clear and easy-to-understand forms for product information.
    - Design a well-formatted stock report table for clear inventory comprehension.
- **Expansion of Machine Learning Applications:**
    - Implement additional predictive analytics techniques (time series forecasting) for improved demand prediction accuracy.
- **Real-Time Decision Support Systems:**
    - Implement intelligent alerting systems for potential stock shortages/surpluses based on predicted demand and inventory levels.
    - Enable proactive decision-making and mitigate overstocking/understocking risks.
- **Expansion of Machine Learning Applications:**

  In the 6th Semester, the integration of machine learning for demand prediction aims to optimise inventory management by accurately forecasting product demand. To further enhance the effectiveness of this predictive model, future directions of the project could involve expanding the scope of machine learning applications. This could include incorporating additional predictive analytics techniques such as time series forecasting, ensemble learning, and deep learning algorithms to improve the accuracy and granularity of demand predictions. Furthermore, the project could explore the integration of external data

sources, such as social media trends and economic indicators, to enhance the predictive capabilities of the model and provide more comprehensive insights into market dynamics.

- **Implementation of Real-Time Decision Support Systems:**

  As the project progresses, there is potential to evolve towards the development of real-time decision support systems that leverage both error-proof data entry mechanisms and machine learning predictions. By integrating these components into a unified platform, businesses can receive timely recommendations and actionable insights to optimize inventory management decisions. This could involve the implementation of intelligent alerting systems that notify users of potential stock shortages or surpluses based on predicted demand and current inventory levels, enabling proactive decision-making and mitigating risks associated with overstocking or understocking.

10. **Reflection**

Anish: Analysed over 15 papers on spreadsheet anomaly detection and inventory management, conducted first-hand testing with the Cin7 inventory management system, and initiated interviews with the Plaksha mess stakeholders for first-hand insights into how customers use inventory management. Helped in creating the reports and presentations.

Jahnavi: I explored the existing market for inventory management solutions and discovered key players like Zoho Inventory and more. Among which I signed up for a profile with Zoho Inventory to understand how they operate. Additionally, I was also helped in interviewing stakeholders, here Plaksha Mess coordinates to gain insights into the end user perspective and pain points. Studied the paper "Reebok NFL Replica Jerseys: A Case for Postponement"

Japsahaj: From identifying the ideal user base to researching the competitive landscape, my contributions to the Intelligent Inventory Management System(IIMS) project have been wide-ranging. By conducting the Mom's Test with small retailers, I played a key role in shifting our focus towards small and medium-sized enterprises (MSMEs) and distributors, where our solution can offer greater impact. Engaging in discussions with the mentor ensured we addressed core project questions and explored optimization strategies. Furthermore,To understand existing solutions, I created a fake GoFrugal account and interacted with customer support, allowing me to analyze competitor offerings and identify areas for our system to differentiate itself.

Rishav: Conducted the MOM's Test by interacting with small-scale retailers and gathered insights indicating the need to pivot the project focus towards small and medium-sized enterprises (MSMEs)

and distributors.Engaged in discussions with the mentor to address fundamental project questions and optimization concerns.Extensively researched inventory management theory through academic literature, gaining insights into optimal inventory management levels and practices.Conducted interviews in collaboration with my team with industry professionals, including the regional head of Plaksha's food serving company and the manager overseeing Plaksha's mess operations, to develop a comprehensive understanding of the customer journey and operational dynamics, facilitating informed decision-making in project development.

10.2: Describe how this project experience has impacted each of the team member's professional development:

Rishav- My active participation in project activities, including research, discussions with mentors, and contributing to deliverables, has significantly boosted my professional growth. I've honed problem-solving skills, improved communication through presentations, learned project management principles, expanded domain knowledge through research, and enhanced adaptability. This experience equips me with valuable skills for future challenges.

Anish- The 3 most important things this project has taught me are-

1. There is always a very good reason why the cons are still around. Since we had been thinking in terms of buzzwords like "innovation", "machine learning" and so on, I had thought this may not be an "innovation" we are doing. But doing what we have done so far showed me how deep and hard even "simple" problems are to solve. After all, if the cons could have been easily solved, they already would have been, right?
2. The only way we can understand a problem's real complexity is to get into the details ourselves. The moment we began hearing from the people we interviewed on how many things they need to consider for the smallest decisions, I realised how hard simply making food for a large group can be.
3. Many great people have done great efforts to tackle the problems we face. The research papers I read, the products I used, and the people I talked to are all proof of that. We must first focus on working with them to understand how they tackle the problem and why, and then give it our unique shot to innovate beyond what everyone has done.

Japsahaj Kaur-This project significantly enhanced my professional development by allowing me to increase my skills in customer research, market analysis, and technical exploration. Through techniques like Mom Tests and algorithm evaluation, I gained a customer-centric approach, identified

a valuable B2B market segment, and developed a solution that bridges existing gaps in inventory management systems. Furthermore, by investigating anomaly detection algorithms, I gained valuable insights into error proofing methodologies, which will be instrumental in creating robust and reliable solutions in the future.

Jahnavi-. The initial research phase, which involved a deep dive into research provided me with a strong foundation and a practical understanding of the subject matter. Furthermore, my contributions during user interviews helped me to understand the process in which inventory in managed and in what hierarchy all actions take place, and by reading on error proofing algorithms and implementing them, I got to know about the importance of error proofing in inventory management system, and how beneficial it is for the end user.

Presentations to get better understanding about our project

Research on Major Market Players:

https://drive.google.com/file/d/1rZ_T3ZWtFubodaVGoiDbFvxHsF2a__WM/view?usp=drive_link

Initial Idea of the Project :

https://drive.google.com/file/d/1HqDdZIGOs_IMHwUgqDywGvIOWF6sMfv5/view?usp=drive_link

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Microsoft Research (Director). (2018, April 6). Anomaly Detection: Algorithms, Explanations, Applications. https://www.youtube.com/watch?v=12Xq9OLdQwQ

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