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Digitization and optimisation food distribution in case : war or pandemic

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Dedication

I dedicate this modest work, To the light of my days, the source of my efforts, the flame in my heart, my life, and my happiness: Mother, whom I adore, Thank you for all the sacrifices you have continuously made for me since my birth, you are a source of tenderness and an example of dedication to me. To my eternal role model, my moral support, and my source of joy: to you, my dear Father. To my beloved sisters Fatima, Meriem and Abir, I thank you for the moral support and encouragement you have given me. To all my friends , my partner, and all those who encourage me.

Imane Beddiaf

Abstract

The food supply chain (FSC) plays a critical role in ensuring the availability, quality, and timely delivery of food products to consumers. However, the FSC faces numerous challenges, including maintaining product integrity, the complexity of the food distribution process, and addressing supply shortages, which can impact healthcare and consumers access to food especially in emergency situations. This study focuses on improving the FSC in case of disaster, specifically within the Food Distribution Centers (FDC) in Algeria. The FDC faced challenges related to food calculations, efficiency, paperwork,demand forecasting, and inventory management. To address these challenges, an intelligent food distribution system is developed with the objectives of improving efficiency, fair distribution and making it more effective,reducing errors, simplifying documentation, and optimizing inventory management. This system utilizes artifical intelligence techniques, specifically YOLO algorithm, for food detection and classification. Limitations and challenges such as data quality, technical expertise, implementation costs, privacy,security, and system integration are considered. Despite these challenges, the proposed intelligent supply chain system has the potential to simplify operations and enhance the effectiveness of food supply chains, eventually benefiting FDC and improving consumers access to essential food products.

Keywords: (Food Supply Chains, Food Distribution Centers, Food Distribution,YOLO)

Résumé

La chaîne d'approvisionnement alimentaire (CAA) joue un rôle essentiel en garantissant la disponibilité, la qualité et la livraison dans les délais des produits alimentaires aux consommateurs. Cependant, le CAA est confronté à de nombreux défis, notamment le maintien de l'intégrité des produits, la complexité du processus de distribution alimentaire et la résolution des pénuries d'approvisionnement, qui peuvent avoir un impact sur la santé et l'accès des consommateurs à la nourriture, en particulier dans les situations d'urgence. Cette étude porte sur l'amélioration du CAA en cas de sinistre, notamment au sein des Centres de Distribution Alimentaire (CDA) en Algérie. Le CDA a été confronté à des défis liés aux calculs alimentaires, à l'efficacité, à la paperasse, à la prévision de la demande et à la gestion des stocks. Pour relever ces défis,un système de distribution alimentaire intelligent est développé dans le but d'améliorer l'efficacité, de rendre la distribution équitable et de la rendre plus efficace, de réduire les erreurs, de simplifier la documentation et d'optimiser la gestion des stocks. Ce système utilise des techniques d'intelligence artificielle, en particulier l'algorithme YOLO, pour la détection et la classification des aliments. Les limites et les défis tels que la qualité des données, l'expertise technique, les coûts de mise en œuvre, la confidentialité, la sécurité et l'intégration du système sont pris en compte. Malgré ces défis, le système de chaîne d'approvisionnement intelligent proposé a le potentiel de simplifier les opérations et d'améliorer l'efficacité des chaînes d'approvisionnement alimentaire, bénéficiant à terme au CDA et améliorant l'accès des consommateurs aux produits alimentaires essentiels.

Mots clés :

(Chaînes d'Approvisionnement Alimentaire, Centres de Distribution Alimentaire, Distribution Alimentaire, YOLO)

ملخص

تلعب سلسلة التوريد الغذائية دورًا حاسمًا في ضمان توافر المنتجات الغذائية وجودتها وتسليمها في الوقت المناسب للمستهلكين. ومع ذلك، فإنها تواجه العديد من التحديات، بما في ذلك الحفاظ على سلامة المنتج، وتعقيد عملية توزيع المواد الغذائية، ومعالجة نقص الإمدادات، والتي يمكن أن تؤثر على الرعاية الصحية ووصول المستهلكين إلى الغذاء.

تركز هذه الدراسة على تحسين سلسلة التوريد الغذائية خاصة في حالات الطوارئ، وتحديدا داخل مراكز توزيع الغذاء في الجزائر. واجهت هذه المراكز تحديات تتعلق بحساب الغذاء والكفاءة والأعمال الورقية والتنبؤ بالطلب وإدارة المخزون. ولمواجهة هذه التحديات، تم تطوير نظام توزيع الغذاء الذكي بهدف تحسين الكفاءة والتوزيع العادل وجعله أكثر فعالية، وتقليل الأخطاء، وتبسيط الوثائق، وتحسين إدارة المخزون.

يستخدم هذا النظام تقنيات الذكاء الاصطناعي، وتحديدًا خوارزمية يولو، للكشف عن الأغذية وتصنيفها.

يتم أخذ القيود والتحديات مثل جودة البيانات والخبرة الفنية وتكاليف التنفيذ والخصوصية والأمن وتكامل النظام في الاعتبار. على الرغم من هذه التحديات، فإن نظام سلسلة التوريد الذكي المقترح لديه القدرة على تبسيط العمليات وتعزيز فعالية سلاسل التوريد الغذائية، مما يعود بالنفع في نهاية المطاف على مراكز توزيع الاغذية وتحسين وصول المستهلكين إلى المنتجات الغذائية الأساسية.

الكلمات المفتاحية: (سلاسل توريد الغذاء، مراكز توزيع الغذاء، توزيع الغذاء، يولو)

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Acronyms

CAA Chaîne d'Approvisionnement Alimentaire

CDA Centres de Distribution Alimentaire

FSC Food Supply Chain

FDC Food Distribution Center

AI Artificial Intelligence

ML Machain Learning

DL Deep Learning

Yolo YOU ONLY LOOK ONCE

OCR Optical Character Recognition

KNN K-Nearest Neighbor

PCA Principal Component Analysis

ANNs Artificial neural networks

BNNs Biological neural networks

CNNs Convoluted Neural Networks

RNNs Recurrent Neural Networks

NLP Natural language processing

General Introduction

The food supply chain (FSC) is a sophisticated network that ensures food products are available, of high quality, and delivered promptly to consumers. However, the FSC encounters various challenges, such as maintaining product integrity, managing the complexity of food distribution, and addressing supply shortages. Disruptions in the FSC can cause food shortages and affect healthcare efficiency. Thus, optimizing the FSC and adopting innovative technologies and strategies is essential to ensure safe and efficient food delivery.

in Algeria, the Food Distribution Centers (FDC) . plays an important role in ensuring the timely availability of food to Shops and consumers in the country . However, the FDC faces challenges become more complex in emergency situations such as war or a pandemic,These challenges related to poor distributionand time-consuming conformity control, lack of efficiency, complicated paperwork, and limited automation. The high inventory costs further emphasize the need for measures to optimize inventory management and thus improve food distribution.

To tackle these challenges, our thesis proposes the development of an intelligent food distribution system tailored for FDCs. The goals of this system are to enhance distribution efficiency, minimize errors, streamline documentation, and optimize inventory management. By meeting these objectives, our system seeks to simplify the FDC product distribution process and improve inventory management, ensuring timely access to food.

Our contributions focus on three key tasks within the intelligent food distribution system: inventory management, Analytics and reporting, and workflow automation. We propose an intelligent Inventory Management module that utilizes object detection techniques to control the number of food, optimize stock levels, and thus minimize time waste, to ensure an adequate supply of food.

we aim to address the problem of distribution food and detection it through the application of object detection techniques, we make use of effective object detection algorithm, YOLO (You Only Look Once) . By utilizing these models, we seek to leverage their capabilities to identify and classify food within our custom dataset. The use of YOLO allowed us to achieve accurate food recognition, enabling us to make significant advancements in this ambitious project.

Document Plan

This thesis is organized according to the following structure:

Introduction

- Provides an overview of the research topic and its significance.
- Outlines the research objectives and questions.

Overview of digitization

- In this chapter, we are going to discuss various aspects of digitization, emphasizing its importance and challenges, and how we can utilize them in our system.

Artificial Intelligence

- In this chapter we focus on overview of artifical intelligence (AI) and its besic bronchs : machain learning and deep learning.
- In machain learning we examine its types as Supervised Learning ,Unsupervised Learning and some common algorithms.
- In deep learning we examine artificial neural networks(ANN) and some common algorithms

Sypply Chain and Our System

- This chapter focuses on overview of supply chain emphasizing its importance and challenges and Impacts of Maldistribution.
- we focuses specialy our perspective of an intelligent food distribution system, examining various tasks that could benefit from the integration of artificial intelligence. We also highlight the objectives of this study, detailing the specific goals we aim to accomplish.
- Results of Yolo v8.

Chapter

1

Overview of digitization

Introduction

Digitization has become a critical buzzword among today's business leaders, signaling the need for innovative approaches to managing both internal and external operations, particularly those facing the market. While digitization is not a novel concept, as it has been ongoing since the advent of computers, its increasing adoption underscores the imperative for businesses to transition from traditional methods to digital alternatives. In today's business landscape, this term has gained prominence as organizations recognize the need to modernize their operations and embrace digital technologies to stay competitive.

In this chapter, we are going to discuss various aspects of digitization and how we can utilize them in our system.

1.1 History of Digitization

Digitization gained prominence in the late 20th century thanks to the emergence of personal computers (PCs) and the internet. These technological advancements facilitated the conversion of a wide array of information types, including text, images, audio, and video, into digital formats [1].

Some significant milestones in the history of digitization include :

- **1950s:** Digitization foundation laid with binary code translation and early magnetic disk storage (IBM's 305 RAMAC and 650 RAMAC), used in systems like United Airlines' reservations.
- **1960s:** Digital audio recording begins, utilizing pulse-code modulation, alongside the invention of the first digital computer-based image scanner for image digitization.
- **1970s:** Personal computers and internet introduction democratize digital storage.
- **1980s 1990s:** Consumer digital tech adoption surges, internet expands, enabling conversion of various information into digital formats.
- **2000s 2010s:** Digital technology prevalence increases with mobile phones, streaming services, digital media players; text digitization accelerates

with e-books and online publications.

Throughout these decades, digitization has revolutionized how information is created, stored, and accessed, shaping modern society in profound ways.

1.2 Digitization

Digitization involves the transformation of conventional analog materials whether they are printed text, manuscripts, images, or audio, as well as film and video recordings into digital formats [2].

Governments may increase the quality of life for their residents, reduce expenditures, and enhance service delivery through the digitization of processes and the restructuring of organizational frameworks[3].

Digitization has become a significant focal point for contemporary business leaders, signaling the necessity for companies to explore inventive methods of managing both internal and market-facing operations. While not a new concept, digitization's increasing prevalence underscores its growing importance as businesses transition from conventional commerce practices to digital alternatives. This shift is increasingly recognized as vital for regulated and unregulated companies alike.

Thriving enterprises seek novel digital tactics to decrease expenses, mitigate risks, and enhance profitability in fiercely competitive industries amidst technological advancements. Traditional businesses face heightened pressure to adopt digitization in order to sustain competitiveness and relevance in the contemporary market landscape. The competitive advantage of digitization has favored pioneers or firms whose leadership embraces new technologies and harnesses them to elevate their organizations to the forefront of high-performing entities.

These companies and their leadership exemplify how a shift in mindset and early integration of digital practices can result in a comprehensive overhaul of the entire organizational landscape. As a result, businesses may gain a deeper understanding of the needs and behaviors of their digital clientele [4].

1.3 Digitization, Digitalization, and Digital Transformation

Understanding the distinctions among digitization, digitalization, and digital transformation can sometimes be confusing. However, these three concepts differ in various aspects, including their objectives and outcomes.
Let us first discuss in terms of the purpose and outcome[5]:

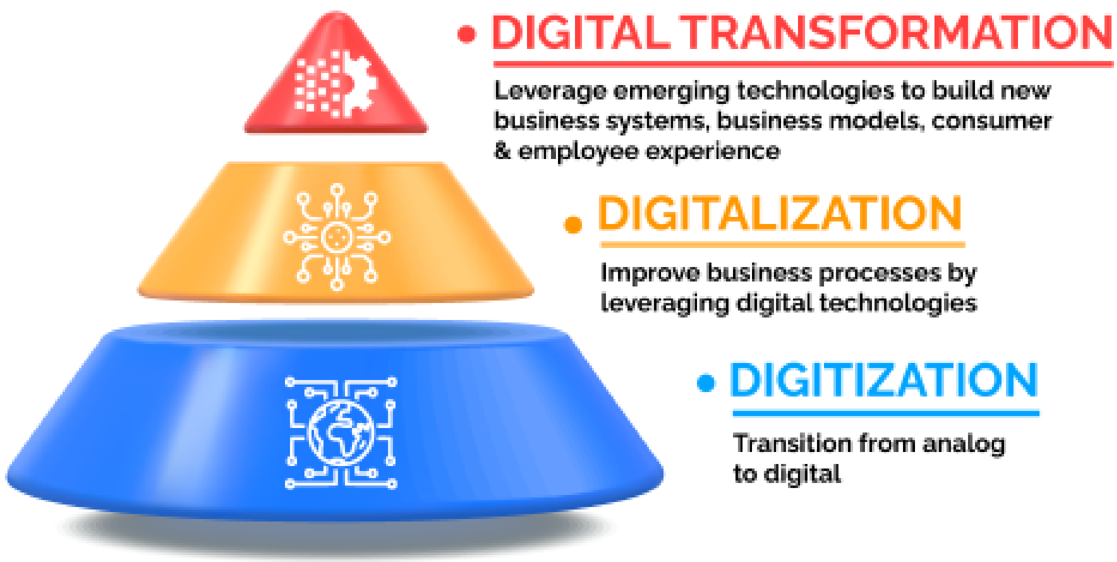


Figure 1.1: Digitization, Digitalization, and Digital Transformation

1. The primary aim of **digitization** is to encode information into computers by converting it from analog to digital format. This process primarily involves recording data that can subsequently be utilized in digital technologies.
2. **Digitalization** focuses on information processing, specifically on how digitized data can enhance workflows by automating current processes.
3. Finally,**digital transformation** entails harnessing knowledge and integrating it across all business sectors to enhance engagement and generate new value.

Although not a linear progression, digitization and digitalization act as stepping stones toward digital transformation. At the forefront, digital trans-

formation commences with data being encoded into the system (digitization), subsequently utilized by the computer to facilitate or enhance a process through digitalization. Through the incorporation of digital technologies and their integration into the entire organizational workflow, digital transformation takes place.
These three concepts are crucial for organizations to adapt to the ever-changing business environment.

1.4 Benefits of Digitization

Certainly, digitization offers numerous benefits to businesses across various aspects of their operations. Here's a concise compilation outlining some primary advantages [1]:

- **Ease of access:** Digital information allows convenient storage, retrieval, and sharing, meeting the needs of employees, customers, and partners.
- **Easy data analysis:** Digital formats enable businesses to analyze and utilize data more effectively, enhancing decision-making processes.
- **Improved customer experience:** Digitization enhances customer experience through tools like chatbots, social media, and automated systems, leading to efficient issue resolution.
- **Digital libraries and archives:** Digitization expands access to resources while preserving them for future generations, making them readily available to a wider audience.
- **Education and online learning:** Digitization simplifies individualized learning experiences and assessments through e-learning resources and interactive tools.
- **Increased operational efficiency:** Digitization streamlines operations, automates tasks, and enhances productivity, leading to improved efficiency.
- **New markets:** Digitization broadens customer reach and allows businesses to explore new markets through internet and technology platforms.

- **Digital transformation in industries:** Digitization drives digital transformation across industries, enabling innovations like smart factories in manufacturing and telemedicine in healthcare.
- **Reduced costs:** Digitization reduces costs by minimizing reliance on paper and analog materials.

1.5 Digitization Approaches

Today, there are diverse approaches to digitization. Let's explore the common types[6]:

1. **Manual Digitizing:** employs a digitizing tablet, where a digitizer manually traces lines from a physical map, like a Toposheet, onto a computer. This real-time process yields digital maps with high accuracy, albeit it can be time-intensive.
2. **Heads-up Digitizing:** resembles manual digitizing but with a twist. Instead of translating hardcopy maps, it scans them directly onto a desktop screen for digitization.
3. **Interactive Tracing Method:** stemming from heads-up digitizing, is notable for its exceptional accuracy and speed.
4. **Automatic Digitizing (Vectorization):** involves converting raster images to vector format using automated pattern recognition and image processing techniques. This method, also known as vectorization, offers high accuracy with minimal time consumption, allowing for image customization and improved quality.

1.6 Digitization Techniques

Common digitization techniques encompass [1]:

- **Scanning:** This method entails utilizing a scanner to produce a digital representation of the original source material. Scanners vary in types and sizes, each tailored to specific needs. Common scanner types include flatbed, feed-forward, and handheld models.

- **Capturing:** Digital cameras are frequently employed to digitize exceptionally large or delicate source materials. If multiple images are necessary to capture the entirety of the original material, they can be seamlessly stitched together using software.
- **Data Entry:** In cases where direct scanning or capturing isn't feasible for textual source material, manual input into a computer device offers an alternative means of digitization. This approach is often utilized when optical character recognition (OCR) proves ineffective.
- **Optical Character Recognition (OCR):** This technology serves to digitize images containing textual content. OCR software identifies text pixels within an image and converts them into a digital text format.
- **Audio and Video Digitization**: Legacy audio or video content is converted into a digital format through this process. It involves routing the output of the original playback device into an analog-to-digital converter (ADC), which transforms the analog signal into digital form.
- **Signal Sampling:** This digitization technique entails sampling the strength or amplitude of an analog signal at regular intervals and converting these samples into numerical values. It's vital for digitizing analog sound and video signals for electronic processing and storage.
- **Format Conversion:** Occasionally, digital source material requires conversion to another format. This process, referred to as transcoding rather than digitalization, ensures compatibility across different platforms or devices.

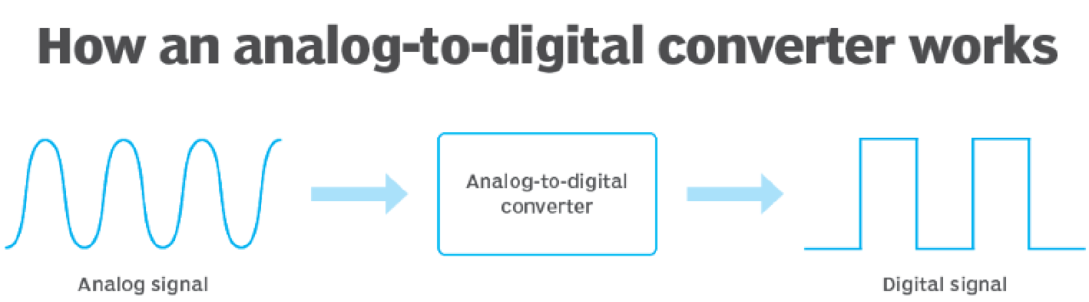


Figure 1.2: Digitization of information

1.7 Examples of Digitization in Different Industries

digitization has significantly enhanced accessibility to crucial resources and information while ensuring their preservation for.Her are some examples of how digitization is applied across different industries include [7]:

- **Libraries:** Among the earliest applications of digitization was the conversion of books, newspapers, and magazines into digital formats. This enables libraries to enhance accessibility to their resources while freeing up physical space for new acquisitions.
- **Film Industry:** Digitization has streamlined the recording, archiving, and digital distribution of movies and TV shows, facilitating easier access and preservation within the film industry.
- **Arts:** Digitization enables the scanning and archival of artworks and historical artifacts, preserving them for future generations and granting public access to cultural heritage.
- **Music Industry:** Recognizing its advantages, the music industry embraced digitization early on, converting music recordings into digital formats. This transition has increased the accessibility and portability of music.
- **Archiving:** Digitization also simplifies the archiving of documents and records, as they can be stored in digital form and retrieved at any time without damaging the originals.

1.8 Challenges of Digitization:

Digitization has transformed how individuals store, retrieve, and distribute textual, visual, and auditory content. Yet, substantial undertakings in this realm pose challenges for businesses[8]:

1. **Resource and Cost Considerations:** Large-scale digitization projects require significant resources and investment in specialized equipment and software, necessitating a careful cost-benefit analysis.
2. **Data Integrity and Preservation:** Safeguarding digitized data's long-term integrity demands robust data management practices, reliable stor-

age solutions, and strategies for migration and obsolescence management.

3. **Copyright and Intellectual Property Issues:** Clear copyright guidelines and permissions are crucial to address potential issues with historical or sensitive materials before digitization.
4. **Data Quality and Standardization:** Challenges like inconsistent formats and poor data quality can hinder effectiveness, requiring procedures for data cleansing and validation.
5. **Technical Expertise and Training:** Specialized technical skills may be needed for operating equipment and managing processes, necessitating investment in training or external support.
6. **Integration with Existing Systems:** Thoughtful planning is essential for integrating digitized information into existing workflows to maximize utility and avoid disruptions.

1.9 Conclusion

Digitization is revolutionizing various fields , It represents significant progress in transforming the world into a more connected, efficient, and accurate place, opening doors to new opportunities and improving the quality of life and business operations across various sectors.

Moving forward, the next chapter will delve into the overview of artificial intelligence

Chapter

2

Artificial Intelligence

In this chapter we focus on overview of artifical intelligence (AI) and its besic bronchs : machain learning and deep learning. In machain learning we examine its types as Supervised Learning ,Unsupervised Learning and some common algorithms like : K-Nearest Neighbor(kNN) and Navie Bayes ,Then in deep learning we examine artificial neural networks(ANN) and some common algorithms as such Principal Component Analysis (PCA) and K-Means Clustering .

2.1 Overview of Artificial Intelligence

The brain, with its remarkable capacity for learning and performing intricate computations essential for perception, cognition, and motor control, represents the epitome of intelligent behavior. Over the years, scientists have strived to replicate its functions in AI systems. Until recently, these endeavors yielded only modest success. However, in recent years, AI has made remarkable strides, becoming an integral part of our daily lives. Through advancements in machine learning, AI can now identify objects and speech, and excel in strategic games like chess and Go, surpassing human capabilities (e.g., DeepMind's AlphaGo Zero). The potential of AI systems extends far beyond mere game-playing, promising transformative impacts across various domains. These include enhancing medical diagnoses, discovering novel treatments for diseases, driving scientific breakthroughs, predicting financial markets and geopolitical trends, and uncovering valuable patterns in diverse datasets.[9]. Artificial Intelligence (AI) has become the prevailing theme of our time, echoed by technologists, academics, journalists, and venture capitalists alike. Like numerous terms originating in technical academia that permeate general discourse, it has gained widespread usage and recognition.[10].

2.1.1 Deffinition of Artificial Intelligence

AI encompasses a branch of computer science dedicated to developing computing machines and systems capable of emulating human learning and decision-making processes. Described by the Association for the Advancement of AI as the scientific comprehension of the mechanisms driving thought and intelligent behavior, manifested in machines[11].

AI encompasses numerous functionalities, including, but not restricted to:

a) Learning, which encompasses various methodologies such as deep learning (for tasks related to perception), transfer learning, reinforcement learning, and their amalgamations.

b) Understanding, which involves a profound knowledge representation necessary for domain-specific endeavors, such as cardiology, accounting, and law.

c) Reasoning, which manifests in multiple forms, including deductive, inductive, temporal, probabilistic, and quantitative reasoning.

d) Interaction, either with humans or other machines, to cooperatively execute tasks and to acquire knowledge from the environment.

AI is already significantly benefiting various sectors of the global economy and society[12]. For instance, humanitarian groups employ intelligent chatbots to deliver psychological aid to Syrian refugees, while physicians utilize AI to craft customized therapies for cancer patients.[13].

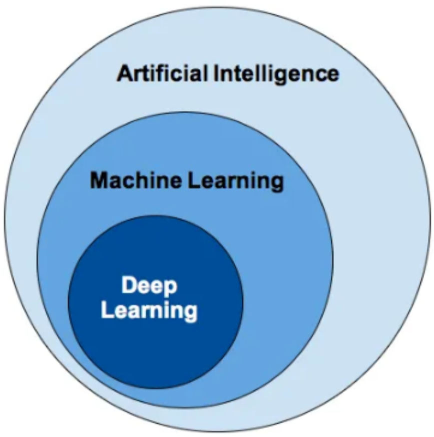


Figure 2.1: Artificl Intelligent

2.1.2 Artifical Intelligence Applications

Here are some applications of AI [14]:

1. **manufacturing:** Integrating AI into the manufacturing process enables companies to capitalize on smarter factories, leading to increased productivity and reduced expenses. AI can be deployed in manufacturing assembly, optimizing the supply chain, utilizing robots on the production floor, enhancing performance through sensor technology, and improving post-production activities
2. **Healthcare:** Artificial Intelligence is extensively utilized across various domains within the healthcare industry. From chronic ailments such as cancer to radiology, AI is harnessed to implement effective and accurate interventions aimed at enhancing patient care for individuals afflicted with these conditions.
3. **Autonomous Vehicles:** Autonomous vehicles are becoming a reality in agriculture, transportation, and military sectors, with their widespread adoption for average consumers on the horizon. Their functionality heavily relies on sensor data and AI algorithms, which enable tasks like data gathering, path planning, and maneuver execution. These vehicles utilize unconventional programming methods and rely on machine learning techniques inherent to AI, especially for path planning and execution.
4. **facial recognition:** Facial recognition technology is employed in phones, laptops, and personal computers through face filters to securely detect and authenticate users. Beyond individual use cases, it finds extensive application in various industries, particularly in high-security settings, showcasing its versatility in AI applications.
5. **Robotics:** AI has long been a staple in robotics, where it is frequently deployed to enable real-time obstacle detection and instant path planning, facilitating the seamless execution of diverse tasks by AI-driven robots.

2.2 Machine Learning

Machine learning (ML) falls within the realm of AI and concentrates on creating algorithms capable of autonomously constructing analytical models from fresh data, bypassing the need for explicit programming of the solution[15] ,That's essentially about enabling AI to perform tasks without precise instructions. It's essentially about instructing machines in the art of learning![16]. Machine learning has become widespread: Pandora refines its music suggestions by adapting to user preferences; Google automatically translates content by learning from online translations; and Facebook identifies individuals in photos through its database of recognized users.[17].

2.2.1 Machine Learning Types

ML is the method through which machines, with access to relevant information, can adjust and customize their actions to autonomously acquire problem-solving skills[18].A variety of ML models exist, typically employing three main types of learning: supervised, unsupervised, and reinforcement. These learning styles primarily determine how and to what extent models are trained [19].

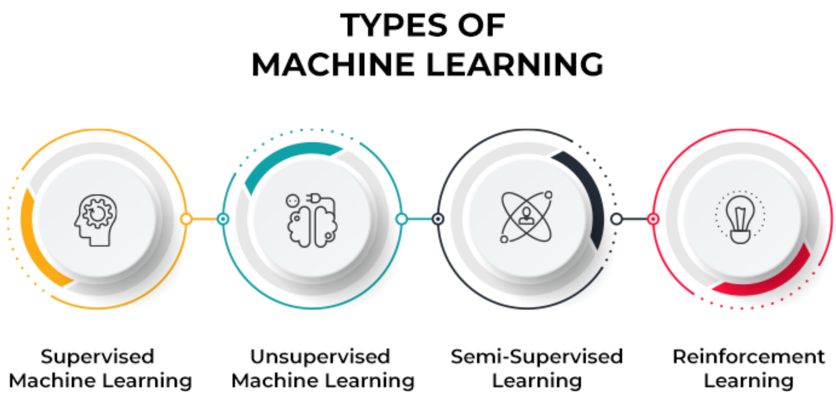


Figure 2.2: Types of Machine Learning

2.2.1.1 Supervised Learning

Supervised learning involves teaching a machine to learn a function that connects input data to corresponding output, relying on labeled input-output pairs. It derives a function from labeled training data comprising a set of examples. Algorithms in supervised machine learning require external guidance. The input dataset is typically split into training and testing sets, with the training set containing the output variable to be predicted or classified. All algorithms extract patterns from the training set and then utilize them to predict or classify data in the test set [20].

Supervised learning can be separated into two types:

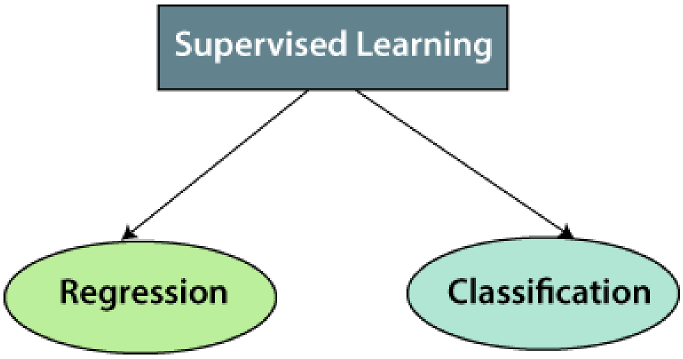


Figure 2.3: Supervised Learning

1. **Classification** refers to the process of categorizing data into different classes or categories based on its features. It is a supervised learning technique where the algorithm learns from labeled data to predict the class labels of unseen data.

   The goal of classification is to build a model that can accurately classify new, unseen instances into one of the predefined classes. For example, in email spam detection, the model learns to classify emails as either spam or not spam based on features such as the presence of certain keywords, sender information, and email structure.
2. **Regression** Regression is a supervised learning technique used to predict a continuous outcome variable based on one or more input features. Unlike classification, where the goal is to predict a discrete class label, regression aims to predict a continuous value.

   In regression, the algorithm learns the relationship between the input features and the target variable from labeled training data and then uses this learned relationship to make predictions on new, unseen data.

liste of common supervised learning algorithms[20]:

- **K-Nearest Neighbor** The k-nearest neighbors (KNN) algorithm is a straightforward supervised ML method applicable to both classification and regression tasks. While it's simple to implement and grasp, a notable drawback is its decreased efficiency as the size of the utilized data increases.
- **Navie Bayes** Naive Bayes is a classification method grounded in Bayes' Theorem, assuming predictor independence. In essence, it posits that the presence of one feature in a class is unrelated to any other feature's presence. Primarily employed in text classification, Naive Bayes is utilized for clustering and classification, relying on the conditional probability of occurrences.
- **Decision Tree** A decision tree is a graphical representation of choices and their outcomes in the form of a tree structure. Nodes in the graph depict events or decisions, while edges represent decision rules or conditions. Each tree comprises nodes and branches, with each node representing attributes grouped for classification and each branch indicating a possible value the node can assume.
- **Linear Regression** This ML classification algorithm utilizes one or more independent variables to predict an outcome, typically measured by a dichotomous variable, indicating only two possible outcomes[21].
- **Neural Networks** A neural network is a sequence of algorithms designed to identify inherent patterns within a dataset, mirroring the functionality of the human brain. These networks consist of interconnected neurons, either organic or artificial. They possess the ability to adjust to varying inputs, allowing them to produce optimal outcomes without necessitating a redesign of the output criteria. Originating from AI, neural networks are rapidly gaining traction in the development of trading systems[20].
- **Logistic regression**
  Logistic regression, a classification algorithm, is employed to determine

the probability of a variable's change. The variable to be predicted is dichotomous, categorized as either 1 (success/yes) or 0 (failure/no) based on encoded data[22].

2.2.1.2 Unsupervised Learning

These techniques are referred to as unsupervised learning because, unlike supervised learning, there are no correct answers or instructors. Algorithms autonomously uncover and reveal intriguing structures within the data. Unsupervised learning algorithms extract meaningful features from the data. When new data is introduced, these algorithms utilize the previously acquired features to classify the data. Unsupervised learning is primarily utilized for clustering and feature reduction [20].

UnSupervised learning can be separated into tow types:

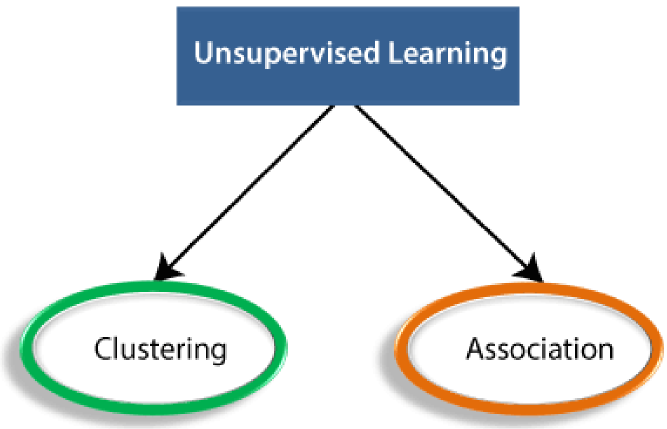


Figure 2.4: Unsupervised Learning

1. **Clustering** is a technique used to group similar data points together into clusters based on their intrinsic characteristics or features. The goal of clustering is to partition the data in such a way that data points within the same cluster are more similar to each other than to those in other clusters. Clustering is an unsupervised learning task, meaning that the algorithm learns to identify patterns in the data without explicit labels.
2. **Association** There are association rules among transactional data. By mining the relationship between transactional data, frequent itemsets can be obtained. Based on this, the probability of certain transactions

occurring simultaneously is predicted. Apriori is a classical algorithm for mining association rules [23].

Common Unsupervised learning algorithms[20]:

- **K-Means Clustering** K-means stands out as one of the simplest unsupervised learning algorithms designed to address the clustering problem. This method follows a straightforward approach to classify a given dataset into a specified number of clusters. The key concept is to define k centers, each representing a cluster, strategically placed to optimize results since different placements yield different outcomes. Therefore, the optimal strategy is to position these centers as far apart from each other as possible. Subsequently, every data point is assigned to the nearest center, marking the completion of the initial stage and the formation of preliminary groupings. Following this, the process entails recalculating k new centroids as the barycenter of the clusters formed in the previous step.
- **Principal Component Analysis (PCA)** Principal Component Analysis (PCA) is a statistical method that employs an orthogonal transformation to convert a collection of potentially correlated variables into a set of linearly uncorrelated variables known as principal components. This technique reduces the dimensionality of the data, facilitating faster and simpler computations. PCA aims to elucidate the variance-covariance structure of a variable set through linear combinations. It is frequently utilized as a dimensionality reduction tool.

2.2.1.3 SemiSupervised Learning

Semi-supervised ML integrates elements from both supervised and unsupervised methods. It proves particularly advantageous in domains of ML and data mining where unlabeled data is abundant and obtaining labeled data is challenging. Unlike conventional supervised methods, where algorithms are trained on labeled datasets containing outcome information for each record, semi-supervised learning operates on a combination of labeled and unlabeled data. Various semi-supervised learning algorithms are explored further below[20].

2.2.1.4 Reinforcement

Reinforcement learning differs from other learning paradigms in that it lacks pre-classified examples, focusing instead on a long-term objective. An agent engages in "experimentation" with a system and receives rewards or penalties based on these interactions. By exploring various possibilities and adjusting its behavior iteratively, the agent aims to maximize rewards and minimize penalties[24].

Although the agent isn't provided with direct instructions on achieving its objective, consistently taking actions that maximize cumulative rewards enables it to refine optimal behaviors through repeated iterations[25]. In most cases, the longer a model is run, the more refined the solution will be [19].

2.3 Deep Learning

Deep learning (DL) represents a sophisticated form of machine learning proficient in recognizing intricate or abstract patterns within datasets through the utilization of a multi-layered artificial neural network [26]. The term "deep" in DL refers to its numerous layers compared to simpler ML methods, enabling more intricate processing capabilities. A significant advancement in ML is deep learning, where algorithms utilize statistical methods to construct models for solving complex problems from vast datasets with minimal programmer intervention. As computer scientist Amit Karp explains, DL involves simulating extensive, multilayered networks of virtual neurons, empowering computers to learn abstract patterns autonomously[26].It earns the name 'deep' because it autonomously creates multiple layers of data abstractions, leveraging them to recognize patterns. As deep learning and other ML methods advance, they promise substantial benefits for individuals and societies.[15].

2.3.1 Importance of Deep Learning

The ability to handle vast amounts of features is what makes DL incredibly potent when addressing unstructured data. However, DL algorithms can be excessive for simpler tasks as they require access to extensive datasets to be effective. For example, ImageNet serves as a common benchmark for training DL models for comprehensive image recognition, containing over 14 million images.

When data is too simple or limited, DL models can easily become overfitted and struggle to generalize to new data. Consequently, DL models may not be as effective as other methods, such as linear models or boosted decision trees, for practical tasks like customer churn prediction or fraud detection, especially with smaller datasets and fewer features. However, in specific cases like multiclass analysis, DL can be suitable for smaller processes and curated datasets[27].

2.3.2 Deep Learning basics

1. **Data:** In DL, data plays a crucial role as the foundation upon which models are trained, validated, and tested. DL models, particularly neural networks, learn from data through a process called training . where they adjust their parameters to minimize the difference between their predictions and the true targets in the data. Here's how data is used in DL:
   - **Training Data:** Training data is the initial dataset used to train the DL model.
   - **Validation Data:** Validation data is a separate dataset used to evaluate the performance of the model during training and tune hyper-parameters.
   - **Testing Data:** Testing data is another separate dataset used to assess the final performance of the trained model.
   - **Data Preprocessing:** Data preprocessing is a critical step in DL that involves cleaning, transforming, and preparing the data for training. Common preprocessing techniques include normalization, scaling, feature engineering, and handling missing values.
   - **Data Augmentation:** Data augmentation techniques are used to artificially increase the size and diversity of the training data by applying transformations such as rotation, flipping, cropping, and

scaling to the original images or samples.

2. **Algorithms :** In DL, various algorithms are used to train and optimize neural network models to learn complex patterns and make predictions from data.

3. **Training :** Training in DL refers to the process of optimizing the parameters (weights and biases) of a neural network model to minimize a predefined loss function on a given dataset. The goal of training is to enable the model to learn meaningful representations from the input data and make accurate predictions on new, unseen instances.

2.3.3 Artificial Neural Networks

Artificial neural networks (ANNs) are ML models inspired by the structure of biological neural networks found in animal brains. ANNs employ multiple layers of nonlinear processing units to extract and transform features. This enables them to capture various levels of abstraction from the data, making them effective for tasks like image, sound, and text analysis. Neural networks with numerous layers are referred to as deep neural networks, and the training process for these networks is termed DL [28].

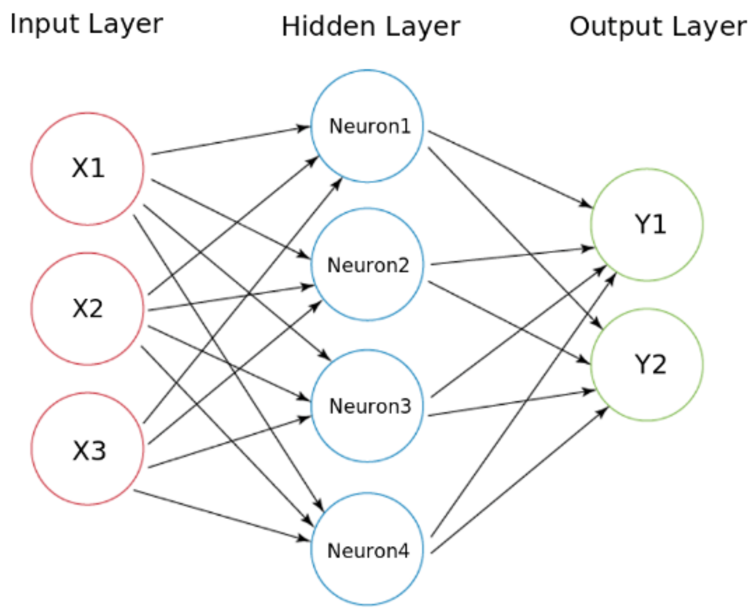


Figure 2.5: Architecture of Neural Networks

2.3.3.1 Layers Types in ANN

ANNs consist of layers of interconnected neurons, each performing specific operations on the input data. Different types of layers serve different purposes and are designed to capture various aspects of the data. Here are some common types of layers found in artificial neural networks:

- **Input Layer:** The input layer is the first layer of the neural network, responsible for receiving the input data and passing it to the subsequent layers. Each neuron in the input layer corresponds to one feature or dimension of the input data.
- **Hidden Layer:** Hidden layers are intermediate layers between the input and output layers. They perform complex transformations on the input data, extracting higher-level features and representations. The number of hidden layers and the number of neurons in each hidden layer are hyperparameters that need to be tuned during model design.
- **Output Layer:** is the final layer in an ANN. It receives input from the preceding layers and produces the network's output, which can vary depending on the type of task the network is designed to solve.

2.3.3.2 Comparison between Biological Neural Network and Artificial Neural Network

Biological neural networks (BNNs) and artificial neural networks (ANNs) have similarities but also notable distinctions[29].

Feature	Artificial Neural Network	Biological Neural Network
Processing	Data is processed in parallel. It is fast but inferior to BNN.	Data is processed in parallel. It is slow but superior than ANN
Learning	Structured, precise and formatted data is needed to tackle uncertainty.	They can tackle the uncertainty.
Size	102 to 104 nodes, based on the type of network designer and application.	1011 neurons and 1015 interconnections.
Fault tolerance	Robust in nature.	Degradation of performance occurs with even partial damage.
Storage capacity	Information is stored in contiguous memory location.	Information is stored in the synapse.

Table 2.1: Comparison between Biological Neural Network and Artificial Neural Network

2.3.3.3 Challenges in Artificial Neural Networks

Artificial Neural Networks (ANNs) have made significant strides in various domains, but they still face several challenges[29]:

- **Comparability:** Due to the diverse range of neural models, network topologies (such as recurrent, multi-layer, single-layer, etc.), and required encoding for different learning algorithms, comparing the efficiency of various neural networks becomes challenging.
- **Generality:** None of the algorithms proposed in artificial neural networks are universally applicable. Each algorithm is tailored for specific network topologies, and no single algorithm can be utilized for general purposes or even for the learning of arbitrary tasks, mapping, or pattern classification.
- **Formulation:** Many of the proposed algorithms lack the ability to address how they compare to other similar approaches. This issue stems from differences in network topologies, neuron models, error functions, and neural codes. The absence of a common, structured language to

discuss these schemes makes analysis and comparison challenging. Additionally, the inherent temporal dimension of spike trains introduces a notational burden, complicating the formulation of equations for these algorithms.

- **Hardware dependence:** ANNs necessitate processors capable of executing parallel processing, tailored to their structure. This dependence on specific hardware is the primary reason neural networks rely on specialized equipment.
- **Unexplained behaviour of the network:** This stands as one of the significant challenges of ANNs. When an ANN generates a solution, it often does not provide insight into the underlying process or reasoning behind it.
- **Determination of proper network structure:** There are no definitive rules to validate the architecture of ANNs. The correct architecture is typically determined through trial and error, guided by experience.
- **Difficulty of showing the problem to the network**: Prior to presenting problems to ANN, they must be translated into numerical values. The chosen display mechanism significantly impacts the efficiency of the network.

2.3.3.4 Neural Network Algorithms

A Neural Network comprises interconnected nodes and artificial neurons. Each neuron executes an instruction within the processing area. The interconnected nodes relay information to the human brain in a recursive manner. Nodes continually interact with each other, conveying information and functions, thereby propelling the process forward. This flow is commonly referred to as the Activation function, which transfers input from one node's output to serve as input for another node. Here are some Categories of DL in Neural Network algorithms [27] :

- **Multi-layer Perceptron:** These are the most fundamental Neural Networks, including feed-forward networks. They primarily deal with nonlinear activation tasks and calculate errors using Log Loss or Mean Square Error. The error is then propagated backward, adjusting the weights more precisely. This process is a common practice in deep learning networks.

- **Convoluted Neural Networks:** CNNs share similarities with traditional Neural Networks but are specifically designed for image processing. The layers of CNNs are organized in three dimensions: width, height, and depth. They are particularly well-suited for handling dimensional data, object recognition, and image analysis due to their complex neuron structures. However, one major challenge for CNNs is their reputation for requiring deep learning expertise. Industries commonly utilizing CNNs include drones, computer vision, autonomous vehicles, and text analytics.
- **Recurrent Neural Network:** RNNs operate as feed-forward networks with recurrent memory loops, allowing them to receive input from previous and/or the same layers. Additionally, their connection structures follow graph-based directionality, providing the model with efficiency in handling sequential data and dynamic progressions over time. In essence, RNNs leverage memory across various time steps to anticipate ongoing processes, enabling high-performance predictions.

2.3.4 Examples of Deep Learning

DL technology has been applied in a multitude of fields. Here are a few instances[27]:

1. **Autopilot cars** An autopilot or self-driving car represents the ultimate advancement stemming from the development of ADAS (Advanced Driver Assistance Systems). Unlike ADAS, self-driving cars operate without immediate human intervention. DL's significance for self-driving systems can be emphasized. Nvidia, for instance, fosters enduring partnerships with car manufacturers, focusing on embedded systems and real-time operating systems tailored precisely to their needs.
2. **Health care system** The application of dDL in healthcare is expanding, addressing a variety of challenges for hospitals, patients, and the healthcare system overall. Research based on Deep Neural Networks has shown promising results, as they can be trained to augment radio-

logical diagnoses with high accuracy using patient data. DL techniques have the potential to detect cancer cells within the brain, exemplifying their utility in medical imaging.

3. **Natural Language Processing** Natural language processing (NLP) is an AI field concentrated on empowering computers to comprehend human language. Despite being intuitive for humans, language involves intricate and abstract connections between words, syntax, context, and nuanced elements like emotion, posing challenges for computer interpretation[15].
4. **Image classifications** The DL algorithm first identifies the edges of the human face and internal facial features to construct the initial hidden layer. Subsequently, the second layer processes by connecting these edges and shapes, while the facial features are amalgamated to form the recognizable human face. Additionally, the algorithm may identify other objects present in the image.
5. **Automated Text Generation** A large Recurrent Neural Network is utilized to train textual data, facilitating the understanding of relationships between sequences of characters. Upon model analysis, the text is converted into words or speech, exemplified by virtual assistants like Alexa and OK Google.

2.4 Conclusion

AI is considered a vital factor in facilitating and simplifying our daily operations. AI powered applications and systems can provide an innovative and effective solution to the challenges we face in our daily lives. Additionally, AI can make it easier to manage everyday tasks, such as personal organization and activity scheduling, through AI applications that provide personalized reminders and precise directions. In general, AI represents an indispensable element in our daily lives, as it contributes to improving efficiency, comfort and personal experience. Therefore, it plays an important and necessary role in our system and we urgently need it to simplify operations and achieve progress.

Chapter

3

Sypply Chain and Our System

3.1 Introduction

In this chapter, we delve into the intricacies of supply chains and introduce our cutting-edge intelligent food distribution system tailored specifically for the dynamic needs of food distribution centers (FDCs) especially in the event of war or pandemic. By leveraging advanced algorithms and ML techniques, our system aims to revolutionize FDC operations. It streamlines processes, optimizes inventory management practices, enhances food discovery capabilities, and enables swift responses in food distribution. Harnessing the power of ML algorithms, the FDC can attain unprecedented levels of accuracy, efficiency, and resilience in managing the food supply chain in Algeria. This innovative approach addresses challenges such as inventory management, logistics optimization, and food recognition, thereby significantly boosting the efficiency and effectiveness of the entire food supply chain in Algeria.

3.2 Supply Chain

The supply chain can be defined as a collaborative effort among various organizations to fulfill the demand for specific products, encompassing tasks ranging from sourcing raw materials to delivering the final product to the end user. It involves activities such as development, production, sales, service, distribution, and operations support[30].
Another definition of the term "supply chain" describes it as the network of participants and processes involved in converting raw materials from the earth into finished products that reach consumers. This definition often encompasses reverse flows such as returns, disposals, and recycling. While referred to as a "chain," it simplifies the intricate network of suppliers, manufacturers, distributors, and logistics providers who play crucial roles in managing the physical flow of goods from production to disposal[31].

3.2.1 Sypply Chain Management Flow

Supply chain management flow refers to the coordinated movement of goods, information, and finances from the initial supplier to the final consumer. It encompasses several key stages:

Figure 3.1: Sypply Chain Management Flow

- **consumers**
  Consumers drive demand forecasting and product development, influencing sourcing, manufacturing, and distribution. Their feedback and preferences shape efficient returns and customer service processes.
- **sale and product product development**
  Sales data informs demand forecasting, guiding product development to meet market needs. This alignment optimizes sourcing, manufacturing, and distribution processes in the supply chain.
- **procurement** Procurement involves selecting suppliers and acquiring raw materials to ensure smooth production and delivery in the supply chain.
- **suppliers** Suppliers provide the necessary raw materials and compo-

nents, ensuring the continuity of production and meeting quality standards in the supply chain.

- **manufacturing**
  Manufacturing transforms raw materials into finished products, ensuring quality and meeting demand within the supply chain.
- **warehousing**
  Warehousing involves the storage, handling, and distribution of goods, optimizing inventory management and facilitating timely order fulfillment in the supply chain.
- **logistics** Logistics coordinates the movement of goods, information, and resources, optimizing transportation and distribution to meet customer demands in the supply chain.

Each stage involves various processes and decisions to ensure the efficient and effective movement of products and services through the supply chain.

3.2.2 Importance of Supply chains

Supply chains play a vital role in various aspects of business and the economy:

1. **Efficiency and Cost Management:** Streamlining processes and optimizing resources lead to cost savings. Effective management minimizes inventory, transportation, and production costs.
2. **Customer Satisfaction:** Well-functioning supply chains ensure timely product delivery, enhancing customer satisfaction and loyalty, resulting in positive word-of-mouth.
3. **Competitive Advantage:** Agile and resilient supply chains enable quick responses to market changes and disruptions, providing a competitive edge and allowing businesses to stay ahead.
4. **Risk Management:** Identifying and mitigating risks such as supplier disruptions and natural disasters is essential for operations and financial performance.
5. **Innovation and Collaboration:** Collaborative relationships foster innovation through knowledge sharing and joint problem-solving, helping companies develop innovative products and processes.

6. **Sustainability:** Sustainable practices minimize environmental impact and promote ethical behavior, enhancing brand reputation and attracting environmentally-conscious consumers.
7. **Global Trade and Economic Growth:** Supply chains connect producers, suppliers, and consumers globally, facilitating trade and contributing to economic growth and international cooperation.

In summary, supply chains drive efficiency, customer satisfaction, risk management, innovation, sustainability, and economic development globally.

3.2.3 Traditional Inventory Management

Traditionally, inventory control leaned heavily on manual methods, including periodic hand counts, and a reactive strategy to handle problems as they cropped up. This meant keeping track of records on paper, relying on simple spreadsheets, and frequently encountering difficulties like excess inventory or shortages due to a lack of clear insight and forecasting abilities. [32]

3.2.4 Traditional vs. Modern Methods of Inventory Management

Approaches	Traditional	Modern
Inventory Tracking Methods	Manual tracking, periodic physical counts.	Real-time tracking through automated systems, barcode scanning, and RFID technology.
Data Handling and Record-keeping	Paper records, manual data entry	Cloud-based solutions, automated data syncing, and centralized digital records.
Demand Forecasting	Reactive approach based on historical data.	Predictive analytics, leveraging real-time data for accurate demand forecasting.
Order Fulfillment	Manual order processing.	Automated order fulfillment, reducing errors and improving efficiency.
Integration and Collaboration	Limited integration with other business processes .	Seamless integration with ERP, CRM, and other business applications for holistic management.

Table 3.1: Contrasting Traditional and Modern Approaches

3.2.5 Impacts of Maldistribution

Poor distribution can have significant impacts on society and on a distribution centers, especially during times of war or pandemic, . Here are some of the impacts:

- **On Society:**
  Humanitarian Crisis: In times of war or pandemic, inadequate food distribution can worsen humanitarian crises, intensifying hunger, malnutrition, and hardships among the populace, especially vulnerable demographics like children, the elderly, and displaced individuals.
  Social Unrest: Food scarcities and disparities in distribution can incite societal turmoil and instability, as individuals strive desperately to obtain food for themselves and their families. Such circumstances may precipitate civil unrest, demonstrations, and disputes over limited resources.
  Health Impacts: Insufficient availability of nourishing food can lead to a decline in overall public health, heightening the likelihood of malnutrition, contagious illnesses, and other health complications. This is particularly crucial during pandemics, where adequate nutrition plays a vital role in supporting immune function.
  Economic Strain: Inadequate food distribution can place pressure on the economy, as productivity suffers from illness and malnutrition, while healthcare expenses escalate. This, in turn, can worsen poverty and inequality across society.
- **Distribution Centers:**
  Loss of Sales: When items aren't easily accessible to customers as required, it can lead to decreased sales, as clients might switch to competitors providing more accessible products, thus diminishing the company's revenue and profitability.
  Excess Storage Costs: The buildup of inventory resulting from inefficient distribution can incur extra expenses related to storage, encompassing space, operational, and maintenance costs. Consequently, this can diminish profit margins.
  Additional Transportation Costs: In instances of distribution chal-

lenges, businesses might need to employ supplementary, expensive transportation methods to guarantee timely delivery of products to customers. This could elevate transportation expenses and diminish profit margins.

Loss of Repeat Customers: Frequent distribution problems can undermine customer confidence and loyalty, resulting in the loss of repeat clientele and decreased sales volume for the company.

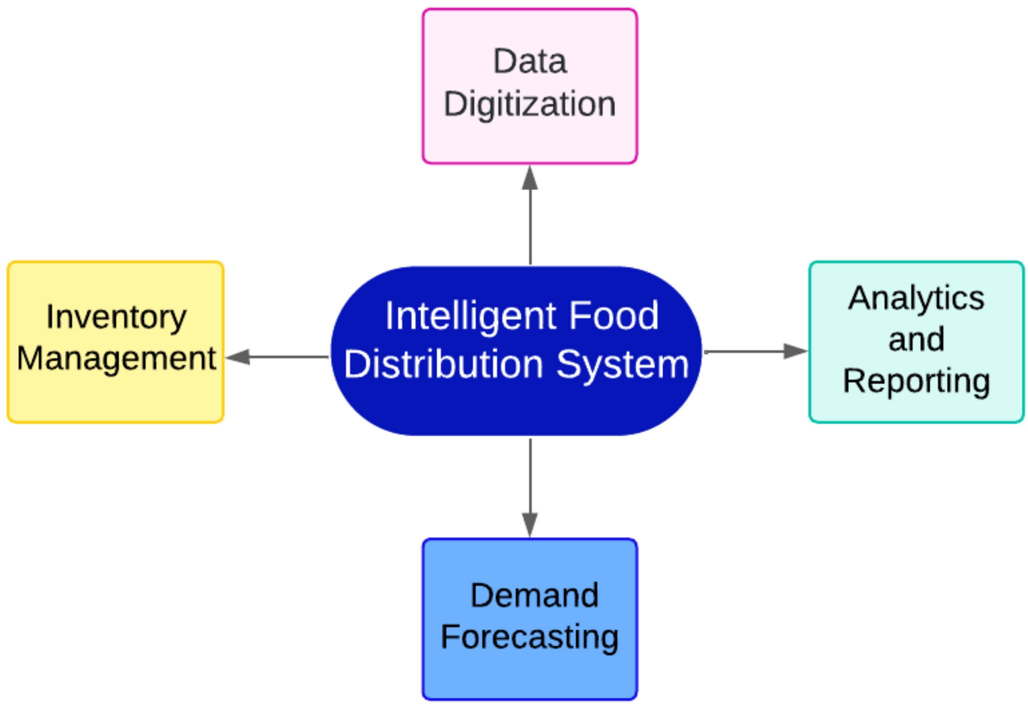
Reputation Effects: Inadequate distribution can harm a company's reputation, resulting in customer grievances and a negative standing in the market. This can impair the company's capacity to draw in new customers and maintain existing ones.

To mitigate these negative impacts, food distribution companies need to improve their distribution and supply chain processes, ensure timely and efficient delivery of products to customers .

3.3 Proposed Intelligent supply chain System

In this segment, we unveil a state-of-the-art food distribution framework meticulously crafted to cater to the nuanced requirements of FDCs. Harnessing the latest advancements in ML algorithms and methodologies, our innovative solution equips FDCs with the tools to enhance their precision, productivity, and adaptability in orchestrating the intricacies of the food supply chain across Algeria.

3.3.1 Intelligent Food Distribution System



3.3.2 Our objectives

Our contribution to this project primarily focuses on four key tasks

- **In Task1**,Food distribution centers face significant challenges in accurately forecasting customer demand for essential items. Therefore,We suggest merging an digitization module focused on digitizing the data of each state in Algeria. This involves examining various criteria, such as population percentages, and detailing all relevant conditions, including necessary stock levels to address state specific needs in various scenarios. This comprehensive approach enables us to effectively monitor ongoing developments and provide timely information. Such efforts aid in precisely anticipating the requirements of each state and ensuring equitable distribution practices, particularly crucial during emergencies like wars, where demand spikes and stock levels diminish.

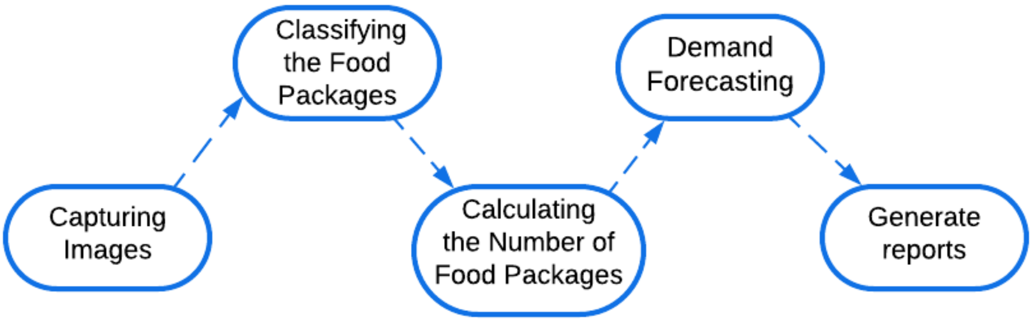
- **In Task2**, our proposal involves creating a sophisticated inventory management module. This module will utilize object recognition techniques to monitor the quantity of food items present at the distribution center and within each state's stock. The aim is to enhance inventory levels at the center, minimize wastage, and guarantee an ample supply of food to fulfill demand.
- **In Task 3**, our suggestion involves incorporating an Analytics and Reporting module. This feature produces detailed reports regarding the quantity of food items within the center, along with additional reports detailing the inventory of each state. These reports offer valuable insights into trends across all stores, consumption patterns, and areas with potential for enhancement.
- **In Task 4**, we suggest that the system should also be equipped with a demand forecasting module in case any inventory reaches the minimum. The developed system will receive notification of this and make automatic decisions on the amount of food needed to suit the needs of consumers. These decisions come as a result of digitizing the states' data in **(Task 1)** and following up on the inventory management results in **(Task 2)**, thus making a comparison between the distributed center's results and the stock results to be supplied. Therefore, there will be a quick response to this matter if one of the states runs out of stock. Which eliminates the need for manual distribution and ensures timely access to vital information in order to achieve fair distribution and thus achieve food security under exceptional circumstances. By automating this process, we not only save valuable time and effort, but also enable quick action and enable proactive measures to maintain optimal food

stock levels.

Our contributions in these areas enable FDCs to effectively manage their food inventory, make data-driven decisions, and streamline reporting processes. Ultimately, this enhances supply chain efficiency and overall productivity, enabling food product distribution companies to better perform their mission of providing essential food products to consumers especially in emergency situations.

3.3.3 Detailed Description of Our System

This section delineates the steps entailed in our smart food distribution system. Figure 2.3 offers a visual representation of the process. Our attention is directed toward a particular aspect of our system, which entails employing AI for efficient inventory management.



- **Step 1: Installing surveillance cameras**
  In this step, surveillance cameras are installed in each main inventory facility belonging to each state. Additionally, the food distribution center is equipped with a dedicated camera that monitors all cameras in real-time. This setup provides the distributor with comprehensive visibility into all warehouses and any ongoing changes within them.

- **Step 2: Take photos of food packages**
  In this step, pictures are taken using a camera of the food packages present in each store in real time.

- **Step 3: Detect and classify food packaging**
  The second step involves using artificial intelligence to identify each food package through the captured image. The AI algorithm uses ML techniques to identify the unique features of each food package, such as its color, shape, and size, to classify it into a specific category.

- **Step 4: Count the number of food packages**
  The third step involves using an algorithm to count the number of food packages in each class. The algorithm can analyze the images to determine the number of packets based on their type Features and characteristics.

- **Step 5: Demand forecasting**
  Stores are automatically analyzed if the level of any stock reaches the minimum level. The system predicts this as a result of comparing stock level conditions with the current level to determine the areas most in need of food, which allows us to make informed decisions regarding stock management, especially food distribution.
- **Step 6: Create reports**
  This step involves generating reports on the number of foods for each item, their type, and all the details.

3.3.4 Benefits of the Proposed Solution

The suggested approach presents numerous advantages compared to the conventional manual counting approach. By employing AI, the necessity for manual counting is eliminated, thereby decreasing the time and labor involved in the process. Moreover, AI algorithms boast high precision, minimizing the likelihood of human errors when tallying food items. Furthermore, AI implementation enables real-time monitoring of food availability, facilitating more effective inventory management and reducing the risk of overstocking or stockouts

3.3.5 Challenges

While leveraging AI to enhance food supply chain management through automated food counting offers numerous benefits, several challenges need addressing:

- **Data Quality:** AI's effectiveness in counting food packages relies on image quality. Blurry, distorted, or poorly lit images can lead to inaccurate classification and counting.
- **Technical Expertise:** Implementing an AI-powered solution demands technical expertise for setup and maintenance, posing challenges for organizations lacking qualified personnel.
- **Cost:** The investment required for implementing AI-powered solutions, including technology, equipment, and personnel, may be a barrier for organizations with limited resources.
- **Privacy and Security:** Managing sensitive food inventory data with AI requires robust privacy and security measures to prevent unauthorized access and data breaches.
- **Integration with Existing Systems:** Integrating AI-powered solutions with existing systems such as inventory management and electronic food records requires careful planning and collaboration across departments.
- **Scalability:** Solutions must be scalable to cater to varying store sizes and locations, necessitating additional resources and technical expertise.

Addressing these challenges entails meticulous planning, implementation, and ongoing maintenance of AI-powered solutions. Overcoming these hurdles can lead to improved efficiency, accuracy, and cost-effectiveness in food supply chain management.

3.4 Experiment and Results

3.4.1 YOLO (YOU ONLY LOOK ONCE)

The YOLO algorithm, introduced by Redmon et al. (2016), transformed object detection by implementing a single-shot approach. Unlike traditional methods that rely on region proposal techniques, YOLO splits the input image into a grid and directly predicts bounding boxes and class probabilities. This allows for real-time object detection with notable accuracy . YOLO accomplishes this through a deep convolutional neural network that extracts high-level features from the input image, performing object classification and localization simultaneously. A major advantage of YOLO is its speed, making it ideal for applications requiring real-time performance. However, YOLO's grid-based method can result in localization errors for small objects or objects with complex spatial structures [33].

This thesis examines the latest version, YOLO v8, which builds on the foundation of its predecessors. YOLO v8 introduces several key improvements that enhance its performance in object detection tasks. These advancements include new architectural designs, improved training strategies, and the incorporation of cutting-edge deep learning techniques. By investigating these developments, we aim to provide a thorough understanding of YOLO v8's capabilities and advancements.

3.4.2 RESULTS OF YOLO V8

Performance of YOLO on the test dataset After the implementation of YOLO v8 on our Custom Dataset the results that we get are representing in the following Figure 3.3 and 3.4 :

Figure 3.2: Example of images before train

Figure 3.3: Yolo v8 results in Train

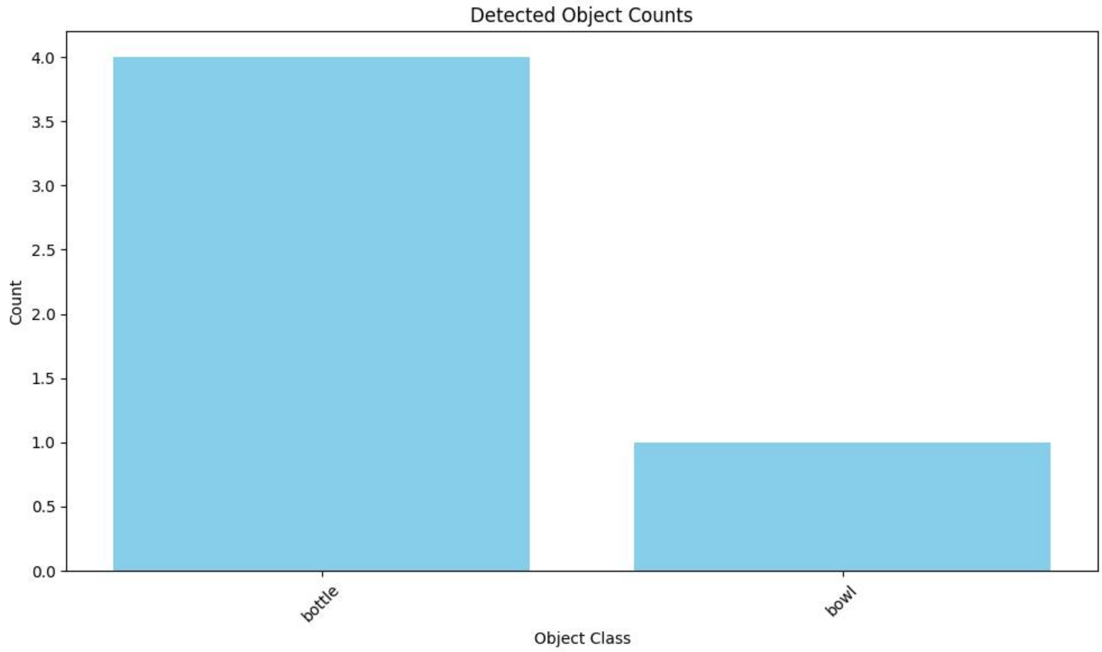


Figure 3.4: Yolo v8 results graph

3.5 Conclusion

This chapter provides an overview of supply chains and our perspective on an intelligent food distribution system for FDCs and the associated tasks,it provides experiment and results. Our thesis primarily focuses on four tasks: digitizing the data ,Inventory management, reporting and a demand forecasting.

Our proposed solution represents a significant advancement in supply chain management of the FDC especially in the event of war or pandemic.By leveraging digitizing the data and AI technology, particularly in food recognition and counting, our aim is to develop a system that streamlines inventory management processes and Precise demand forecasting by automatically generating reports and make clear decisions. This automation will result in time and effort savings and ensuring fair distribution of food.

General Conclusion

In this thesis, we aimed to highlight the importance of applying machine learning techniques in the food supply chain (FSC) to upgrade its efficiency and effectiveness. Our focus was on the particular case of the food distribution centres (FDCs), the unique supplier of food and food products for Algerian shops. For this purpose, we first provided an overview on a supply chain , explicating different tasks, then we focused on tasks that constitute the main part of this work, which is food inventory management. The proposed solution presented in this thesis represents a substantial advancement in managing. By using the power of artificial intelligence (AI) technology, specifically in food recognition and counting, the system facilitates inventory management processes, saving time and effort. Object detection techniques, such as YOLO, have been explored to upgrade the system's capabilities. This personalized approach strengthens the practical utility of the system in real-world FSC applications. The evaluation of object detection models YOLOv8 , for food recognition tasks in the food supply chain, has provided valuable vision. YOLOv8 demonstrated excellent performan, accurately detecting and localizing food objects with high precision. This makes it the preferred choice for real-time applications in food inventory management, ensuring accurate and efficient food recognition. However, it is important to mention that regarding the sensitive task we aim to perform, the accuracy of the system must be enhanced in order to attain better accuracy. In conclusion, the application of machine learning techniques, using image recognition , offers a valuable solution to optimize the food supply chain. The proposed approach can make a starting point in the design of an intelligent food supply chain.

Bibliography

[1] Katie Terrell Hanna Kinza Yasar. What is digitization? | definition from techtarget. 12 2023. URL https://www.techtarget.com/whatis/definition/digitization.

[2] Harsha Parekh. Digitization: An overview of issues. page 10.

[3] Vidhya Ganesan Bjarne Corydon and Martin Lundqvist. Transforming government through digitization. page 5, 2016.

[4] Shaulah Hamid. The digitization of the energy business are you prepared? page 4, 2019.

[5] Aryne Leigh Monton. Difference and similarities: Digitization, digitalization, and digital transformation. 03 2023. URL https://www.globalsign.com/en-sg/blog/difference-and-similarities-digitization-digitalization-and-digital-

[6] Vishnu Durga. Types of digitization and its error in gis | digitizing map data. 04 2020. URL https://www.agiratech.com/types-of-digitization-and-error-in-gis.

[7] Francesco Fusaro. Digitization, digitalization and digital transformation explained - understanding differences incl. examples. 10 2023. URL https://morethandigital.info/en/digitization-digitalization-and-digital-transformation-explained-un

[8] Natalie Medleva Margaret Rouse. What is digitization? - definition from techopedia. 11 2023. URL https://www.techopedia.com/definition/6846/digitization.

[9] Jacob Reimer Matthias Bethge and Andreas S. Tolias Fabian H. Sinz, Xaq Pitkow. Engineering a less artificial intelligence. page 13, 2019.

[10] Michael I. Jordan. Articial intelligence—the revolution hasn't happened yet. page 9, 2019. doi: 10.1162/99608f92.f06c6e61.

[11] Robert D. Atkinson. Ai overview: Broad discussions of artificial intelligence. URL http://aitopics.org/topic/ai-overview.

[12] Olivia Solon. Karim the ai delivers psychological support to syrian refugees. 03 2016. URL https://www.theguardian.com/technology/2016/mar/22/karim-the-ai-delivers-psychological-support-to-syrian-refugees.

[13] Robert D. Atkinson. "it's going to kill us!" and other myths about the future of artificial intelligence. 06 2016. URL http://www2.itif.org/2016-myths-machine-learning.pdf.

[14] Athanasios Valavanidis. Artificial intelligence (ai) applications. he most important technology we ever develop and we must ensure it is safe and beneficial to human civilization. page 50, 04 2023.

[15] Daniel Castro and Joshua New. The promise of artificial intelligence. page 48, 2016.

[16] Colin Paterson. An introduction to artificial intelligence. page 36, 2023.

[17] Pedro Domingos. *The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World*. New York: Basic Books, 2015.

[18] Stephen Marsland. Machine learning: An algorithmic perspective. 07 2009. URL http://thuvienso.bvu.edu.vn/handle/TVDHBRVT/15957.

[19] Lauren McMillan and Liz Varga. A review of the use of artificial intelligence methods in infrastructure systems. *ELSEVIER*, (116):21, 2022.

[20] Batta Mahesh. Machine learning algorithms - a review. page 7, 01 2020.

[21] Xin Yan Xiaogang Su and Chih-Ling Tsai. *Linear regression*. Wiley Interdisciplinary Reviews: Computational Statistics, 2012.

[22] Vladimir Nasteski. An overview of the supervised machine learning methods. page 51–62, 2017.

[23] Teng Xiuyi and Gong Yuxia. Research on application of machine learning in data mining. 392:5, 2018. doi: doi:10.1088/1757-899X/392/6/062202.

[24] M Kubat. An introduction to machine learning. page 331–339, 2017.

[25] Rongpeng Li and al. Intelligent 5g: When cellular networks meet artificial intelligence. 24(5), 03 2017. doi: 10.1109/MWC.2017.1600304WC.

[26] Amit Karp. Deep learning will be huge—and here's who will dominate it. 04 2016.

[27] S. Balakrishnan and Aswin G. Deep learning: An overview and its practical examples. page 4, 2020.

[28] Caspar van Leeuwen and Volker Weinberg. Best practice guide - deep learning. page 51, 2019.

[29] Avita Katal and Niharika Singh. Artificial neural network: Models, applications and challenges. page 16, 01 2022. doi: 10.1007/978-3-030-78284-9_11.

[30] Marcin Gębarowski Agnieszka Kawecka. Short food supply chains – benefits for consumers and food producers. *Journal of Agribusiness and Rural Development*, 47, 2015. doi: :10.17306/JARD.2015.48.

[31] Yossi Sheffi Duncan McFarlane. The impact of automatic identification on supply chain operations.

[32] Traditional vs. modern methods of inventory management. 16 2023. URL `https://subscribed.fyi/blog/traditional-vs-modern-methods-of-inventory-management/`.

[33] G. Anirudh Diwan and J. V. Tembhurne. Object detection using yolo: Challenges, architectural successors, datasets and applications. *Multimedia Tools and Applications*, 82, 2023.

Appendix