Food & Beverage Quality Anomaly Detection

The Food & Beverage (F&B;) industry in India faces major challenges in ensuring consistent product quality, meeting regulatory compliance, and minimizing production losses. Variations in raw material quality, equipment parameters, and operator practices often lead to anomalies in the final product. This report presents a systematic approach to anomaly detection in F&B; production, focusing on bakery products as a case study.

1. **Manufacturing Process Steps & Raw Materials** Bakery production involves several stages: mixing of flour, water, yeast, and additives, fermentation, baking, cooling, and packaging. Raw materials include flour (quality measured by protein %), yeast (viability), sugar, salt, and water. Equipment includes mixers, proofers, ovens, and packaging machines. Quality parameters include dough consistency, fermentation time, oven temperature, baking duration, moisture retention, and final weight. The outcome is judged based on visual inspection (color, texture) and measurable data (moisture %, weight, temperature).

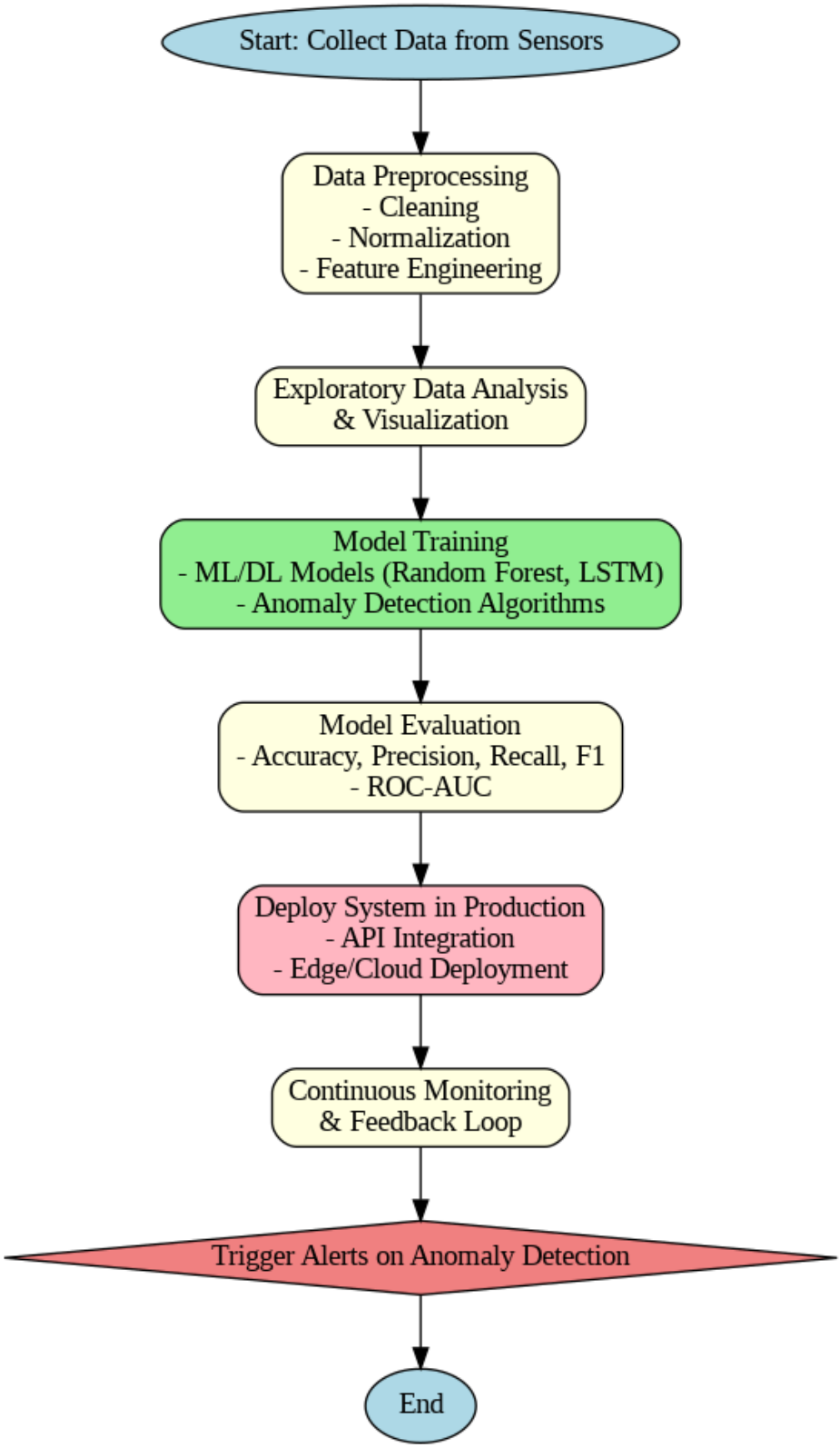
2. **Relevant References & Publicly Available Datasets** Public datasets from Kaggle, UCI Machine Learning Repository, and FAO Food Quality Standards are used as references. Research papers on anomaly detection in manufacturing and food safety monitoring provide additional insights. Example: Liu et al. (2008) introduced the Isolation Forest algorithm, which is effective for anomaly detection.

3. **Relevant Data Streams** - Raw material data: Quantity, pH, moisture, temperature. - Equipment parameters: Oven temperature, baking time, humidity control. - Final product measurements: Weight, moisture content, core temperature, and sensory scores. Time series and discrete data together help in monitoring process consistency.

4. **Defining Final Product Quality** For baked goods, quality is defined by: - **Core temperature after baking** (ideal range ensures food safety). - **Final weight** (ensures correct portion size). - **Moisture percentage** (impacts shelf life and crispiness). - **Visual grading** (brownness, texture, semi-charred detection).

5. **Multivariable Predictive Model** A predictive model was developed using Isolation Forest, applied to both raw material deviations and process parameter shifts. Features include: batch-level numeric values (temperature, moisture, weight) and categorical fields (machine ID, operator). The model identifies outliers, flags high-risk batches, and generates anomaly scores. Results are summarized in Excel dashboards and interactive charts. Alerts are triggered when anomaly rates exceed defined thresholds.

Proposed Workflow


Start: Collect Data from Sensors
Data Preprocessing
- Cleaning
- Normalization
- Feature Engineering
Exploratory Data Analysis
& Visualization
Model Training
- ML/DL Models (Random Forest, LSTM)
- Anomaly Detection Algorithms
Model Evaluation
- Accuracy, Precision, Recall, F1
- ROC-AUC
Deploy System in Production
- API Integration
- Edge/Cloud Deployment
Continuous Monitoring
& Feedback Loop
Trigger Alerts on Anomaly Detection
End

Conclusion This solution demonstrates that anomaly detection can play a critical role in improving food quality, reducing wastage, and ensuring compliance with safety standards. By leveraging machine learning and continuous monitoring, Indian F&B; manufacturers can improve efficiency and trust in their supply chains.