AMERICAN Journal of Science on Integration and Human Development
Volume 3, Issue 11, 2025 ISSN (E): 2993-2750

AI-Based Temperature Automation and Location Tracking for Maritime and Food Container

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Abstract: This study presents a comprehensive system for automated temperature control and position tracking, designed for application in food and maritime containers. The system utilises photos and a YOLO (You Only Look Once) algorithm to identify and categorise various types of food. GPS technology enables customers to track the container's location in real-time, providing visibility at all times. The deep learning aspect, based on YOLO, is highly critical for enabling the automatic detection and categorisation of food in the container. YOLO is very adept at identifying things, so it can quickly and reliably categorise them, ensuring that different kinds of food are placed in the correct group. A PID controller is a typical feedback device for control loops that does an excellent job of maintaining things at the appropriate temperature. The PID controller continuously adjusts the Peltier device's operation to maintain the container's internal temperature within the predetermined range. This keeps the food fresh and prevents it from spoiling and being thrown away during transportation. When you add GPS technology to the system, it gains new functionality, including the ability to see your location in real-time. Users can see exactly where the container is at all times, which makes it easier to plan logistics and keeps things safer. This feature is highly beneficial in the shipping industry, where container ships travel vast distances, and in the food industry, where delivering food to its destination on time is crucial.

Keywords: Goods Quality, Real-Time Location Tracking, Perishable Goods, Logistical Challenge, YOLO Model, PID Controller, Food Analysis, Machine Learning, Food Computing

Introduction

In today's interconnected world, transporting perishable commodities by sea and in food containers poses a significant logistical challenge [34]. To keep these things safe and of good quality, it is essential to closely monitor their location and maintain the ideal temperature. Perishable foods, such as fruits, vegetables, fish, dairy products, and meat, must travel vast distances across different climates, as global food supply chains span continents [59]. Changes in storage conditions, particularly temperature, can cause food to spoil, lose its nutritional value, and result in financial losses. To solve these problems, we need a robust system that not only controls the temperature automatically but also tracks the position of commodities in real-time to ensure they remain safe, fresh, and easily accessible during their voyage [47]. This paper combines deep learning, the YOLO model, a Proportional Integral Derivative (PID) controller, and GPS technology to develop a novel system that addresses the challenges of transporting food.

The basis for this new system is the combination of artificial intelligence, control systems, and positioning technologies [66]. The YOLO model is renowned for its ability to detect and identify objects in real-time. It is also important to determine what kinds of food are in a container [57]. This feature goes beyond just keeping track of inventory, as it provides the necessary information to ensure that each item receives the correct temperature control. For instance, seafood needs colder circumstances than tropical fruits [46]. A system that can distinguish between these two types of food can adjust the environmental settings to better suit them. Deep learning ensures that recognition is quick, accurate, and adaptable to various product designs, packaging styles, and container layouts. This method recognises that food items are different and have different storage needs, unlike traditional monitoring systems that regard all cargo as one load [38]. This improves storage conditions and reduces the likelihood of spoilage, which is crucial in the food industry, where maintaining the freshness and quality of perishable goods is essential.

The PID controller, which is the main component of the intelligent classification system, works in conjunction with it to regulate the temperature inside the container. A Peltier device, a thermoelectric system known for its accuracy, dependability, and flexibility, is used to control the temperature. The PID controller utilises proportional, integral, and derivative control to continuously monitor deviations from the desired setpoint and adjust the heating or cooling systems as necessary [39]. The proportional part ensures that temperature changes are responded to immediately, the integral part corrects long-term drift, and the derivative part examines the rate of change to predict future changes. These three mechanisms work together to generate a highly tuned response that maintains stable temperatures, even when external conditions become challenging, such as during a marine voyage when the temperature outside changes [58]. Therefore, the PID controller is crucial for maintaining the security of commodities in transit, reducing waste, and enhancing the overall efficiency of the cold chain logistics process

By incorporating GPS technology, you can track the real-time locations of shipping containers and food containers, adding even more value [56]. In a globalised market where commodities that go bad can span oceans and borders, it is more critical than ever to be open about the supply chain. GPS systems enable everyone involved to monitor the movement of containers at every stage of the voyage [33]. This ensures that everyone is responsible, that containers can be traced, and that any delays or route changes can be addressed promptly. For instance, if a container takes longer than usual to reach its destination due to port congestion, the system may predict potential threats to the cargo's quality and make adjustments to the environment ahead of time. Additionally, the location data can be utilised with logistics platforms to enhance routing, expedite delivery times, and facilitate collaboration among shipping companies, distributors, and retailers [60]. When you combine GPS tracking with temperature control, you have a comprehensive monitoring system that maintains perishable commodities in optimal condition while ensuring they remain visible and traceable throughout the supply chain [48].

Combining these three technologies creates a highly advanced system that addresses both the challenges of transporting perishable commodities and ensuring they maintain high quality. The YOLO model for deep learning ensures that food items are recognised and classified intelligently [37]. The PID controller ensures that the temperature is controlled accurately and adaptively. The GPS ensures that location monitoring and logistical transparency are accurate [61]. This synergy not only makes container operations easier but also makes them more reliable and efficient for moving a wide range of food commodities across long distances [55]. This kind of system may have numerous benefits, including reducing food waste, enhancing consumer safety, and increasing the profitability of businesses that trade food globally.

Food deterioration during transit remains a significant issue worldwide. Every year, billions of dollars are lost due to poor storage conditions and late deliveries [54]. For instance, tropical fruits that are shipped to temperate areas often lose quality if the temperature isn't kept within a certain range. Seafood is also quite sensitive to small changes in temperature, which can cause bacteria to proliferate and the meal to lose its freshness [45]. This system takes a proactive approach by continually monitoring the cargo's conditions and the transit state. This way, it reduces the likelihood of mistakes made by people, equipment breakdowns, and unexpected external events such as changes in weather or logistics issues.

Another key aspect of this initiative is its role in maintaining food security and enhancing public health. Transporting perishable commodities without adequate monitoring not only incurs costs but can also be detrimental to people's health [36]. Foodborne infections can happen when food is contaminated or spoiled, and they can have big effects on society and the economy. By maintaining strict control over storage settings, the suggested system ensures that food arrives in a safe and edible state [62]. Additionally, implementing smart monitoring systems enables the tracking of storage conditions, which can be particularly helpful when addressing food safety concerns [49]. If there is a chance that a batch of items is contaminated, stakeholders can quickly determine its origin, identify the cause of the issue, and rectify it.

From a technological perspective, the system also demonstrates the importance of integrating AI with embedded systems in real-world applications [7]. The YOLO model is computationally intensive, but it can be optimised to run on embedded systems, allowing for real-time detection without requiring continuous cloud connectivity. This lowers latency, makes things more reliable, and ensures that monitoring continues even in areas with poor connectivity, such as shipping routes in the deep sea. The PID controller also works well in embedded settings, allowing it to maintain stable temperatures without consuming excessive energy [65]. The GPS part works with low-power communication modules to provide you with constant position data, using very little energy. The careful design of these parts ensures that the system remains cost-effective, energy-efficient, and scalable for use in large-scale maritime and food logistics.

Using these kinds of systems can also change how supply chains are managed, providing them with more visibility and control than ever before [43]. In the past, individuals involved in the food supply chain relied on periodic updates and manual inspections to monitor the status of shipments. These approaches require a significant amount of time and are also likely to be incorrect or take longer than expected. In contrast, the automatic solution described here provides real-time information about both the weather and your location at all times [32]. This enables informed decision-making based on predictions, allowing for the identification and resolution of issues before they escalate [52]. For instance, if the system detects that the cooling device isn't functioning properly, it can notify operators immediately and suggest ways to rectify the issue. This reduces downtime, prevents shipments from getting lost, and gives people greater confidence in the reliability of supply chain operations.

This system can be applied to various transportation situations because it is scalable. The modular architecture enables its use in various logistical situations, ranging from large ships carrying thousands of containers to smaller trucks transporting goods within a country [40]. You can train the YOLO model to recognise different types of products, modify the PID controller to suit the environment's needs, and set up GPS modules to integrate with current logistics management systems. This flexibility ensures that the system can operate in global marketplaces while also addressing the specific challenges that regional supply chains encounter [50].

The system can integrate with other emerging technologies in the future, making it even more effective. For example, blockchain technology can be used to create immutable records of cargo conditions and transit data. This would make sure that everyone involved is honest and open [42]. The Internet of Things could enable containers to communicate with each other and with central hubs, facilitating more efficient resource allocation [6]. For example, during emergencies, containers could share cooling capacity. For more advanced analytics, you may use machine learning models other than YOLO. For example, you could use predictive spoiling detection based on environmental trends and product characteristics [63]. These kinds of new ideas would make food transportation systems even more resilient and smart.

We should also consider the environmental impact of using this type of technology. The method supports sustainability initiatives and promotes global ambitions to reduce carbon footprints by minimising food waste through improved preservation [44]. A significant portion of greenhouse gas emissions stems from food waste, and addressing cold chain logistics is a direct approach to mitigating this issue. Additionally, the system operates sustainably, utilising energy efficiently through optimised PID control and low-power embedded platforms [53]. This fits with the growing focus on eco-friendly technologies in global supply chains.

In conclusion, the shipping of perishable goods in food and maritime containers is a crucial aspect of global trade that requires close monitoring and regulation [35]. This new system, which utilises the YOLO deep learning model, a PID controller, and GPS technology, addresses the long-standing issues of food preservation and logistical management [51]. The technology makes things more efficient, reduces waste, protects public health, and enhances the supply chain's resilience by ensuring that temperature control is customised, location tracking is done in real-time, and products are recognised intelligently [64]. It represents a revolutionary step forward in cold chain logistics, as it can evolve, adapt, and integrate with new technologies [41]. As the world becomes increasingly dependent on the smooth movement of perishable goods over long distances, these smart systems will play a crucial role in shaping the future of food transportation, ensuring that quality, safety, and sustainability are never compromised.

Literature Review

Food is a crucial part of our lives that extends beyond just sustaining us. Food has a significant impact on behaviour, emotions, and social interactions [5]. It has recently become a major emphasis for apps that use multimedia and social media. Food computing is a relatively new topic that is gaining significant interest. It aims to do autonomous food analysis [29]. This is because there is now a significant amount of picture data available, artificial intelligence is evolving rapidly, and people are becoming increasingly aware of their dietary choices [20]. Food computing utilises advanced machine learning technologies, including deep learning, deep convolutional neural networks, and transfer learning, to enhance its performance [14]. These technologies are widely employed to tackle new issues and challenges in food-related domains, including food recognition, categorisation, detection, calorie estimation, food quality assessment, nutritional evaluation, and meal recommendation, among others. However, the food classification problem is especially challenging since food picture data exhibit certain traits, such as visual heterogeneity. We examined the most recent machine learning and deep learning technologies used for food classification, with a focus on data considerations, to provide an overview of the current state of the art in this field [19]. We gathered and examined over 100 publications on the application of machine learning and deep learning in food computing jobs.

Emerging technologies like computer vision and artificial intelligence (AI) are expected to make vast amounts of data more accessible for active training and create intelligent robots that can operate in real-time, as well as predictive models [21]. The computer vision and AI-driven food business refers to this trend of utilising vision and learning approaches to enhance the food sector. This evaluation helps us understand the most advanced AI and computer vision technologies that can help farmers with farming and food processing. This study examines several scenarios and use cases of machine learning, machine vision, and deep learning from a global viewpoint, emphasising sustainability [4]. It discusses how the AgTech industry is growing due to computer vision and AI, which could lead to more sustainable food production in the future [1]. This review also discusses some of the challenges and offers suggestions for utilising technology in real-time farming, as well as major global policies and investments [28]. Lastly, the study talks about how Fourth Industrial Revolution [4.0 IR] technology, like deep learning and computer vision robotics, could help make food production more sustainable.

A healthy diet and a balanced intake of essential nutrients are crucial components of a modern lifestyle [27]. Estimating the nutrient content of a meal is an important part of serious disorders like diabetes, obesity, and heart disease [15]. In recent years, there has been a growing interest in the creation and use of smartphone apps that promote healthy habits. The accurate, real-time calculation of the nutrients in meals eaten every day, whether automatically or semi-automatically, is viewed in the literature as a computer vision problem that utilises food photos captured with a user's smartphone [13]. In this document, we introduce the most advanced approaches for automatic food detection and estimating food volume, beginning with its foundation: food picture databases. This review study systematically organises the extracted information from the reviewed studies, facilitating a comprehensive evaluation of the methods and techniques employed for segmenting food images, classifying their content, and calculating food volume, while correlating the results with the characteristics of the utilised datasets [8]. Second, by objectively discussing the pros and cons of various methods and suggesting practical ways to address the cons, this review

can guide future research in the area of nutritional assessment systems [18].
A container terminal is an integral part of the logistics chain that facilitates the movement of containers between ships. For harbour automation to work effectively, it's essential to know the location of the vehicles that carry containers within the port [10]. This will help save money and time [22]. An active radio-frequency identification (RFID)- based real-time locating system (RTLS) is a good way to obtain location information because it is scalable, cost-effective, and energy-efficient. An RTLS typically determines the location of objects by measuring the time it takes for wireless signals to reach them. For accurate distance measurement, you need to be able to measure time and have guaranteed line-of-sight (LOS) communication [26]. However, in a container terminal setting, the performance of current technology can be significantly reduced by closely spaced impediments, such as trucks and containers.
There are also not many places in a terminal where readers may be mounted; therefore, there aren't enough readers to provide reliable communication. This research proposes an innovative and pragmatic solution to address non-line-of-sight (NLOS) RF propagation challenges in asset tracking systems for container ports [12]. In the suggested system, we have taken into account both practical ways from real-world unit experiments and theoretical methodologies [31]. The system attempts to minimise range estimations acquired in NLOS settings and to ascertain tag locations by utilising vehicles' range estimates and route data [25]. To test the proposed system, it was implemented in an actual container terminal in South Korea, and the experiments demonstrated its effectiveness.
Seaports are crucial players in global logistics and supply chains, as they handle a significant portion of the cargo that moves around the world. When the cold chain breaks down, and products are being moved and stored at ports, bacteria can develop quickly because the conditions of humidity, nutrition, temperature, and time are right [23]. The products also tend to lose their quality quickly [2]. In logistics, it is crucial to maintain the cold chain when transporting medicines, chemicals, and food. It's necessary to monitor and control temperature and humidity levels throughout the period between loading these containers in specific regions of ports, loading goods in open areas, or loading goods on roads and trains [16]. Because of this, it is crucial to closely monitor and oversee the system in port logistics management.
Every day, an incredible number of goods and commodities are sent and moved throughout the world using numerous types of transportation [30]. Due to its complexity, the marine industry faces challenges with trust, proof of ownership, lengthy documentation processes, and excessive data collection [9]. These problems manifest as delays in cargo processing and increased transportation costs. Most of the systems and technologies used today to manage shipping containers in unimodal and multimodal logistics lack qualities such as transparency, traceability, reliability, auditability, security, and trust. This article proposes a blockchain-based solution enabling users to monitor and track their container shipments in a decentralised, transparent, auditable, secure, and reliable manner [24]. We utilise the InterPlanetary File System (IPFS) to address the issue of insufficient storage space [3]. We create smart contracts and develop algorithms, along with all the necessary information, for their full implementation, testing, and validation in both unimodal and multimodal logistics [11]. We demonstrate that the proposed approach is both safe and cost-effective through security and cost evaluations. We also compare our proposed solution to existing ones to highlight its novelty [17].

Paper Description

There are still significant problems with food transportation systems today that make it harder for perishable items to be transported safely and efficiently [94]. Checking the temperature by hand is still a difficult and error-prone part of these systems since they depend on labour-intensive steps that are easy to mess up [69]. Not only does this manual method consume valuable time, but it also increases the likelihood of obtaining incorrect temperature readings, which could lead to spoilage and lower product quality. Additionally, the limitation of current systems to track only a few things exacerbates these problems [81]. Stakeholders often struggle to obtain real-time information about the location of shipping containers, which hinders effective supply chain management. If you don't maintain accurate and up-to-date records, you risk delays, lost shipments, and logistical problems.

Additionally, the poor handling of data exacerbates these problems, as outdated methods of data entry and processing hinder decision-making and hinder improvement. The results are unfavourable for temperature-sensitive items, such as fresh fruits and vegetables and dairy products, which require maintaining a specific temperature throughout transport to remain fresh [73]. If items aren't constantly checked, there's a higher chance that they will arrive at their destination in poor condition, which will harm both customer satisfaction and supplier reputation. Additionally, the lack of effective tracking systems raises security concerns, as shipping containers can be easily stolen from and accessed without permission [83]. Due to these challenges, we require innovative solutions that will automate temperature monitoring, display real-time location information, simplify data management, and enhance the efficiency and safety of food transportation systems.

The proposed effort seeks to revolutionise the domain of marine and food container transportation by incorporating advanced technology. Artificial intelligence (AI) will be at the heart of it all, utilising picture recognition to instantly identify and categorise different types of food [68]. The system will quickly and reliably identify the different food items in the container using deep learning models, such as YOLO (You Only Look Once). This rapid identification enables real-time temperature adjustments based on the AI's categorisation results [82]. A Proportional-Integral-Derivative (PID) controller will monitor the temperature within the container and make small adjustments to ensure that each type of food is stored at an optimal temperature [95]. This AI-powered temperature control not only reduces the risk of spoilage and quality loss during shipping, but it also ensures that the food remains fresh and of the highest quality.

GPS integration will enable real-time tracking of the container's location during transit, in addition to AI-based temperature control. GPS sensors inside the container will always send back information about its exact location [74]. This will provide logistics managers and other interested parties with up-to-date information on the container's location. This capacity to observe things in real-time makes the supply chain more efficient by enabling smarter decisions, such as optimising routes and making changes ahead of time to address unexpected delays (Table 1) [96].

For a computer to run any software, it requires specific hardware components or other software resources [80]. People typically utilise these system requirements as a guide rather than a strict rule. Most software has two sets of system requirements: minimal and recommended. As new versions of software are released, they require more processing power and resources. This means that system requirements tend to go up over time [75]. Analysts in the industry suggest that this trend has a greater impact on updates to existing computer systems than on new technologies [93].

Table 1. Pin Identification and Configuration.

No:	Pin Name	Description
		For DHT11 Sensor
1	VCC	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	NC	No Connection, and hence, it is not used
4	Ground	Connected to the ground of the circuit
		For the DHT11 Sensor module
1	VCC	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	Ground	Connected to the ground of the circuit

A relay is an electrical switch. There are input terminals for one or more control signals and terminals for operating contacts [79]. The switch can have any number of contacts, and they can be in various forms, such as generating contacts, breaking contacts, or combinations. When you wish to control a circuit with a low-power signal that is separate from the circuit you want to control, or when you want to control numerous circuits with one signal, you use relays. Relays were first used as signal repeaters in long-distance telegraph circuits [90]. They send the signal from one circuit to another to keep it fresh. Relays were widely used in early computers and telephone exchanges to execute logical tasks.

The Global Positioning System (GPS) consists of 31 satellites that orbit the Earth. They constantly transmit radio signals with their location and time, allowing us to always know where they are [72]. The breakout board works due to the NEO-6M GPS module produced by u-blox. It may be small, but it boasts numerous features. It can track up to 22 satellites on 50 channels and only needs 45mA of power. It operates effectively within a voltage range of 2.7V to 3.6V. One of the most remarkable features of this module is its power-saving mode. This lets the system use less power [85]. The module requires only 11mA of current while in power-saving mode [97]. You may find more information about the NEO-6M GPS Module in the NEO-6M Module datasheet.

A programming language is a group of functions that work together to get something done [84]. Most people are familiar with software that enables them to accomplish tasks on their computers. Embedded software, on the other hand, is often difficult to see and equally challenging to understand. There are strict rules governing the addition of hardware or software from other firms to embedded software. On the other hand, application software does not. When the device is constructed, the embedded software must have all the necessary drivers. These drivers are made to work with the specific hardware [67]. The chips and CPU that were selected are crucial to the software. Most embedded software engineers know how to study data sheets and schematics for parts to learn how to use communication systems and registers [89]. It is useful to be able to shift bits and switch between decimal, hexadecimal, and binary numbers.

People don't use web apps very often, even though they can transmit XML files and other output to a computer for display. There aren't normally any SQL databases or file systems with directories [88]. You need a cross-compiler that works on a computer and creates code that can be run on the device you want to run it on. You can utilise an in-circuit emulator, JTAG, or SWD to debug. A lot of the time, programmers can look at the complete source code for the kernel (OS). The amount of RAM and storage memory may vary significantly [98]. Some systems have 16 KB of Flash and 4 KB of RAM, and their CPUs run at 8 MHz. Other systems can work with current computers. [8] More work is done in C or embedded C++ than in C++ because of these space demands [76]. A small number of users utilise interpreted languages like BASIC (for example, Parallax Propeller can use compiled BASIC) and Java (for example, Java ME Embedded 8.3[9] is available for ARM Cortex-M4, Cortex-M7 microcontrollers, and older ARM11 Microcontrollers Used in Raspberry Pi and Intel Galileo Gen. 2).

MicroPython is a version of the Python 3 language specifically designed for microcontrollers, such as the 32-bit ARM-based BBC micro:bit and the 16-bit PIC microcontroller. It's quite crucial that processors can communicate with each other and with other sections of the computer. Besides direct memory addressing, I²C, SPI, serial ports, and USB are among the most commonly used protocols [70]. InterNiche Technologies and CMX devices are two companies that market closed-source communication protocols that are developed for use in embedded devices. These are the origins of open-source protocols like uIP and lwIP [78]. This program teaches you how to utilise regular variables to put structure inside structure in C. The "student_college_detail" structure is declared inside the "student_detail" structure in this application.

Both of these are structural factors. This step involves detecting and removing data items, variables, or features that are not valuable for the analysis or that may introduce noise [87]. What to Do When Values Are Missing: You can address missing numbers by either filling them in with rough estimates based on other data or eliminating them. This prevents bias and ensures that the analysis is conducted on all the data. Changing the way data is stored so that it may be examined [91]. This could involve converting categorical categories into numbers, scaling numbers, or applying mathematical operations to adjust the distribution of numbers [77]. Finding and dealing with outliers, which are data points that are considerably distinct from the rest of the data. Outliers can mess with machine learning models and statistical analysis. To minimise their impact, they can be removed or modified.

Normalising or standardising numerical features to make sure they all have the same range and scale [92]. This makes it easier to compare and comprehend different variables, and it also improves the performance of certain algorithms, such as those that utilise distance metrics. To gather more data or make a model function better, you can create new features or variables from old ones. Some methods for feature engineering include binning, polynomial features, and constructing interaction terms [86]. To avoid biasing models towards the majority class, ensure that the classes or categories in the dataset are evenly distributed. This is especially important when you're trying to classify objects. Keeping important information while discarding some of the dataset's features or variables [99]. Principal component analysis (PCA) and feature selection are two methods to reduce dimensionality, making models clearer to understand, less complicated to compute, and better at generalisation. Ensuring that different datasets or sources use the same data formats, units, and representations [71]. It's easier to compare and interpret data that is consistent. The primary purpose of cleaning and preparing data is to prepare it in a manner that reduces noise, bias, and errors, enabling data analysis and machine learning models to operate more effectively and reliably.

Data Splitting

When data is divided into two or more parts, this process is known as data splitting. In a two-part split, one component is used to test or evaluate the data, while the other part is utilised to train the model. One key feature of data science is separating data, especially when making models from it. Typically, the majority of the data is used to train the machine learning model. This smaller group provides the model with the necessary information to identify patterns and connections between the input features and the target variables. A portion of the dataset is set aside for validation, independent of the training data [102]. You can use this validation set to adjust the model's hyperparameters, such as the learning rate or the level of regularisation, and to monitor the model's performance during training. It helps determine how well the model performs on new data and prevents it from fitting too closely to the training data. The test set is a different part of the data than the training and validation sets. The test set is used to check how well the trained model works on data it hasn't seen before. It provides an unbiased evaluation of the model's effectiveness and helps you determine its performance in real-world applications. Cross-validation approaches extend beyond simply splitting the data into training and testing sets. They further break the data into several smaller groups (folds), then train and test the model on different combinations of these groups repeatedly. Cross-validation provides a more accurate assessment of a model's performance and helps determine its stability and generalizability. Data splitting helps address the bias-variance tradeoff by allowing the model to learn from one set of data (the training set) while being evaluated on other sets (the validation and test sets).

This helps identify and address issues with underfitting or overfitting. Data splitting facilitates the comparison of different models or algorithms by providing them with the same training, validation, and test sets. It allows you to compare different techniques fairly and consistently, which helps you choose the most suitable model to use. The data science team works to determine the appropriate weights and biases for an algorithm during model training, which is a crucial step in the data science development lifecycle [109]. This is done to minimise the loss function over the prediction range. During training, the model learns to identify patterns and relationships in the input data that correlate with the target variable or outcome. To achieve this, you need to adjust the model's parameters so that it can discern the underlying structure of the data. The trained model should not only perform well on the training data, but it should also be able to generalise effectively to data it hasn't seen before. The model learns to make predictions about new, previously unseen instances from the same underlying distribution by being trained on a diverse range of samples. The goal of model training is to enhance the model's performance metrics, which may include accuracy, precision, recall, or other relevant measures, depending on the specific task at hand. The goal is to reduce the number of mistakes made when predicting and improve the model's ability to make accurate predictions on new data. The model may learn to extract useful representations or features from the input data that are relevant to the prediction goal as it is being trained [117]. This process of learning features helps the model pick up on crucial traits of the input. To improve the model's performance, model training involves adjusting its parameters or hyperparameters.

To improve the model's performance, you may consider using methods such as gradient descent optimisation, regularisation, or learning rate scheduling. In other circumstances, model training may need to be performed regularly or in small increments to keep pace with changes in the data distribution. This is especially important in contexts that are constantly evolving, where the data is also constantly changing [107]. Training a model also helps you understand how the input features and the target variable are related, which can aid in understanding the processes or causes that affect the predictions. Training a model is often a process that repeats itself, with the model's performance being tested and improved over and over again. This method of doing things repeatedly allows performance and resilience to improve incrementally.

Model evaluation is the process of measuring how well an ML model works to determine the one that works best for the situation at hand. It is crucial to thoroughly test models to ensure they perform well and accurately before being put into production [116]. Model evaluation tells us how well the model works on data it hasn't seen before by measuring its accuracy, reliability, and consistency. This involves examining various performance metrics, such as accuracy, precision, recall, F1-score, and the area under the receiver operating characteristic curve (AUC-ROC). The main purpose of model evaluation is to assess how well the model can apply what it has learned to new examples that come from the same distribution as the training data but that it has never seen before [101]. A good model should do well on both the training and test data, which means it has learnt useful patterns instead of just memorising the training samples. Model evaluation helps you determine whether the model is too good or too bad at fitting the training data. When the model learns to pick up noise or patterns that are irrelevant to the training data, it overfits and performs poorly on new data [108]. Underfitting occurs when the model is too simplistic to capture the patterns in the data, resulting in poor performance. Model evaluation facilitates the comparison of different models or algorithms trained on the same dataset. By employing standardised assessment metrics to compare and evaluate the performance of different models, stakeholders can choose which model to use or improve.

Model evaluation helps identify the most effective model from a pool of options. Stakeholders can select the most suitable model for their application by examining various performance metrics and considering factors such as computational efficiency, interpretability, and domain-specific requirements [106]. Model evaluation provides information on areas of the model's performance that could be improved. Based on the evaluation outcomes, stakeholders can make adjustments to the model over time by modifying hyperparameters, feature engineering techniques, or training algorithms. Risk Assessment: Model evaluation helps us understand what could happen if we apply the model in real-life situations, including when we need to make important decisions or assess risk. This involves testing how well the model performs in diverse situations and identifying any potential sources of bias or uncertainty [115]. Joseph Redmond and others introduced YOLO in 2015. It was suggested as a way to fix the issues that the object recognition models were having at the time. At the time, Fast R-CNN was one of the most effective models, but it had certain limitations. For example, it can't be utilised in real time because it takes 2–3 seconds to forecast a picture. In YOLO, on the other hand, we only need to glance at the network once. To create the final predictions, the network only needs to be sent through once.

It takes a picture as input, resizes it to 448x448 while maintaining the aspect ratio, and adds padding. The CNN network gets this picture next. There are 24 convolution layers and four max-pooling layers in this model. Then there are two completely connected layers. We utilise 1x1 convolution to reduce the number of layers (Channels), and then we use 3x3 convolution. The last layer of YOLOv1 predicts a cuboidal output. To do this, you take the output of the last fully linked layer, which is (1, 1470), and change its shape to (7, 7, 30). The complete architecture employs Leaky ReLU as its activation function, except for the last layer, which uses a linear activation function. You may find the definition of Leaky ReLU here. Batch normalisation also helps make the model more stable. The dropout technique is another way to stop overfitting [110]. When trained on VOC between 2007 and 2012, the simple YOLO has a MAP (mean average precision) of 63.4%. The Fast YOLO, which is approximately three times faster in generating results, has a MAP of 52%. The best Fast R-CNN model achieved 71% MAP, whereas the R-CNN model achieved 66% MAP, which is lower than this. However, it is more accurate than other real-time detectors, such as DPMv5 (33% MAP). YOLO is designed for finding objects in pictures and videos in real-time, making it ideal for applications that require fast processing, such as self-driving cars, surveillance, and robotics [100]. YOLO performs object detection in a single pass through the neural network, unlike typical object detection algorithms that require sliding windows or region proposal techniques.

This makes the process faster and more efficient. YOLO is quite effective at detecting items, especially in environments with numerous objects and overlapping instances. It works better since it can find things at varied sizes and aspect ratios. YOLO is a single framework for finding, locating, and classifying objects [105]. YOLO makes more accurate and consistent predictions than systems that perform these tasks independently by optimising them all at once in a single neural network design. YOLO proposes the concept of an "objective" score, which indicates the likelihood that a specific bounding box contains an object of interest. This enables YOLO to distinguish between important objects and background noise, making it easier to locate things and reducing false positives. Users can train the YOLO model on their own datasets and customise it to fit their specific needs in particular domains or applications. Because it can perform various tasks, YOLO is suitable for a wide range of object detection applications across different businesses and scenarios. YOLO is trained from start to finish, which means that the whole network is optimised for the purpose of finding objects. This makes training easier and faster than systems that have separate training steps for detection, localisation, and classification. Researchers, developers, and practitioners worldwide can utilise YOLO because it is available as an open-source implementation [114]. Pre-trained models, code repositories, and community support make it easier to experiment, do research, and build applications. YOLO is quite accurate and works in real-time, yet it doesn't require as much processing power as other object detection algorithms. This makes it good for use on devices with limited resources, such as embedded systems, mobile devices, and drones.

YOLO has trouble locating small objects or objects with complex shapes precisely where they are. This can make bounding box predictions less accurate, especially for objects that are hard to see or have complicated shapes. YOLO might struggle to detect small objects in pictures because it only scans the image once and has a fixed grid size. This is because the grid cells may not display the objects clearly enough. This restriction can impact the algorithm's performance in situations where there are numerous small objects. YOLO splits the input image into cells and then predicts bounding boxes for each cell [111]. Because of this, it may struggle with items that have very long or thin shapes, or those with irregular shapes, which could result in incorrect bounding box predictions. YOLO looks at the whole picture at once and doesn't consider factors such as context or the relationships between objects in the scene. Not being able to understand the context can occasionally lead to wrong object detections, especially in settings with a lot of stuff or when objects are very close together.

The Unified Modelling Language (UML) is a standardised language used for design specifications in software engineering. Recommender systems, on the other hand, are machine learning systems that don't follow a set technique and are built based on the needs and context of the application. Models typically help illustrate each part of the system, enabling people to better understand it. Additionally, UML features object-oriented properties that are well-suited for this case [104]. This paradigm enables the design of any music recommender system using any algorithm, as it abstracts the essential functionality while specifying the high-level functional components. The main graphical symbols on the diagram indicate the type of diagram it is. A class diagram is an example of a diagram where the main symbols in the contents section are classes [113]. A use case diagram is a picture that illustrates actors and use cases. A sequence diagram illustrates the sequence of messages sent and received between lifelines. UML standard does not prohibit the amalgamation of various diagram types, such as integrating structural and behavioural components to illustrate a state machine within a use case. So, the lines between the different types of diagrams aren't always clear. Some UML tools, on the other hand, limit the number of graphical elements that can be utilised when working on certain types of diagrams (Figure 1).

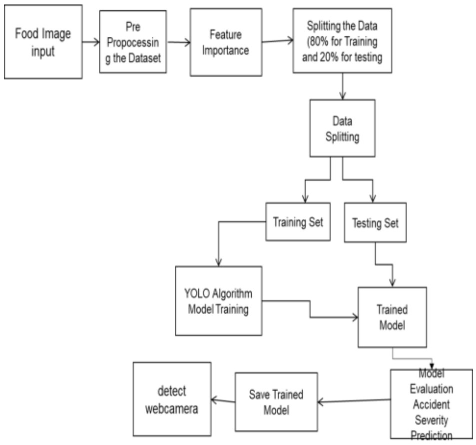

Figure 1. System Architecture Diagram.

A block diagram is a simple way to visually represent a system, process, or idea. It uses geometric shapes connected by lines or arrows to illustrate how the system's components work together and interact. The most important parts of a block diagram are the rectangular or square blocks that represent specific parts or entities within the system, accompanied by labels that indicate their functions. Lines or arrows connect these blocks to show how information, signals, or interactions between parts move. The direction of the flow shows the order in which things are processed. Inputs and outputs are shown as the system's entry and exit points, respectively. Feedback loops are occasionally used to illustrate how outputs can influence subsequent inputs [112]. People commonly add notes and labels to give more information or context about the parts and relationships shown in the diagram [103]. Block diagrams are excellent visual tools for understanding, discussing, and analysing complex systems in various fields. They help make things clearer, more organised, and give you a better idea of how the system works and what it does.

Conclusion

We utilised a variety of technologies to create this smart and efficient food container. Deep learning and YOLO work together to enable computers to recognise and categorise different types of food by analysing images. Rapidly identifying what's in the container makes it easier to keep track of inventory and ensure food safety. A Proportional-Integral-Derivative (PID) controller and a Peltier device work together to maintain a very stable temperature in the container. This is crucial for maintaining the freshness and quality of the food you store. The PID controller continuously adjusts the temperature based on the chosen setpoint, making it ideal for a wide range of food types. Improvements to the smart food container system include various enhancements to make it more useful and durable. The system can recognise and sort food items more accurately by improving deep learning algorithms through training on a wide range of datasets. Machine learning algorithms enable the PID controller to intelligently control the temperature by predicting and adjusting for changes based on external factors, such as weather and transportation. This ensures that the best storage conditions are always maintained. Users can easily monitor and operate their devices from afar thanks to integration with IoT devices. They can adjust settings and receive real-time notifications for temperature changes through a smartphone app. To make the system more energy-efficient, consider incorporating energy-efficient Peltier devices and renewable energy sources, such as solar panels. This will use less electricity and make the system more sustainable.

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