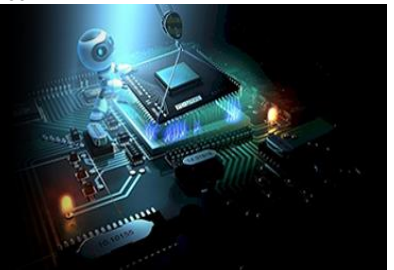


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Estimating the remaining shelf-life using CNN SLEM of fresh fruit and vegetables while transportation

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Abstract

For scheduling and quality cost assessment, it is necessary to anticipate the remaining shelf life of fresh vegetables and fruits (FFVs) during transit. The IoT allows for the real-time processing of measured environmental factors. The translation of environmental observations into dynamic RSL estimations, however, requires a verified, real-time computing approach. There are a lot of qualitative, intrusive, and static generic RSL models out there for FFVs. Under unpredictable and ever-changing logistical circumstances, this research develops a general RSL model for FFVs. The model's foundation is an approximation of the product's anticipated respiration rate, which is then used to estimate the present general decay rate. This estimate is then integrated with regard to time. You won't need to do accelerated shelf-life tests on samples before using it, and it won't damage or invasively alter the sample in any way. Furthermore, a surrogate model was suggested to enable the model's implementation in rapid, real-time applications for 'Edge IoT,' since the initial design is computationally demanding. Using three fresh products—strawberries, apricots, and spinach—in a residential refrigerator, the model was experimentally validated. The original model had a maximum variation in prediction error of 1.3 days, whereas the surrogate model had a deviation of 2.95 days. However, even at the 0.01% significance level, neither the original nor the surrogate models' predictions were statistically different from the samples' actual shelf life.

Keywords: Shelf Life Estimation, Fresh Fruits and Vegetables (FFVs), Internet of Things (IoT)

Introduction

A major problem in the food supply chain is the loss of fresh produce. Cold chain hazards, including transportation delays or breakdowns, temperature misuse, and cross-contamination, reduce food merchants' profit margins, according to Srivastava *et al.* A third of the world's consumable food goes to waste every year, which is a major problem for society as a whole.

The fact that fresh items' degradation processes speed up at temperatures higher than their authorized storage temperatures and that temperature variations is unavoidable throughout the supply chain are well-known. Consequently, at whatever stage of the supply chain, the RSL of the product must be estimated taking temperature variations into consideration. Thanks to the Internet of Things (IoT), we can now track environmental factors like temperature and humidity as we travel and send the data to the cloud in real-time. This allows us to optimize fleet routing in real-time and keep an eye on quality. Using an appropriate computational approach, the RSL of the product may be calculated in real-time. Thus, the effectiveness of such sophisticated decision-making systems hinges on a mathematical model that, given real-time measurements of environmental data, produces the RSL for a specific product. We know how to use simple and trustworthy mathematical models to predict how long closed dried out, heavily processed, and chemically preserved foods will last. However, the prediction of the shelf life of biologically active, unsealed, and unprocessed foods—including fresh produce, dairy, seafood, and meat—when transported in a jumbled logistical mess is still a contentious and unsolved issue. This is not because there aren't sophisticated mathematical models that account for the primary variables that cause these items to spoil. Actually, existing theoretical models aren't practical because of all the constraints, how particular they are to a certain food species, and how damaging and/or time-consuming the testing are. This study introduces a novel computational approach to

predicting the remainder of the shelf-life of FFVs under unanticipated logistic circumstances. The technique is real-time, non-destructive, and highly generalizable. Since the approach is initially set up using simply the product's well-documented and readily available thermos physical qualities, it eliminates the requirement for characterization pre-tests and makes use of real-time temperature and humidity data. In addition, the suggested model has been tested with three different FFVs in different packing scenarios with different temperature disruption frequencies.

Related work

"The spread of hazards and how they affect fresh food retail performance"

Applying interpretative structural modeling (ISM), this article aims to conduct a structural study of possible hazards and performance metrics in the fresh food retail supply chain. General framework/approach/design: The following stages of the food retailing supply chain were considered: sourcing and logistics external to the shops; storage inside the stores; and the contact with customers. The experts in the field provided input on how to identify and comprehend the interdependencies across these levels. A hierarchical structure is used to produce subsystems of interdependent parts that may be used to get theoretical and practice-relevant insights from interdependencies across hazards and their influence on performance indicators.

What we found: Clustering the risks as well as efficiency metrics based on their driving and dependent powers was done using the ISM technique. The most powerful factor, the need for increased emphasis and targeted mitigation measures, is shown by the lowest level of the hierarchy, which is the government's inability or unwillingness to adequately regulate the issue. Threats with medium driver and reliance powers include intractable materials, transportation delays or breakdowns, improper handling of temperature, and cross-contamination during storage and transit.

Constraints and implications of the research: It is not possible to generalize the results since the technique is focused on food sales distribution networks in the Indian environment. Academics and professionals were chosen based on their availability and how convenient it was for them.

Practical implications: It provides managers with a tool to prioritize risks and performance evaluates based on their influence on others and a better understanding of which measures are most driven and which are most influenced in the fresh food retail industry. Strategically, managers may utilize this data to figure out which performance metrics are most important and how to manage the trade-offs between them. The results and their practicality have been confirmed by professionals and working managers in the food retail supply chain. Relevance and uniqueness: This study describes how risks spread across food retail supply networks and is one of the first to connect supply chain risks to performance. Addressing certain research gaps, it adds to theory and gives practitioners useful insights for management.

"Brief overview and bibliometric study of the role of the internet and technology in ensuring the safety of food,"

The purpose of this research was to review the existing literature on optimizing food fermentation processes via the

use of the Internet of Things (IoT). In this study, we used bibliometric research to subjectively evaluate 44 publications published from 2013 and 2022. The bibliometric analysis centered on research trends, publications by author, publications per nation, and a research center that relied on co-occurrence keywords. Uptake has been sluggish and in its infancy during the last eight years, despite the fact that existing literature in this field demonstrates how IoT may be used to enhance the fermentation process. In analyzing the co-occurrence of keywords in the scholarly articles, five clusters were identified. These clusters include: (i) using the Internet of Things (IoT) for fermentation process forecasting and quality control; (ii) automating and remotely monitoring the production process for process control; (iii) tracking temperature in real-time during fermentation; (iv) using WLAN to digitally store parameters during fermentation; and (v) using middleware to the analyzing characteristics of agricultural produce. These areas of convergence demonstrated the potential of the Internet of Things to enhance the fermentation process of food. Internet of Things (IoT) technologies are becoming more important in the food fermentation process. This research aimed to review the literature and identify the best examples of IoT technologies for strategy development in food fermentation and forecasting of fermented food items. Useful results Manufacturers may enhance their regulatory processes and product quality with the use of Internet of Things technology. This allows them to track metrics like temperatures, carbon dioxide, humidity, the viscosity and more throughout the feeding process in real-time. This real-time data may also be used by food makers to ensure food safety. It is possible to anticipate the fermentation process's phases and identify potential obstacles with the help of modern smart sensors and predictive analytics tools hosted on the cloud.

"A summary of the literature on vehicle routing in the logistics of cold food supply chains"

Purpose To ensure that temperature-sensitive goods remain undamaged and unspoiled throughout transportation, cold the supply chain (CSC) methods of distribution are essential. In addition to leaving a large carbon imprint, CSC is considered to be an energy hog. Therefore, in order to increase safety and decrease profit losses, CSC necessitates a stringent control and monitoring management system throughout transit and storage. This study summarises current research on food CSC product distribution via a literature analysis and identifies potential future research directions in the domains of modeling and decision-making. Approach, methodology, and design This report provides an analysis of 65 recent papers that discuss CSC in relation to goods that are about to expire. The first search yielded 214 articles after using a number of pertinent keywords. Relevance to food truck routing modeling and article quality were the primary criteria for article screening. Cost components, modeling framework, and solution technique were used to classify and evaluate the chosen articles. Lastly, suggestions for further study are made. Findings There are a number of areas in the CSC logistics literature that need more investigation, as highlighted by the study. To begin, there is a need for more study into dynamic vehicle modeling and routing that takes product quality and environmental implications into account, according to the

evaluation. Second, when it comes to quality deterioration models, academics aren't in agreement on how to determine how fresh cold food is after transportation. Consequently, it is necessary to look at key factors and quality modeling. Third, constructing heuristics and Metaheuristics to solve these models is necessary because of the intricacy of the problems. Lastly, multi-compartment multi-temperature routing modeling is required, expanding the single-product, single-compartment CSC. Value and originality The paper pointed some potential avenues for further investigation into decision-making and CSC distribution modeling. Practitioners, food authorities, and academics may make better, more timely judgments to decrease food waste and increase the quality of transported food by using modified models that represent real-world applications.

"Concerns regarding long-term storage of perishable foods in cold environments"

There has been a recent uptick in both academic and practical interest in the topic regarding food cold chain management. We discuss cold chain solutions that prioritize food safety and quality, as well as a study of temperature misuse in food cold networks that operate in various nations. Our main findings are as follows: 1) most research focused on controlling temperatures in chilled food products; 2) most reports of temperature abuse are from developed countries, while developing countries' cold chains are mostly unknown; 3) new temperature monitoring technology has a significant impact on food cold chains, but its implementation needs more study to produce accurate data; and 4) improved temperature leadership in food cold chains could lead to less food waste. On top of that, we looked at a potential new avenue for study into food cold chains in the future.

Methodology

A procedure to put this agricultural product tracing project into action, we used the Ethereum blockchain in conjunction

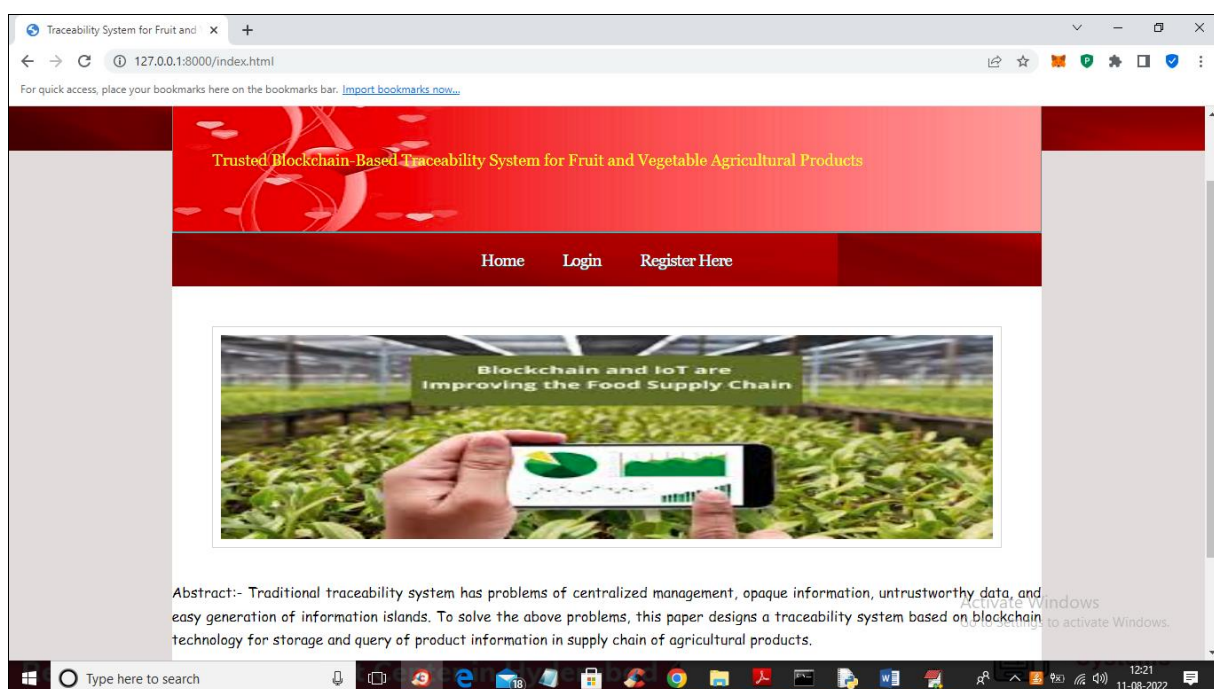
with the Truffle environment. In order to save or retrieve data on the blockchain, we had to create SOLIDITY (Smart Contract) code that has the necessary functionality. Below is the Solidity code that we have built to accomplish this project.

1. We have built methods for saving and retrieving USERS and Product Tracing data in the aforementioned Solidity code, which is also known as a smart contract. The next step is to implement the aforementioned contract on Ethereum using the steps outlined below.
2. Obtain the screen shown below by navigating to the "hello-eth/node modules/.bin" folder and executing the "runBlockchain.bat" file by double-clicking on it.
3. Thirdly, the blockchain has generated some initial accounts and private keys; to deploy the contract, just type "truffle migrate" into the command bar and hit the enter key; the next screen will provide the results.
4. The 'Agricultural' contract has been deployed and its address has been obtained; to save and retrieve tracking information, we need to provide this address in the Python application. It can be seen in the upper screen in white text. You can see the Python code that I used to access the blockchain contract at the address shown above in the screen capture below.
5. To learn how to use a Python application to contact a Blockchain contract in order to save and retrieve data, see the notes in red on the previous screen.

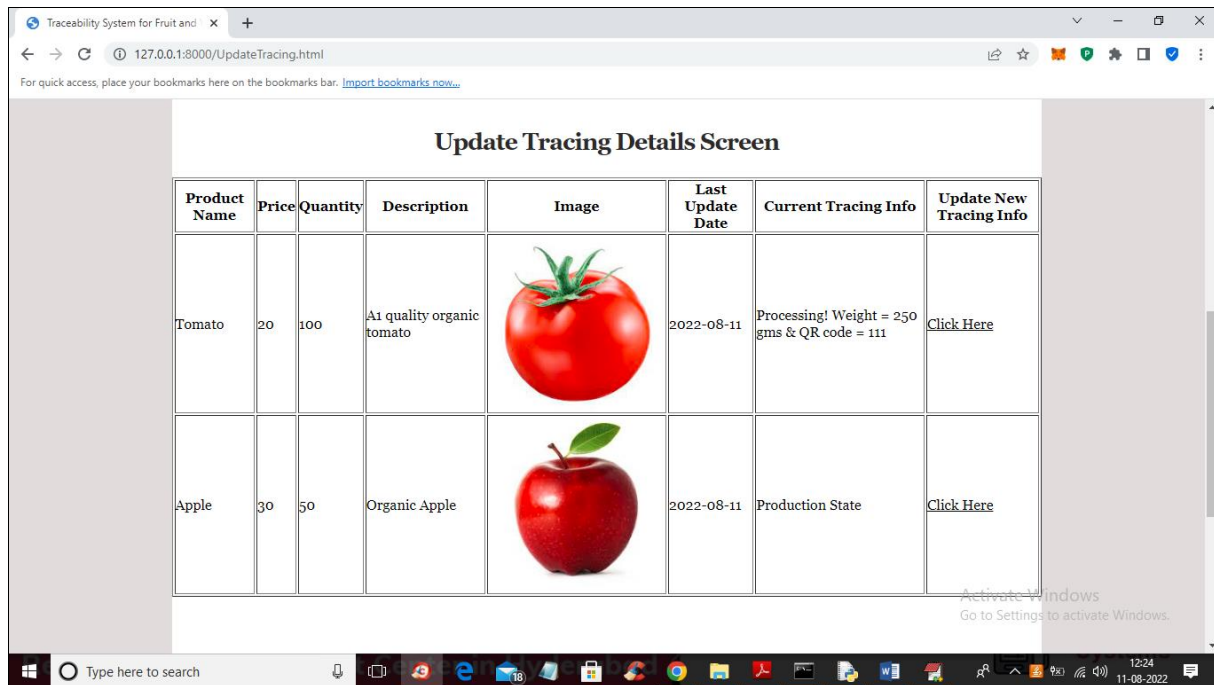
We have created two modules, Admin and User, to carry out this project. The 'admin' username and password allow the administrator to access the program. The administrator may update tracing information and add product data after logging in.

Users may get up-to-date product tracking information when they register and log in.

Results and Discussion

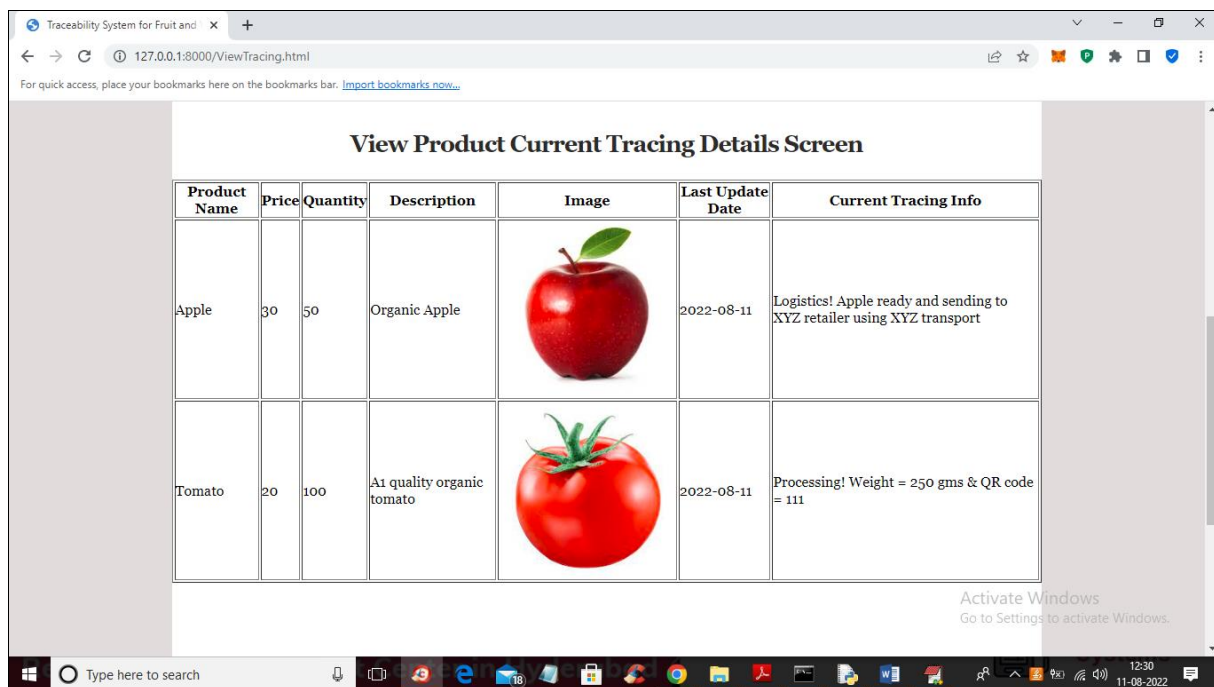


In above result click on 'Login' link and login as admin.



In above result admin can view all product details and to update tracing details from current state, admin will click on

‘Click Here’ link to get below screen.



In above result user can view all product details and in last column he can see current tracing data of each product

Conclusion

This work introduced a MATLAB-based white-box Shelf-Life Estimation Model (SLEM) that can estimate the RSL of a fresh food value (FFV) in real time based on any historical data of ambient temperature. Experimental validation of the proposed SLEM was carried out for three perishable goods in both sealed and unsealed packaging, subjected to dynamic temperature profiles. With a margin of error of 0.04 to 1.2 days, the model worked well with apricots and strawberries that weren't sealed. When it came to strawberries, a prime example of a non-climacteric fruit, the

model worked well. While the suggested surrogate approach (Nd) for quickly calculating pulp temperature in real-time applications worked well for apricots and strawberries, it failed miserably when used to sealed and bunched spinach. The SLEM produced statistically valid predictions even when assumptions were simplified. This lends credence to the idea that respiration rate, in conjunction with temperature, time, and local CO₂ concentration, is the most important factor in predicting decay, even when controlling for microbiology action, humidity levels, and exogenous ethylene. The substitute model is not a good choice for sealed fresh items or protracted trials if the end user is not willing to tolerate forecast errors greater than 2 days, even if both the initial and substitute models have solid statistical

backing. Despite the focus on the transportation context, the model's critical inputs remain constant regardless of the product's state of motion or rest. Souvenir shops and showrooms may also use it for real-time product pricing and stock value. Potentially related to this is the goal of minimizing the expense of poor quality in vehicle routing challenges. To sum up, we think this approach might be a great answer to the issues of last-mile routing optimization and quality monitoring. Because it just requires a thermostat and humidity sensor, it is inexpensive, non-invasive, and doesn't damage the target area. Some potential upgrades for future work could increase versatility. For example, it could account for the porousness of various plastic bags, monitor O₂ levels to better predict when anoxia will set in, and account for the interaction impacts between products that generate and those that are sensitive to ethylene.

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