Using Artificial Intelligence technology to smartly track the product expiry in retail stores to avoid food wastage and increase revenue

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Abstract

Food waste is one of the worst problems currently affecting the world, needlessly exhausting natural resources and polluting our planet. For comparison, if food waste were a country, it would be the third in terms of greenhouse gas emissions, according to the Food And Agriculture Organization of the United Nations. Retail businesses need to prioritize profit and productivity to remain competitive in today's global market. It's necessary to act quickly and effectively to ensure success and to stay ahead of competitors. Food waste is something we've come to accept as the status quo for grocery retailers. No one wants to eat expired food, so it gets tossed. Research has spilled the beans over the extent of food waste, and the results aren't pretty. The US wastes more food than any other country in the world- 30-40% of the entire US food supply goes straight from the store shelf into the trash. But who's to blame?

In this report, I have devised an optimal way of how to make use of the artificial intelligence technology to reduce the food wastage in small retail stores and manage their finance accordingly.

1. Problem Statement

The small retail stores owners do not have an idea about the stock of old products residing in their shop which is going to be expired soon. Ignoring those products can have the following impact:-

Financial losses:- Retail stores can suffer significant financial losses if they sell expired products, as the products need to be thrown away and the money invested in them is lost.
Legal issues:- Selling expired products can lead to legal issues, as it can be a violation of food safety regulations. Retail store owners may be fined or face legal action if they sell expired products.
Reputation damage:- Selling expired products can harm the reputation of the retail store and damage its relationship with customers. Customers may lose trust in the store and choose to shop elsewhere.
Customer dissatisfaction:- If customers receive expired products, they may be dissatisfied and may choose not to shop at the store again. Stock management problems: Without proper tracking of expiration dates, retail stores may struggle to manage their stock effectively, leading to overstocking, stockouts, and waste.

2. Market/Customer/Business Need Assessment

Reducing food waste is a complex issue with many more moving parts than just the vegetable aisle and the shoppers browsing it. But it's undeniable that retailers have a huge part to play. So how can retailers strike a balance between being less wasteful while staying profitable?
Expiration Date Tracking technology automates the manual checking of expiration dates and gives store teams complete visibility into what's about to expire. An AI software can be used to detect an old product and can give an alert or pop-up message to the store owner that which product has to be sold earliest and which product can be suggested to the customer.
By keeping track of expiration dates using AI, retail store owners can avoid these problems and improve the overall operations of their store. They can ensure that they are selling fresh and safe products, minimize waste, and reduce the risk of legal and financial problems.

3. **Target Specifications and Characterization**

   The target audience for retail stores and small businesses can vary depending on the type of products or services offered and the target market segment that the business wants to reach like:-

   - <u>Local community</u>:- Many small businesses target their local community, offering products or services that are specifically tailored to the needs and preferences of the people living in the surrounding area.

   - <u>Demographic groups</u>:- Retail stores and small businesses may also target specific demographic groups such as young adults, families with children, seniors, or specific ethnic or cultural communities.

   - <u>Niche markets</u>:- Some retail stores and small businesses focus on serving niche markets, such as pet owners, outdoor enthusiasts, gamers, or foodies.

   - <u>Lifestyle groups</u>:- Retail stores and small businesses can also target consumers based on their lifestyle or personal interests, such as health and wellness, travel, or home improvement.

   - <u>Online audience</u>:- With the rise of e-commerce, many retail stores and small businesses are now targeting online audiences, offering products or services that can be purchased and delivered via the internet.

   So there are no particular target specifications/ peoples because,
   people of every age are going to retail stores selling different products. Therefore it's a big opportunity to grow the business and revenue.

4. **External Search**

   Here are some external references and links:-

   - [How expiry date tracking technology will help grocery retailers](#)
   - [How large food retailers can help solve the Food Waste Crisis](#)
   - [Supermarkets moving towards zero food wastage](#)
   - [New monitoring system could save thousands of tons of wasted food](#)

5. **Bench marking**

   Product expiry date tracking technology is used by many big companies, supermarts and big retail stores. There are several benchmarking technologies available for product expiry date tracking software. Here are a few common ones:

   - <u>Barcode scanning</u>:- Barcode scanning technology is widely used in product expiry date tracking software to quickly and accurately capture information about the product, including its expiration date.
   - <u>RFID technology</u>:- Radio-frequency identification (RFID) technology is also commonly used in product expiry date tracking software. RFID tags can be attached to products and can be read by RFID readers to quickly and accurately track product information, including expiration dates.

   But these Existing optical character recognition systems have very poor performance when it comes to expiry date recognition. So some better options are:-

Tesseract OCR

Tesseract OCR is one of the most popular open-source engines for optical character recognition. Results obtained using this system (Table 1) show that it can't be applied to the task at hand. This system is more specialized in Expiry date recognition using deep neural networks optical character recognition for scanned documents, while the problem of expiry date detection is similar in difficulty with the problem of "scene text detection". The output of Tesseract OCR is empty, even if the date is written using ordinary fonts and not the dot-matrix type. Also, even if only the portion containing the expiration date is cropped from the image, results are still poor, due to the high level of noise (background, overlap with other packaging elements, etc.)

Scene Text Detectors

Given the failure of Tesseract OCR it is clear that a more robust system is needed. The scene text detector deep learning models should be a better solution, being specialized in the detection of text "in the wild", such as house numbers, advertising panels, or traffic signs. hese models are usually combined with the CRNN model to extract text from the regions in which it was detected.

Google Cloud Vision API

Google Cloud Vision API is a service which gives application developers access to ready-made computer vision models that run in the cloud. The "out of the box" performance of the Google Cloud Vision OCR system is the best out of all the pre-trained models mentioned above

Cloud-based software: Cloud-based software is becoming increasingly popular for product expiry date tracking. This type of software allows for real-time tracking and management of product expiration dates from any location, as long as an internet connection is available.

Artificial intelligence and machine learning: Artificial intelligence and machine learning technologies are being integrated into product expiry date tracking software to automate and streamline the process of tracking expiration dates. For example, AI algorithms can be used to predict the shelf life of products and suggest expiration dates based on historical data.

Mobile applications: Mobile applications are also being developed for product expiry date tracking. These apps allow users to quickly and easily track expiration dates and receive notifications when a product is about to expire.

6. Applicable patents

There are many patents related to product expiry date tracking technology. Here are a few examples of technologies that have been patented in this field:

- Smart label system for product expiration date tracking:- This patented technology uses a smart label system that can be attached to products to track and manage their expiration dates. The system includes a barcode or RFID tag that stores information about the product and its expiration date, as well as a scanning device that can read the information.

- Mobile application for product expiration date tracking:- This patented technology includes a mobile application that allows users to track and manage the expiration dates of their

products. The app can be used to scan barcodes or QR codes on products and store information about their expiration dates.

- Cloud-based product expiration date tracking system:- This patented technology includes a cloud-based system that allows businesses to track and manage the expiration dates of their products in real-time. The system can be accessed from any location with an internet connection and provides real-time updates on product expiration dates.

- AI-powered product expiration date prediction system:- This patented technology uses artificial intelligence algorithms to predict the shelf life of products and suggest expiration dates. The system can be integrated into existing product expiration date tracking systems to automate and streamline the process of tracking expiration dates.

These are just a few examples of patented technologies related to product expiration date tracking. Some of the patents reference links are:-

https://patents.google.com/patent/US7464873B2/en

https://patents.google.com/patent/US10185733B2/en?q=(expiry+date+tracking+technology)&oq=expiry+date+tracking+technology

7. **Applicable Regulations**

Some examples of the government and environmental regulations that are imposed by different countries related to product expiry date tracking technology includes:-

- United States:- The Waste Reduction Act of 1990 (RCRA) regulates the disposal of hazardous waste, including expired or unsold products. The Food, Drug, and Cosmetic Act (FD&C Act) requires the labelling of food and drug products with an expiration date. The Federal Trade Commission (FTC) enforces privacy laws, such as the Children's Online Privacy Protection Act (COPPA) and the Privacy Act of 1974, which regulate the collection and use of personal information, including information related to product expiry dates.
- European Union:- The Waste Framework Directive regulates the disposal of waste, including expired or unsold products. The General Data Protection Regulation (GDPR) sets standards for the protection of personal information, including information related to product expiry dates. The Packaging and Packaging Waste Directive regulates the environmental impact of packaging and packaging waste, including the impact of product expiry dates on waste.
- Australia:- The National Waste Policy regulates the disposal of waste, including expired or unsold products. The Privacy Act 1988 regulates the collection and use of personal information, including information related to product expiry dates. The National Packaging Covenant regulates the environmental impact of packaging and packaging waste, including the impact of product expiry dates on waste.

These are just a few examples of the government and environmental regulations that may be imposed by different countries related to product expiry date tracking technology. It's important for companies to be aware of the regulations in their specific country or region and to ensure that they comply with the latest regulations in order to avoid penalties and ensure the safety and privacy of consumers.

In many countries, there are regulations regarding the disposal of waste, including expired or unsold products. The use of technology for tracking product expiry dates can help companies comply with these regulations by ensuring that expired products are removed from circulation and disposed of properly.

The use of technology for tracking product expiry dates often involves the collection, storage, and sharing of sensitive information, such as the date of manufacture and the date of expiration. In order to comply with data privacy regulations, companies must ensure that this information is protected and used only for the purposes for which it was collected.

8. Applicable Constraints

The implementation of product expiry tracking technology may be subject to certain constraints, including:-

- Space Constraints - Depending on the technology used for product expiry tracking, there may be physical space requirements for the installation of hardware or storage of data. This may impact the feasibility of implementing the technology in smaller facilities or retail locations.
- Budget Constraints - The cost of implementing product expiry tracking technology can vary depending on the type of technology used and the size of the organization. For some small businesses or retailers, the cost of the technology may represent a significant financial investment.
- Expertise Constraints - The implementation of product expiry tracking technology often requires specialized knowledge and expertise in areas such as data management, software development, and hardware installation. The availability of internal expertise or the need to hire external consultants can impact the feasibility of implementing the technology.

It's important for companies to carefully consider these constraints when deciding whether to implement product expiry tracking technology and to choose a solution that meets their specific needs and budget. By carefully managing these constraints, companies can ensure that they are able to implement an effective and efficient product expiry tracking system.

9. Business Model

There are several potential monetization models for product expiry tracking technology, including:-

Subscription-based Model:- In this model, companies charge a recurring fee for access to the product expiry tracking technology, typically on a monthly or annual basis. This model is well-suited for small and medium-sized businesses that need to track expiry dates for a limited number of products.
License-based Model:- In this model, companies charge a one-time fee for the use of the product expiry tracking technology, typically based on the number of products being tracked or the size of the organization. This model is well-suited for larger organizations that need to track expiry dates for a large number of products.
Pay-per-use Model:- In this model, companies charge for the use of the product expiry tracking technology based on the number of products being tracked or the frequency of use. This model is well-suited for organizations that have variable or unpredictable product tracking needs.
Data Monetization:- In this model, companies use the data generated by the product expiry tracking technology to create new revenue streams. For example, they may sell data insights to suppliers, manufacturers, or retailers to help them optimize their supply chain operations.

These are just a few examples of monetization models for product expiry tracking technology. The best monetization model will depend on the specific needs and goals of the organization implementing the technology, as well as the target market for the technology. Companies should carefully consider the benefits and limitations of each monetization model in order to choose the one that best fits their needs.

10. Concept Generation

The steps in the concept generation process for product expiry tracking technology includes:-
Identify the problem:- The first step is to identify the problem that the technology is trying to solve. In this case, the problem is the need to effectively track product expiry dates in order to minimize waste, improve inventory management, and ensure the safety of consumers.

Gather information:- Once the problem has been identified, the next step is to gather information about the current state of the market, including existing products and services, consumer needs and preferences, and industry trends. This information can be gathered through market research, industry reports, competitor analysis, and customer surveys.

Brainstorm ideas:- The next step is to generate a large number of ideas for product expiry tracking technology, using techniques such as brainstorming sessions, mind mapping, and lateral thinking. The goal of this step is to generate as many ideas as possible, without worrying about their feasibility or commercial viability.

Evaluate and refine ideas:- Once a large number of ideas have been generated, the next step is to evaluate and refine them, taking into account factors such as market demand, technical feasibility, and commercial viability. This may involve conducting market research, prototyping, and testing to validate the concepts.

Select the best idea:- The final step is to select the best idea from the pool of refined concepts, taking into account factors such as market demand, technical feasibility, and commercial viability. This is the idea that will form the basis for the product expiry tracking technology.

By following these steps, companies can effectively generate new and innovative ideas for product expiry tracking technology and develop products that meet the needs of their target market.

11. Concept Development

Product expiry tracking technology is a solution that helps companies keep track of the expiry dates of their products and manage inventory in an efficient and effective manner. The goal of this technology is to minimize waste, improve supply chain operations, and ensure the safety of consumers by providing real-time information about the status of products. The concept of product expiry tracking technology can be developed in several ways, including:-

Smart Shelves - Smart shelves equipped with sensors and RFID tags that automatically track the expiry dates of products as they are stocked and sold. This information can be accessed by employees or customers through a mobile app or in-store display.

Cloud-based System - A cloud-based system that integrates with a company's existing inventory management systems to provide real-time information about the status of products, including expiry dates. The system could also provide analytics and reporting capabilities to help companies optimize their supply chain operations.

IoT Devices - IoT devices, such as sensors and RFID tags, that can be placed on products to track their expiry dates and provide real-time information about their status. The information can be accessed through a cloud-based platform or mobile app.

Mobile App - A mobile app that allows customers to scan the barcodes of products and receive real-time information about their expiry dates. The app could also provide reminders to consumers when products are close to expiring and suggest alternatives or recipes that can be made with expired products.

The specific product or service that is developed will depend on the needs and goals of the organization implementing the technology, as well as the target market for the technology. By carefully considering these factors, companies can develop a product expiry tracking technology solution that meets the needs of their target market and helps them achieve their goals.

12. Final Product Prototype

The final product prototype for a product expiry tracking technology using artificial intelligence can include the following features:-

Image Recognition:- The system will use computer vision and image recognition technology to identify the product and read its expiration date.

Data Collection:- The system will collect data on the product, including product name, brand, type, expiration date, and other relevant information.

AI Algorithm:- The system will use an AI algorithm to analyse the data and predict the likelihood of a product reaching its expiration date based on factors such as temperature, storage conditions, and historical data.

Alerts and Notifications:- The system will send alerts and notifications to retail store managers when a product is approaching its expiration date, or if there is a change in the product's storage conditions that could impact its shelf life.

Dashboard:- A dashboard will be provided for retail store workers to view and manage their products, track expiration dates, and receive alerts and notifications.

Integration with Smart Devices:- The system will integrate with smart devices such as refrigerators, pantries, and other storage devices to monitor storage conditions and send notifications when necessary.

Mobile Application:- A mobile application will be provided for users to access the dashboard and receive alerts and notifications on-the-go.

This prototype can be further developed and optimized based on user feedback and market demand.

(Schematic Diagram)

13. Product Details

- **Working**:-

  A product expiry tracking software using machine learning works by collecting data on various products and analysing that data to predict when each product will expire. The following are the steps involved in the process:-

  Data Collection:- The software collects data on products, including product name, brand, type, expiration date, and other relevant information. This data can be entered manually or automatically collected through barcode scanning or image recognition technology.

  Feature Engineering:- The software then processes the collected data to extract relevant features that can be used to train a machine learning model. This includes converting raw data

into numerical or categorical representations that the machine learning algorithm can understand.

Model Training:- The software uses the processed data to train a machine learning model, such as a decision tree, random forest, or neural network. The model is trained on historical data to identify patterns and relationships between product features and expiration dates.

Predictive Modelling:- Once the model is trained, it can be used to make predictions on new products. The model takes in the features of a product and outputs a predicted expiration date.

Model Validation:- The accuracy of the model is validated using various techniques, such as cross-validation, to ensure that it is making accurate predictions.

Monitoring and Notification:- The software continually monitors the products and sends notifications to users when a product is approaching its expiration date or if there is a change in the product's storage conditions that could impact its shelf life.

This process allows the software to continuously learn and improve its predictions over time as it collects more data on products and their expiration dates.

- **Data Sources**:-
  There are several data sources that can be used for developing a product expiry tracking software using machine learning for retail stores:-

  Point-of-Sale (POS) data:- This includes transaction data collected from the cash registers in the store, which can provide information about the product quantities sold, purchase date, and expiry date.

  Inventory data:- Retail stores often maintain an inventory system to keep track of their stock levels. This data can be used to train machine learning models to predict the expiration date of products based on the purchase date and usage patterns.

  Barcode scanning data:- Retail stores often use barcode scanning technology to track products as they move through the supply chain. This data can be used to track the movement of products and estimate the shelf life of each product based on its journey.

  Customer feedback data:- Retail stores can gather customer feedback data through surveys, online reviews, and social media to gather information about the quality of the products they sell. This data can be used to train machine learning models to predict the shelf life of products based on customer feedback and usage patterns.

  External data sources:- In addition to the internal data sources mentioned above, retail stores can also use external data sources such as weather data, consumer spending patterns, and economic indicators to train machine learning models and make more accurate predictions about product expiration.

- **Algorithms, frameworks, software etc. needed:-**
  To develop a product expiry tracking software using machine learning for retail stores, you would need the following components:-

  Algorithms:- Machine learning algorithms such as decision trees, random forests, neural networks, and time series forecasting can be used to predict the expiration date of products based on the available data.

  Frameworks:- There are several open-source machine learning frameworks that can be used to build the product expiry tracking software, such as TensorFlow, PyTorch, and scikit-learn. These frameworks provide a set of pre-built algorithms and tools that can be used to build, train, and deploy machine learning models.

  Software:- A software development platform such as Python, R, or Java can be used to build the product expiry tracking software. These programming languages provide a range of libraries and tools that can be used to process and analyze the data, build machine learning models, and integrate the software with existing retail systems.

  Data storage:- The data collected from the retail store will need to be stored in a database or data warehouse. This can be done using a relational database management system (RDBMS) such as MySQL, PostgreSQL, or Oracle, or a non-relational database management system (NoSQL) such as MongoDB or Cassandra.

Data visualization:- The results of the machine learning models need to be visualized in a way that is easy for retail store staff to understand. This can be done using data visualization tools such as Tableau, Power BI, or D3.js.

It's important to note that the specific components you'll need will depend on the specific requirements of your project and the data you have available.
The choice of algorithms, frameworks, software, data storage, and data visualization tools will be influenced by factors such as the size and complexity of the data, the computational resources available, and the skills of the development team.

- **Team required to develop:-**
  The team required to develop a product expiry tracking software using machine learning for retail stores will typically consist of the following roles:-
  Project Manager:- This person will be responsible for overseeing the overall development process, ensuring that the project is completed on time and within budget.
  Data Scientists:- Data scientists will be responsible for cleaning, transforming, and analysing the data, as well as building and training the machine learning models. They should have a strong understanding of statistical analysis, machine learning algorithms, and data visualization.
  Software Developers:- Software developers will be responsible for building the product expiry tracking software, integrating it with existing retail systems, and deploying it to production. They should have experience with the programming languages and software development tools used to build the software.
  Quality Assurance (QA) Engineers:- QA engineers will be responsible for testing the product expiry tracking software to ensure that it works as expected and meets the requirements of the retail store.
  Business Analysts:- Business analysts will work closely with the retail store to understand their needs and requirements, and to ensure that the product expiry tracking software meets those needs. They should have a good understanding of the retail industry and the challenges faced by retail stores.

  The size and structure of the team will depend on the complexity of the project, the amount of data involved, and the resources available. In some cases, it may be possible for a smaller team to complete the project, while in others, a larger team may be required to ensure that the project is completed successfully.

- **What does it cost?**
  The cost of developing a product expiry tracking software using machine learning for retail stores can vary widely depending on several factors, including:-
  Size and complexity of the project:- The cost of development will be influenced by the size and complexity of the project, including the amount of data involved, the number of retail stores to be integrated, and the number of features and functions required.
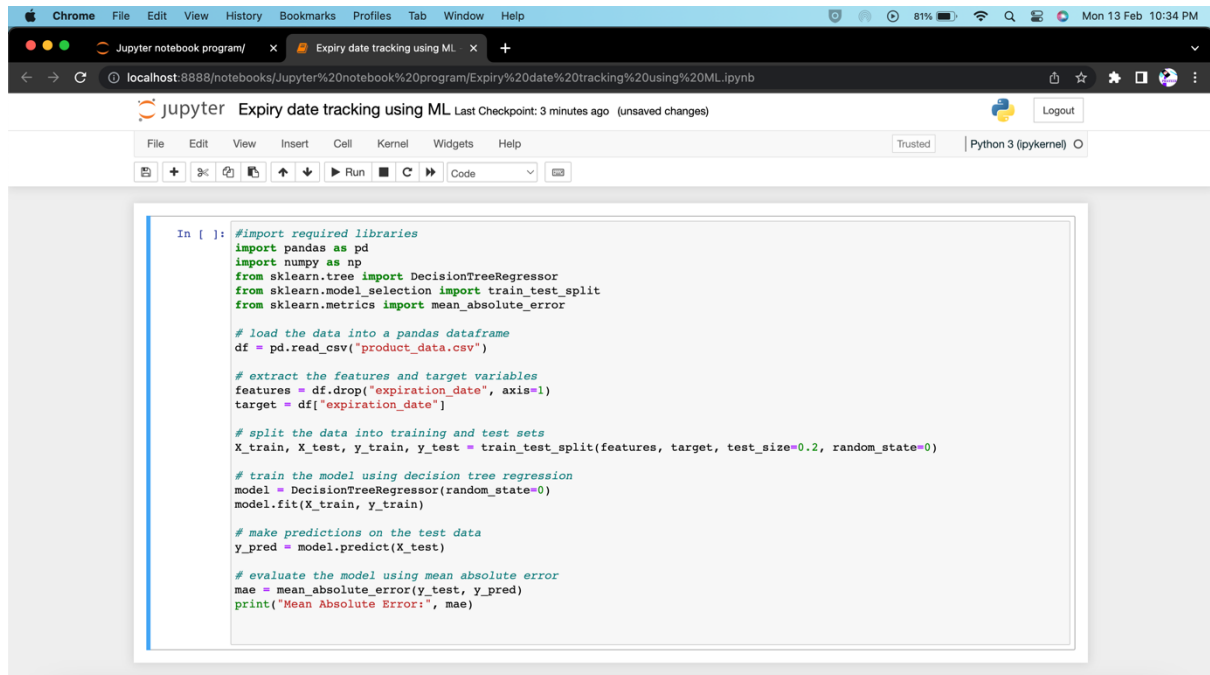 Location and cost of labour:- The cost of development will also be influenced by the location of the development team and the cost of labour in that location. In general, the cost of labour is higher in developed countries than in developing countries, so the cost of development will be higher in countries such as the United States, Canada, and Western Europe.
  Technical expertise of the development team:- The cost of development will also be influenced by the technical expertise of the development team, including their experience with machine learning, software development, and data analysis. Teams with more experience will typically command higher rates than teams with less experience.
  Tools and technologies used:- The cost of development will also be influenced by the tools and technologies used, including the machine learning algorithms and frameworks, software development platforms, and data visualization tools.

A rough estimate for the cost of development could range anywhere from $10,000 to $100,000 or more, depending on the factors mentioned above. It's important to work with a development team to get a more accurate estimate of the cost of development, as the specific requirements of your project will influence the overall cost.

14. Code Implementation/Validation on Small Scale

This is a simple example to give an idea to implement a product expiry tracking software using machine learning. In a real-world scenario, the data and the complexity of the problem would be much greater, and more sophisticated algorithms and techniques would likely need to be used. It's also important to note that this example assumes that the data is already clean and pre-processed, which is a critical step in any machine learning project.

This is how the prototype application will look like:-
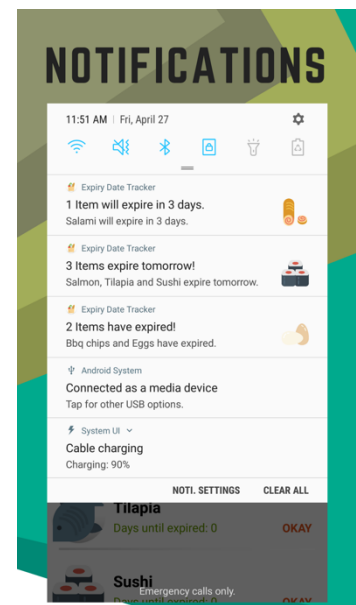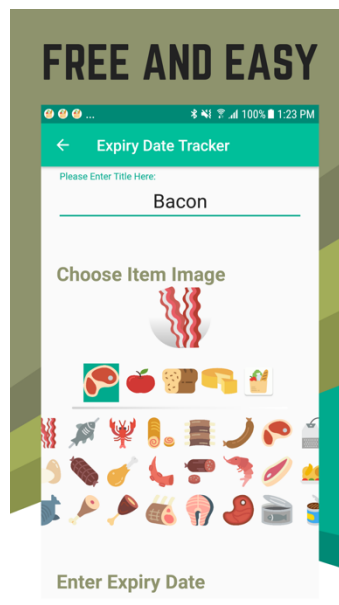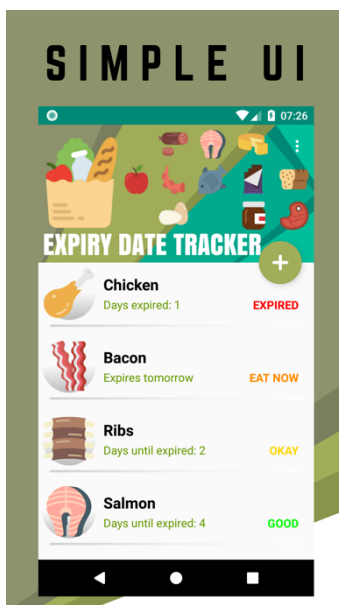
15. Conclusion

In conclusion, developing a product expiry tracking software using machine learning is a valuable investment for retail stores as it can help them to manage their inventory more effectively, reduce waste, and improve their bottom line. The key steps to building such a system include data collection, data cleaning and pre-processing, feature engineering, model selection, model training, model validation, model deployment, and monitoring and maintenance. The success of the system will depend on the quality and quantity of the data used, the choice of machine learning algorithm, and the skill and expertise of the data scientist or developer responsible for building the system. With the right approach, however, a machine learning-powered product expiry tracking software can provide significant benefits to retail stores and help them to stay ahead of the competition.