

CSST 102 - BASIC MACHINE LEARNING

Machine Learning

Introduction to Machine Learning

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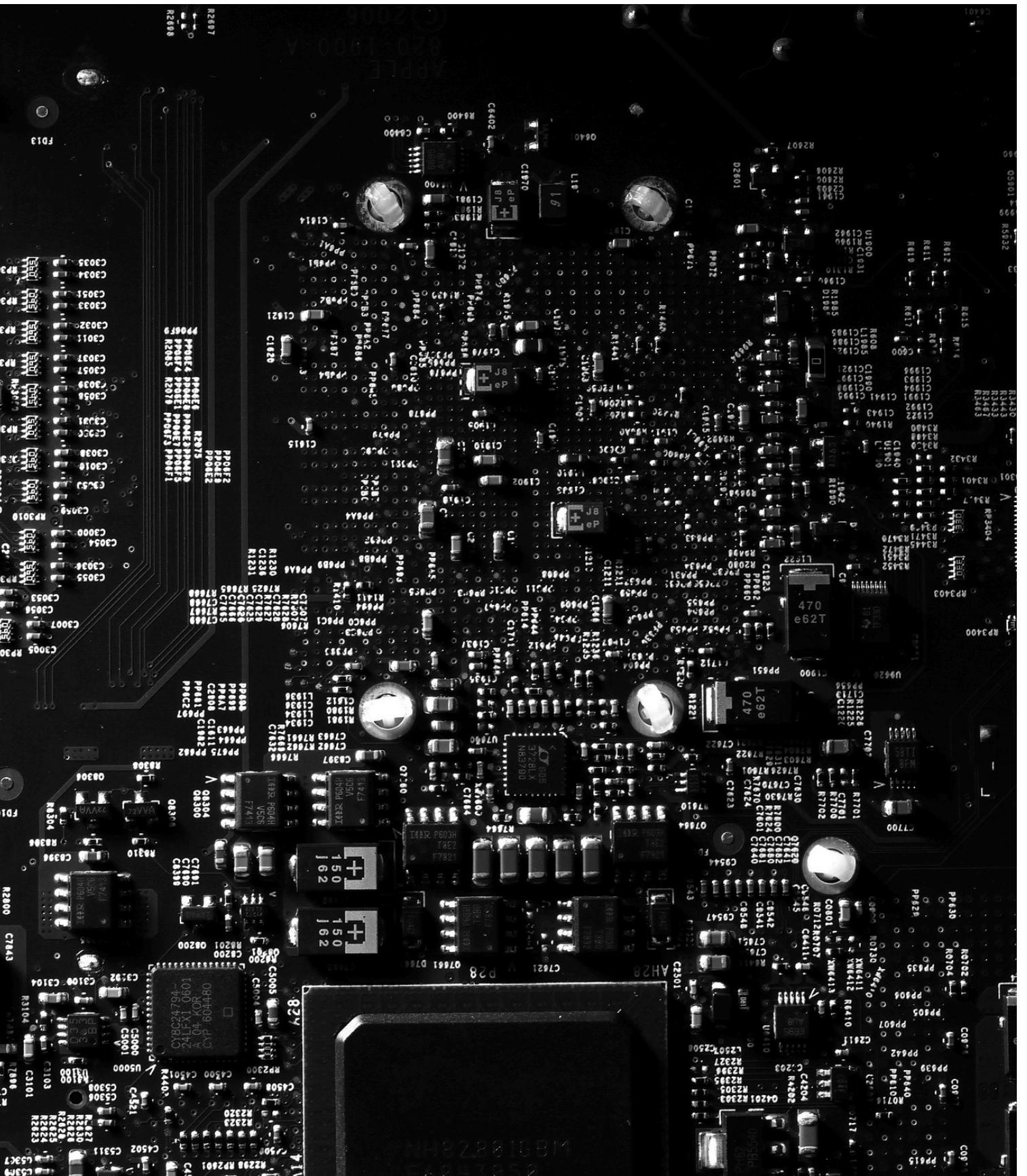
Table of Contents

Points to discuss:

- About Machine Learning
- Three Different Applications of ML
- The Problem Being Solved
- The Type of Machine Learning used (Supervised, Unsupervised, Reinforcement)
- The Impact of the Solution

About Machine Learning

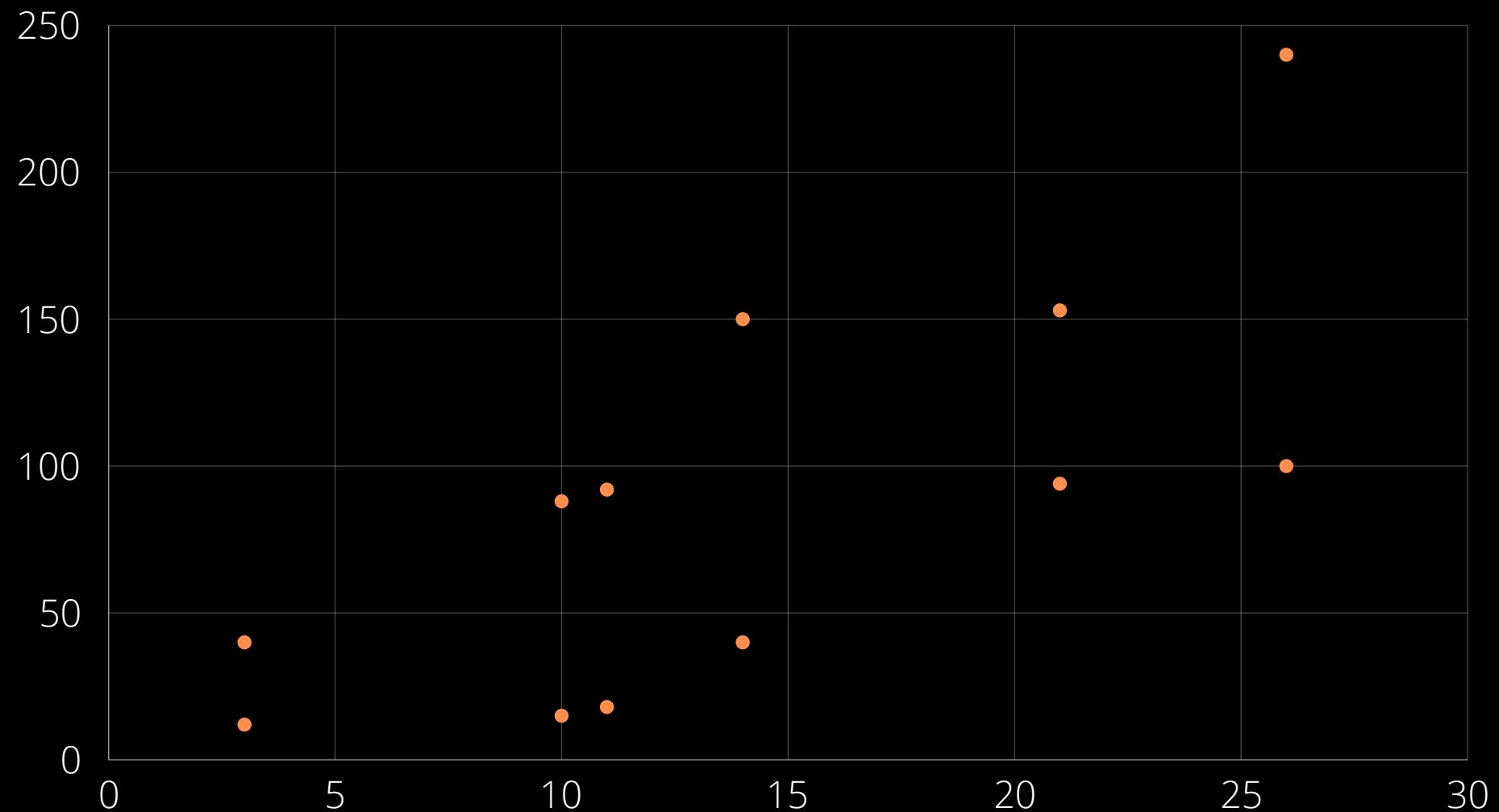
Machine Learning is a sub-set of artificial intelligence (Ai) which provides machines the ability to learn automatically and improve from experience without explicitly being programmed.



Types of Machine Learning

Supervised Learning

is an approach to creating artificial intelligence (AI) where a computer algorithms trained on input data that has been labeled for a particular output. The model is trained until it can detect the underlying patterns and relationships between the input data and the output labels, enabling it to yield accurate labeling results when presented with never-before-seen data.



Unsupervised Learning

- is a type of machine learning where the algorithm is **trained on unlabeled data without any specific target or output variable**. Instead, it identifies patterns, structures, or relationships within the data on its own. It's used for tasks like clustering, dimensionality reduction, and anomaly detection.

Reinforcement Learning

- is a machine learning paradigm where an **agent learns to make decisions by interacting with an environment**. The agent receives feedback in the form of rewards or penalties, allowing it to learn optimal behavior through trial and error. This approach is often used in applications like game playing, robotics, and autonomous systems.

The Three Different Applications of ML

Pharmaceuticals

accelerates drug development and enhances clinical trial efficiency.

Food and Beverages

boosts food quality, reduces waste, and improves inventory management.

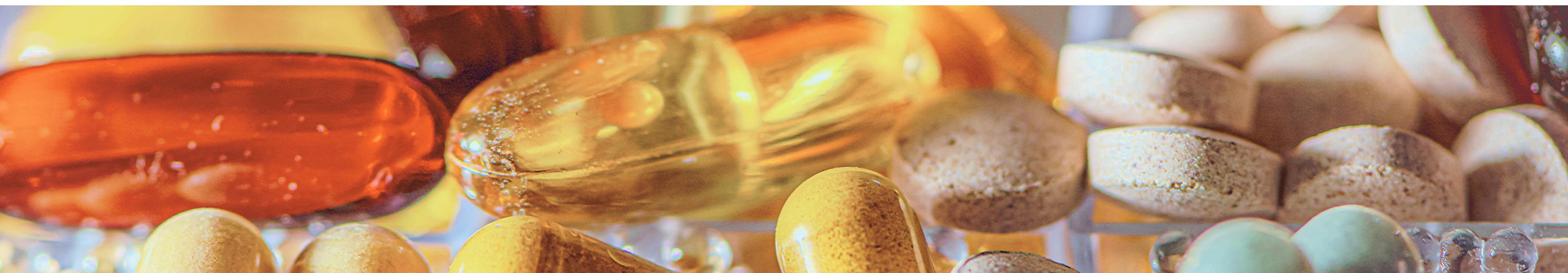
Security and Surveillance

advances security through better threat detection, video analysis, and facial recognition.

Pharmaceuticals in Machine Learning

Revolutionizing Radiology: How AI Assists Radiologists in Disease Identification

Doctors rely on medical imaging like X-rays, CT scans, MRIs, and ultrasounds for diagnoses. Analyzing these images requires specialized expertise, which AI now supports. Machine learning algorithms, trained on extensive datasets, recognize disease patterns and highlight areas of interest on scans. AI suggests possible diagnoses for anomalies, helping radiologists work faster and more accurately. This improves the likelihood of detecting subtle signs of illness early and enhances diagnostic precision.



Major Challenges

The pharmaceutical industry deals with slow drug discovery, inefficient clinical trials, and difficulties in monitoring drug safety. Machine learning tackles these challenges by accelerating the identification of promising drug candidates, optimizing clinical trial designs and participant selection, and enhancing safety monitoring through advanced data analysis. This results in faster drug development, more efficient trials, and better safety outcomes.

The Problems Being Solved

01

Drug Discovery and Development

- **Predictive Modeling:** ML algorithms analyze chemical properties and biological data to predict the efficacy of new drug compounds. By predicting which compounds are most likely to succeed, AI allows researchers to focus on the best candidates first.
- **High-Throughput Screening:** Speeds up the testing of vast numbers of compounds to pinpoint potential drug candidates.

02

Clinical Trials

- **Patient Recruitment:** Identifies suitable candidates for clinical trials based on medical history and genetic information. For example, AI can select the most appropriate participants by setting eligibility criteria. It also suggests the best dosing amounts and schedules, taking into account factors like age, gender, and weight to adjust doses.
- **Trial Optimization:** Analyzes data to optimize trial design, including dose selection and treatment regimens.

03

Pharmacovigilance

- **Adverse Event Detection:** Monitors and analyzes patient reports to detect and predict adverse drug reactions. It processes large datasets quickly to identify potential safety issues early.
- **Safety Monitoring:** Uses ML to identify patterns in drug safety data, improving risk management and regulatory compliance. These systems continuously refine their predictions for more accurate safety assessments.

How Pharmaceutical Companies Use Machine Learning to Improve Health Records Accuracy

Maintaining accurate health records is crucial but difficult. Handwritten notes and prescriptions are prone to errors. Medical jargon and abbreviations also introduce ambiguity. Pharma companies apply machine learning to address these problems. Algorithms can decipher handwritten text with high accuracy. They also understand common medical shorthand and acronyms. Additionally, natural language processing structures free-text notes. Medical concepts get codified into consistent data. Together, these AI applications boost the accuracy of patient records. They reduce mistakes from human error. Complete information improves healthcare operations and research.

Types of Machine Learning Used:

Supervised Learning: Used to predict which drug compounds will work best based on historical data and chemical properties.

Unsupervised Learning: Helps find patterns in patient data to choose the best trial participants, such as clustering patients with similar genetic or health profiles.

Reinforcement Learning: Improves trial designs by learning from ongoing trials and adjusting parameters like dosage and treatment schedules dynamically.

The Impact of the Solution

Machine learning in pharmaceuticals accelerates the entire drug development process, reducing costs and bringing new treatments to market more quickly. It enhances the safety and efficacy of clinical trials, ensuring that the right patients receive the right treatments. Additionally, by improving pharmacovigilance, ML helps protect patients from adverse drug reactions, leading to better overall healthcare outcomes.

Food and Beverages in Machine Learning

AI in Food Production: How It Helps with Cycle Optimization?

For food manufacturers, artificial intelligence technologies emerge as invaluable tools, facilitating the optimization of the food production process to meet demand, reduce waste, and ensure product quality control. The demand for AI in production is significant during the food production stage and expected to continue growing.



Major Challenges

The food and beverage industry faces challenges with quality control, supply chain inefficiencies, and product development. Machine learning addresses these issues by improving quality control through defect detection, optimizing supply chain management by predicting demand and reducing waste, and enhancing product development by analyzing consumer preferences to create better recipes and personalized nutrition recommendations, leading to higher quality products and more efficient operations.

The Problems Being Solved

Quality Control

When food production relies on manual inspection processes, it encounters errors and inconsistencies, jeopardizing food safety and quality control.

Problem

Solutions They Offer

AI technologies with computer vision systems, commonly utilized in both the food industry and manufacturing, utilize deep learning architectures, such as CNNs and object detection models like YOLO to inspect food products for defects, contaminants, or anomalies and ensure food quality control. Through the application of transfer learning methods and data augmentation, these systems are meticulously trained on diverse datasets to provide robust performance across a spectrum of product varieties and environmental conditions.

Inventory Management

Inaccurate inventory forecasting often leads to waste and lost sales, but advanced AI/ML algorithms can predict demand with high accuracy, helping restaurants optimize inventory and reduce waste.

Problem	Solutions They Offer
	<p>Leveraging advanced AI/ML algorithms, such as recurrent neural networks or time series forecasting models, restaurants can harness the power of data to predict demand with unprecedented accuracy. By analyzing consumer data, seasonal trends, and even social media sentiment, these algorithms provide actionable insights for optimizing inventory levels in the food industry. This not only reduces food waste but also ensures that restaurants always have the right items in stock.</p>

01 Quality Control and Inspection

- **Image Analysis:** ML algorithms inspect food products for defects, contaminants, or consistency issues using image recognition.
- **Sensor Data Analysis:** Monitors production processes using sensor data to ensure quality and safety standards are met.

02 Supply Chain Optimization

- **Demand Forecasting:** Predicts demand for food products to optimize inventory and reduce waste.
- **Logistics Management:** Enhances supply chain efficiency by optimizing transportation routes and schedules.

03 Product Development

- **Recipe Optimization:** Analyzes consumer preferences and ingredient interactions to develop new and improved food products.
- **Flavor Profiling:** Uses ML to analyze flavor profiles and suggest new combinations or enhancements.

Personalized Nutrition Recommendations

ML technologies are revolutionizing nutrition by providing personalized recommendations tailored to individual needs and preferences. AI algorithms analyze user data to tailor personalized recommendations based on dietary habits, health conditions, and goals. Predictive analytics forecast how foods impact health outcomes, promoting informed dietary choices and helping to move from junk food to healthy food products. AI technology creates personalized meal plans tailored to users' goals, whether it's weight loss, muscle gain, or simply switching to healthy foods.

Types of Machine Learning Used:

Supervised Learning: Used to inspect food quality during production by analyzing images to detect defects or contaminants.

Unsupervised Learning: Helps forecast demand by analyzing sales data and identifying patterns that inform inventory decisions.

Reinforcement Learning: Enhances personalized nutrition recommendations by continuously learning from user feedback and adjusting suggestions accordingly.

The Impact of the Solution

Machine learning in the food and beverage sector ensures that food products meet high safety and quality standards, reducing the risk of foodborne illnesses. It also optimizes supply chain efficiency, minimizing waste and improving inventory management, which leads to cost savings and better resource utilization. Personalized nutrition solutions created by ML contribute to healthier eating habits and increased customer satisfaction.

Security and Surveillance in Machine Learning

Role of ML in Security and Surveillance

Machine learning is significantly enhancing security and surveillance by improving video analytics, facial recognition, asset monitoring, and predictive analytics, resulting in greater operational efficiency and security.



Major Challenges

The security and surveillance sector struggles with detecting intrusions, managing video footage, and predicting threats. Machine learning improves security by identifying unusual patterns that indicate potential breaches, enhancing facial recognition for accurate identification, and predicting threats by analyzing historical data. These advancements lead to more effective threat detection, better video analysis, and proactive security measures.

The Problems Being Solved

01

Intrusion Detection

- **Anomaly Detection:** Identifies unusual patterns in security footage or network activity that may indicate security breaches.
- **Behavioral Analysis:** Analyzes behavior patterns in surveillance footage to detect suspicious activities.

02

Facial Recognition

- **Identity Verification:** Uses ML to identify and verify individuals in real-time based on facial features.
- **Access Control:** Enhances security systems by controlling access to restricted areas using facial recognition technology.

03

Threat Prediction:

- **Cybersecurity:** Analyzes network traffic and user behavior to predict and prevent potential cyber threats and attacks.
- **Physical Security:** Monitors public spaces to predict and respond to potential security threats based on historical data and behavior patterns.



Examples

Video Forensics

ML-based deep learning can also help in solving crimes if captured on CCTV cameras. Machine learning techniques can be used for color conversion, regeneration, and comparison between two video backgrounds, which will help forensic teams to identify vehicles or objects during the post-incident investigation. **AI-based machine learning algorithms** can help in other forensic activities such as:

- Vehicle model detection
- 3D face reconstruction
- Video enhancement by Image Super-resolution
- Video De-hazing and noise reduction
- License Plate De-hazing
- Predictive Image searching

Face Detection

Face Detection, Recognition and Alert Accurate face detection and recognition are very critical to law enforcement agencies. It helps in identifying people of interest and is also helpful in post-incident investigations. Broadly, some of the benefits of Facial Recognition application are:

- Automatic attendance
- Automatic recognition of authorized individuals or re-identification of unknown people
- Automatic alert for blacklisted/barred people or no-go zone breach
- Customizable MIS reports (alerts / movements / area-access / area-usage).

Object Tracking

During post-incident analysis, object tracking facilitates tracking a vehicle in case of a hit-and-run or to track a person who may have left a suspicious package at the incident site. Using computer vision algorithms, once the object in a frame is detected and segmented, it can then be matched against a set of defined categories: a car, bike, truck, man/woman with a cap, jacket, or backpack, etc.

The VCA software can be trained to identify these categories by using DNN models. Once the object of interest is detected and matched, the object segmentation defines the pixels used by the object and the movement of those pixels across the video frames can be tracked from multiple CCTV Cameras, thereby giving the entry/exit route of the object.

Traffic and Road Safety

AI technology has enabled VCA applications to detect traffic violations accurately and automatically. The availability of a large set of video data and computational resources have enabled the respective DNN models to be trained effectively.

Here are some of the VCA uses cases for Traffic & Road Safety:

- No-Helmet and Triple riding detection
- Wrong-way Driving or Illegal turn detection
- No-Parking violation detection
- License Plate Detection
- Stop-Line Crossing detection
- No-Seatbelt or Mobile Usage detection
- Over-Speeding Detection

What Is The Future Of AI In Security And Surveillance?

AI continues to transform the facets of various industries, and Security and surveillance are no exception. The future of AI in security and surveillance holds significant prominence across various security applications as discussed above. Rapid improvements in cutting-edge technology and the trend toward AI integration in systems, applications, and assets continue to enhance the accuracy of security measures.

Types of Machine Learning Used:

Supervised Learning: Powers facial recognition by matching faces with known identities to verify access and enhance security.

Unsupervised Learning: Detects anomalies in surveillance data that may indicate a security issue, such as unusual patterns of movement or behavior.

Reinforcement Learning: Improves threat prediction by learning from past incidents and continuously refining security measures based on observed patterns and outcomes.

The Impact of the Solution

Machine learning in security and surveillance leads to more accurate and timely detection of potential threats, enabling faster and more effective responses. Enhanced facial recognition improves security by ensuring that only authorized individuals gain access to secure areas. Predictive threat analysis helps prevent incidents before they occur, making environments safer for everyone and reducing the risk of security breaches.

Advantages of ML in Surveillance and Security

- 01 Proactive risk management
- 02 Advanced video forensics
- 03 Efficient access control
- 04 Automated alerts
- 05 Behavioral pattern analysis



Conclusion

Machine learning is revolutionizing various industries by improving efficiency and outcomes. In pharmaceuticals, it accelerates drug discovery and enhances safety monitoring. In the food and beverage sector, it helps reduce waste, optimize inventory and personalize nutrition. In security and surveillance, it strengthens threat detection, improves video forensics, and enhances facial recognition. These advancements lead to more effective and precise operations, benefiting both businesses and consumers. As technology continues to advance, its impact across these fields will only grow.

Resource Page

Here are the website links I used for research and information gathering to compile this report. These sources contributed important details and context for the whole content.

- <https://datasciencedojo.com/blog/machine-learning-101/>
- <https://www.geeksforgeeks.org/types-of-machine-learning/>
- <https://www.spiceworks.com/tech/artificialintelligence/articles/what-is-ml/>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8726514/>
- <https://www.askgxp.com/post/applications-of-machine-learning-in-the-pharma-industry#:~:text=A%3A%20Machine%20learning%20in%20pharma,and%20progress%20in%20the%20field.>
- <https://spd.tech/machine-learning/machine-learning-and-ai-in-food-industry/>
- <https://www.hyena.ai/impact-of-ai-on-the-security-and-surveillance-industry/>

Merci.