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REMAINING SHELF-LIFE ESTIMATION OF FRESH FRUITS AND VEGETABLES DURING TRANSPORTATION:

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ABSTRACT:

The calculation of quality cost and planning during transportation depend heavily on the forecast for Fresh Fruits and Vegetables' (FFVs) Remaining Shelf-Life (RSL). Measured environmental variables may be analysed in real-time thanks to the Internet of Things (IoT). To convert environmental observations into dynamic RSL estimations, a real-time computing approach that has been tested is necessary. The majority of general RSL models that are currently in use for FFVs are either static, intrusive, or qualitative. For FFVs operating in unpredictable and dynamic logistical environments, this work develops a general RSL model. The estimation of the present general decay rate, which is integrated with regard to time, is the basis of the model. This is based on the predicted respiration rate that produces the product. Before deployment, accelerated shelf-life trials are not necessary for its non-invasive and non-destructive implementation. To enable the model to be used in quick, real-time applications for "Edge IoT," a surrogate model was also suggested since the initial design is rather computationally demanding. The surrogate model produced a prediction error maximum deviation of 2.95 days, whereas the original model produced a maximum deviation of 1.3 days when three fresh goods (strawberries, apricots, and spinach) were used in an experimental validation of the model in a residential refrigerator. Still, even below the 0.01 significance level, the predictions generated by either the surrogate or original models remained statistically sound and did not deviate substantially from the observed shelf life of the samples.

INTRODUCTION

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Fresh fruit and vegetable (FFV) waste is a major problem for the food supply chain businesses. Food merchants suffer profit margin losses as a result of cold chain hazards such cross-contamination, temperature misuse, and transit delays and breakdowns, according to Srivastava et al. Over a third of the total edible food consumed by humans is wasted yearly, which causes food losses that are also a cost on society. The supply chain will inevitably experience temperature variations, and when it comes to fresh items, degradation processes are known to speed up at temperatures higher than those advised for storage. The product's RSL must thus be estimated at each stage of the chain while taking temperature variations into consideration. IoT enables real-time data transfer to the cloud for quality control and fleet routing optimisation, allowing for the assessment of environmental factors like temperature and humidity while in route. Using an appropriate computational technique, the product's RSL may be calculated in real time. For such sophisticated decision systems to be successful, an equation that takes the observed environmental data and produces the RSL for a specific product in immediate form is thus essential. It is widely known and confirmed that straightforward and trustworthy mathematical models may be used to predict the shelf life of foods that have been sealed, dried, heavily processed, and chemically preserved. However, estimating the shelf-life of unsealed, raw, and biologically active goods (such fresh produce, dairy products, seafood, and meat) that are sent in bulk alongside other fresh food varieties under uncertain logistical circumstances continues to be a highly contentious and unsolvable issue. It is not for lack of intricate mathematical models accounting for the primary elements responsible for food deterioration. On the contrary, the many drawbacks, high species specificity for a food source, and need for invasive experiments and/or laborious preliminary testing make the existing theoretical models untenable in real life. In order to anticipate the remaining shelf-life for FFVs under unforeseen logistical situations, we provide a novel, real-time, non-destructive, and highly generalizable computational technique in this study. The approach makes advantage of real-time humidity and temperature readings, and most importantly, it eliminates the requirement for pre-test characterisation by

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starting with simply the product's readily available and well-documented thermophysical parameters. Additionally, three different FFV types were used to evaluate the suggested model under varied packing scenarios and temperature disruption frequencies.

RELATED WORK

Spread of hazards and how they affect fresh food retail performance

Using interpretative structural modelling (ISM), this research aims to provide a structural analysis of possible supply chain hazards and performance indicators in fresh food retail. Approach, methodology, and design: In order to identify and comprehend the interdependencies among the risks associated with the food retail supply chain at various levels (purchasing and logistics beyond the retail shops; storage and customer interaction at the stores), input was gathered from industry experts. In order to extract subsystems of interdependent components and relevant insights both theory and practice, interdependencies among hazards and their influence on performance metrics are arranged into a hierarchy. Conclusions: The risks and success metrics were grouped based on their reliance and driving power using the ISM technique. Government rules that are changed or are inadequate fall to the bottom of the hierarchy, indicating that they have the most driving force. As such, they need more attention and targeted mitigating measures. Hazards involving medium driver and reliance powers include those that are not traceable, transport delays or breakdowns, temperature abuse, and cross-contamination during storage and transit.

Research constraints and implications: The technique restricts the generalizability of the results since it focuses on food sales distribution networks in the Indian environment. Based on availability and convenience, the specialists and academics were chosen.

Practical implications: It provides managers with an improved awareness of hazards and performance metrics in fresh food retail that have the greatest impact by other people (dependent performance metrics) and those that are driven by others (driving performance metrics). It also provides managers with a tool to prioritise these

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metrics. For managers, this kind such information is crucial since it helps them decide which performance metrics to focus on controlling the trade-offs between them. Professionals with experience managing foods retail supply chains as well as specialists have confirmed the results and practical relevance. Uniqueness and worth: This study is maybe the first to describe how risks spread across food retail supply networks and to establish a connection between supply chain risks and performance. It addresses some research gaps and offers practitioners pertinent management insights, which advances theory.

Internet of Things and food safety: A survey of the literature and bibliometric evaluation

This study looked at the body of research on using the Internet of Things (IoT) to enhance food fermentation. This study evaluated 44 publications published between 2013 and 2022 using bibliometric analysis and a subjective inspection approach. The research centre based on co-occurrence keywords, research patterns, publications by author, and publications per nation were the main foci of the bibliometric analysis. Although there are publications in this field that demonstrate how IoT may be used to optimise the fermentation process, adoption of this technology has been sluggish and in its infancy over the previous eight years. Through the use of co-occurring keywords, five (5) clusters were identified from the scholarly articles: (i) using IoT to forecast the fermentation process in order to achieve efficient quality control; (ii) remotely tracking and automating the manufacturing process in order to achieve efficient procedure control; (iii) monitoring temperature in real-time during the fermentation process; (iv) using WLAN to digitally store parameters throughout the fermentation process; and (v) applying middleware in the fermentation properties. These cluster sections demonstrated how the food fermentation procedure may be optimised using IoT. Considering the increasing popularity and interest in IoT technologies for food fermentation, this research reviewed the literature to identify IoT technologies that may be used to build food fermentation strategies and predictably analyse fermented food items. Real-world uses By monitoring food fermentation process factors including temperature, carbon

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dioxide, humidity, viscosity, and so forth in real-time, producers may use IoT technology to optimise their regulatory processes and product quality. For food safety, food makers may also receive and use this real-time data. Advanced smart sensors and cloud-based predictive analytics systems have the ability to forecast fermentation phases and perhaps identify obstacles throughout the process.

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

Goal Systems for the cold supply chain (CSC) transmission are essential for maintaining the freshness and integrity of goods that are temperature-sensitive throughout transportation. Additionally, CSC is renowned for having a large energy footprint and emissions. To increase safety and lower profit losses, CSC needs stringent control and monitoring management systems throughout storage and transit. This study identifies potential topics for further modelling and decision-making research after conducting a thorough evaluation of existing literature on the transportation of food CSC items. Approach, Design, and Methodology The study examines the content of 65 current publications on perishable foods and CSC. The first search produced an assortment of 214 articles and included some pertinent keywords. The relevance of the articles' content to food vehicle routing modelling and quality was taken into consideration while screening them. Based on the cost components, modelling framework, and solution strategy, a selection of papers were categorised and examined. Lastly, suggestions for more study are made. Conclusions The evaluation of the literature on CSC logistics revealed a number of research gaps that call for further, targeted investigation. Research on dynamic vehicle modelling and routing that takes into account the quality of the goods and the effects on the environment is still lacking, according to the study. Regarding the quality deterioration models that are used to evaluate the freshness or transported cold food, researchers are divided, to start with. Consequently, a study of essential factors and quality modelling is necessary. Third, heuristics and metaheuristics must be developed in order to solve such models because of the intricacy of the issue. Ultimately, multi-compartment multi-temperature routing modelling requires an extension of the single product single

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compartment CSC. Originality and worth the study suggested potential directions for further investigation into CSC distribution modelling and decision-making. Redesigned models that take into account practical uses will assist researchers, food authorities, and practitioners in making prompt and more informed choices that will decrease food waste and enhance the freshness of food that is carried.

Abuse of chilled food in terms of timing and temperature

The scholarly literature and practical applications are increasingly focusing on the management of food-related cold chains. In this article, we examine temperature manipulation within food cold chains operating in various nations, along with cold chain remedies that prioritise food safety and quality. Our main conclusions are as follows: 1) the study focused primarily on temperature management within chilled food products; meat, dairy, fish, fruit, as well as vegetable products were the most researched food categories; 2) the majority of temperature abuse reports come from developed countries' cold chains, while little is known regarding the situation in less developed nations; 3) recent advancements in temperature monitoring technology significantly improve the food cold chain, but more research is needed to produce relevant data; and 4) food wasted may be decreased with improved temperature management of food cold chains. Furthermore, we also looked at a fresh avenue for food cold chain studies going forward.

METHODOLOGY

To implement this project, we have designed 2 modules called Admin and User.

Admin: Admin can login to application using username and password as ‘admin’. After login admin can add product details and then update tracing information.

User: User can sign up and login and then can view current tracing information of products

RESULT AND DISCUSSION

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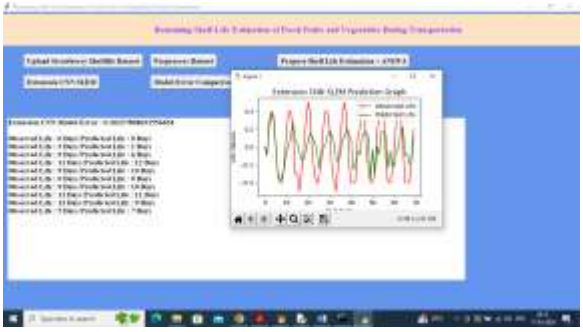
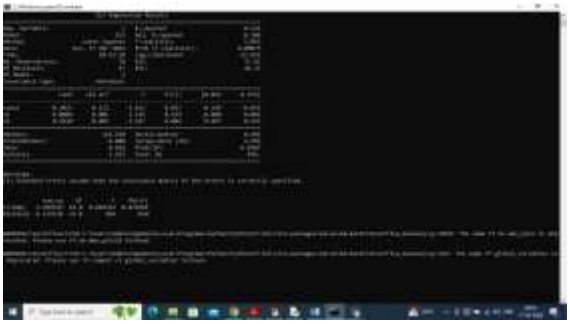
In above screen click on ‘Upload Strawberry Shelf-Life Dataset’ button to upload dataset and get below output



In above screen extension CNN model got 0.26% error which is lesser than propose algorithm and can see original and predicted shelf life and in graph also can see green and red line overlapping closely. Now click on ‘Model Error Comparison Graph’ button to get below comparison



In above screen we can see ANOVA model summary which contains R2 square error and other metrics.

CONCLUSION

In this work, a white-box Longevity Estimation Model (SLEM) built in MATLAB was provided. It estimates an FFV's RSL in real time using any historical ambient temperature data. Three fresh items, both sealed and unsealed, were tested experimentally under dynamic temperatures to confirm the suggested SLEM. Regarding open apricots and strawberries, the model did a good job; the inaccuracy varied from 0.04 to 1.2 days. When it came to strawberries, a prime example of a non-climacteric fruit, the model performed remarkably well. When it came to strawberries and apricots, a surrogate approach called Quds was suggested as a quick and accurate way to determine the pulp temperature. However, it did not perform well when it came to bunched and sealed

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spinach. Even with simplified assumptions, the SLEM was still able to produce statistically significant predictions, supporting the idea that the main predictors of decay—aside from the impacts of microbiology activity, relative humidity, as well as exogenous ethylene—are the respiration rate as well as its interactions with temperature, time, and local CO2 concentration. For sealed fresh items or long-term trials, the surrogate model should be avoided, even when the findings of both the original or surrogate models are statistically sound, if the end user finds prediction errors longer than two days intolerable. Despite being specifically focused on the transportation environment, every important input into the model is unaffected by the product's motion or stillness. Therefore, it may also be used for inventory valuation and dynamic product pricing in cold shops and showrooms. Automobile routing issues provide another possible use, where minimising the expense of subpar performance is the goal. To sum up, this model seems to be a viable approach to address issues related to last-mile route optimisation and quality monitoring. Given that it just needs a thermostat and humidity sensor, it is non-invasive, non-destructive, and reasonably priced. Upgrading the versatility of the work in the future may involve adding features like tracking O2 levels in order to anticipate the first signs of anoxia, taking into account the permeability of various plastic bag types, and examining the interactions between products that generate and sensitive to ethylene.

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