# Decay Robot: A robot that detects the lifespan of fruits or vegetables in or out of Warehouses


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## I. Introduction (*Heading 1*)

Decay Robot is an innovative device designed to detect the lifespan of fruits and vegetables, both inside and outside of warehouses. The robot uses advanced sensors and machine learning algorithms to analyze various factors such as temperature, humidity, and light exposure to determine the level of decay of the product.

The Decay Robot can help farmers, distributors, and retailers to reduce waste and improve the quality of their products. By accurately detecting the lifespan of fruits and vegetables, the robot can alert users to potential spoilage, allowing them to take appropriate action to prevent food waste. This can help reduce costs and increase profits for businesses that deal with perishable goods.

Additionally, the Decay Robot can help consumers make more informed purchasing decisions by providing accurate information about the freshness and quality of the products they are buying. This can help reduce food waste at the consumer level and promote healthier eating habits.

Overall, the Decay Robot has the potential to revolutionize the way we manage perishable goods and reduce food waste, making it an exciting development in the field of food technology.

## II. Background and Motivation

Li et al [1], represented and analyzed 300 'Xuxiang' kiwifruit in order to observe the lifespan including rotting process in cold storage (2° C) using RGB recognition software that will provide results following some parameters like NMR analyzer, Total plate counts (TPC), Total soluble sugars (TSS) and central R/B and B/G which refers to the storage time of kiwifruits using smartphone.

Kathirvelan et al [2], highlighted a new approach of detecting ethylene with Infrared (IR) thermal emission based ethylene gas sensor, since most of the fruits produce a wavelength, therefore, applying a silicone temperature detector and infrared rays on a fruit with wavelength changing applications can detect ethylene and artificial ethylene more accurately from the absorption of IR across the fruit's wavelength and converting the output in electrical signal (mV).

Chakraborty et al 3], proposed a model to prevent the propagation of rottenness using Convolutional Neural Network (CNN) and some other image processing methods like Max Pooling, Average pooling and MobileNetV2, then training the machine on a Kaggle dataset for achieving the highest accuracy rate as 99.46%.

Megalngam et al [4], used artificial intelligence along with image processing by Convolutional Neural Network, k cluster algorithm (a machine learning algorithm) and Hue Saturation Value (HSV) that can detect the spoilage percentage of food even it is a vegetable or fruit to reduce food poisoning and help color blind people to detect fresh food.

Goel et al [5], develops an algorithm while combining other three algorithms, for instance, Moth Flame Optimization (MFA), Particle Swarm Optimization (PSO) and Gravitational Search Algorithm (GSA) to detect rotten food and this hybrid algorithm contains 83.33% accuracy rate.

Tian et al [6], proposed a new technology known as hyperspectral transmittance image within 325-1100 nm spectral region with watershed segmentation algorithm and Principle component analysis (PCA) to detect early decaying process causes by Penicillium Spp. and to differentiate between stem end tissue (used PC2 image) and decayed tissue (used PC3 image) using pseudo color image transformation where the accuracy rates are 93% and 96% respectively for citrus fruits like orange.

Hemamalini et al [7], used image processing techniques with k-means clustering, support vector machine (SVM) and addedGaussian elimination method for removing noise from collected photos. Then in order to enhance the size of noise less photo, they used here histogram equalization and photos are being segmented using k means clustering and some other algorithms to detect spoiled food.

Karthickeyan et al [8], enclosed Convolutional Neural Network (CNN) and Object Detection Algorithm YOLO for identifying spoiled areas on food skin as well as added some specifications including MQ2 (mathane) and MQ135 (ethane) gas level detection from rotten food and spoilage level using Artificial Neural Network.

Chen et al [9], introduced a new cost effectve approach of biodegradable and disposable colorimetric geometric fabricated barcode sensors which can be easily placed in the upper part of food or over raw chicken and by using smartphones, the barcode can be scanned and after scanning, the system automatically extracts color information compared with a dataset and shows then the analytics whether the food can be consumed or it is time for discard.

Paul et al [10], proposed a new approach that can be easily implemented in our refrigerators as a detection method of rotten foods using deep machine learning algorithms (YOLOv5), image processing methods and FPGA based food spoilage detection methods and awares user by creating buzzing sound.

R. Torres-Sánchez et al proposed a real-time monitoring system using electronic nose technology and machine learning algorithms to estimate the shelf life of fruits and vegetables, providing a non-invasive and accurate method for quality control, potentially reducing food waste, and improving product quality for the produce industry. The electronic nose technology captures the volatile organic compounds (VOCs) emitted from the produce, and the machine learning algorithms process the data to estimate the remaining shelf life [11].

E. Sonwani et al presents the use of artificial intelligence to detect and analyze food spoilage to enhance food safety. The approach focuses on predicting spoilage before it becomes hazardous, and it involves the use of image processing, machine learning, and data analysis techniques. They proposed a CNN for object detection and prediction model. This is trained over three different classes. In our model, there are a total of 11 layers. The output layer is SoftMax, and there are four convolutional layers, four max pooling layers, and two fully connected layers. The model has been trained on 50 different types of fruits and vegetables, and it is also capable of identifying multiclass images. The proposed device shows an accuracy of 95% [12].

K. Jaspin et al propose a real-time surveillance system using computer vision techniques to identify the ripening stages of fruits, maturation stages of vegetables, and detect infections. The system uses image processing algorithms to extract features such as color and texture and classify them into different stages. The proposed system has the potential to improve quality control and reduce the losses in the fruit and vegetable industry. The overall accuracy of the proposed method for three classes of fruits and vegetables is 96 percent. The time taken for processing per frame is 1.1s, which is the quickest when compared to the other methods. The memory taken is 300 mbs which is least used when compared to the other methods. In the method the main challenge arises when they have to count fruits when it is not fully ripe [13].

J. S. Tata et al proposes a real-time quality assurance system that uses a combination of image processing and machine learning techniques to detect and classify defects such as bruises, cuts, and rot. The AI algorithms were trained on a large dataset of images and were able to achieve high accuracy rates in detecting defects. The system was tested on a range of fruits and vegetables, including tomatoes, cucumbers, and strawberries, and was found to be effective in detecting defects in real-time. The authors conclude that the system has the potential to improve the efficiency and accuracy of fruit and vegetable quality control in the food industry [14].

This proposed system will use image processing to classify and grade the quality of fruits and vegetables by extracting features such as color, shape, and HOG (Histogram of Gradient) to classify the given fruit or vegetable. Image pre-processing techniques like data-augmentation and normalization along with Principal Component Analysis (PCA), and Deep learning (CNN) are used for getting good accuracy and for dimensional reduction. An artificial neural network (ANN) is used to detect the shape, size, and color of fruit samples. The result of this project was obtained from the quality analysis process and the Android application. D. M. Bongulwar presents a deep learning approach for fruit identification, which can be used to automate fruit sorting and grading processes. The proposed approach uses a Convolutional Neural Network (CNN) architecture to extract features from fruit images, followed by a fully connected Neural Network for classification. The dataset used in the study includes 10 types of fruits, and the accuracy of the model is evaluated using several metrics. The RGB images, with three color channels R, G, and B are utilized in the dataset. The dataset is divided into training and validation datasets in which 90% of the images are trained and 10% are validated. The proposed CNN model has achieved classification accuracy of 92.23% on the dataset. As a future scope, the model can be used to train more variety of fruits. It can also examine the impact of various parameters like activation function, pooling function and optimizers [15}.

K.A.Ahmad et al [16], discussed a classification of star fruit ripeness systems using artificial neural networks. They found the system classified the star fruit ripeness based on the RGB color intensity. The clustering technique used in a neural network is an important part to achieve an accurate result. The classification system has an accuracy of 97.33%. The system can recognize the unripe, ripe and overripe of starfruit.

Indrabayu Indrabayu et al [17], discussed detection of fruit ripeness based on color characteristic, which is the Red, Green, Blue (RGB) value of the object. They used MultiClass Support Vector Machine (SVM) with Radial Basis Function (RBF) kernel function to classify the ripeness. The highest overall accuracy yielded using these optimal parameters is 85.64%. The accuracy for Unripe (UR), Partially Ripe (PR), and Ripe (RP) classes are 97.07%, 62.94%, and 96.27%, respectively.

Fatma M. A. Mazen & Ahmed A. Nashat [18], their proposed techniques are based on HSV color, development of brown spots, and texture analysis of the banana fruit. Here, supervised classification algorithms like the SVM, the naive Bayes, the KNN, the decision tree, and the discriminant analysis classifiers. The system was able to correctly predict with more than 94% the seven ripening stages of the banana bunch.

J.J Jijesh et al [19], discussed a system captures the fruit placed on a conveyor belt then the captured image is compared with the trained data set using Convolutional Neural Network Network (CNN) algorithm which extracts the features of the fruits like texture, color, and size.Thus according to their results obtained CNN is most accurate than SVM and KNN.

Shalini Gnanavel et al [20], they discussed developing a detection sensor that can sense the fruit and indicate the level of hazardous substance in the fruit. It is a user-friendly device where the level of accuracy is very high. The proposed system has an efficiency of 91% in the identification of the ripened fruit. The device is implemented using raspberry pi. There are three modes in the device: First, to check the inner quality of the fruit is determined, secondly Artificially ripened fruit are detected and lastly pesticide residue level of the fruit is indicated.

Anuja Bhargava & Atul Bansal [21], discuss making a critical comparison of various algorithms proposed by researchers for fruit and vegetable quality inspection, whereas image processing and computer vision systems have significant performance, increasing cost, ease of use, and algorithmic robustness, scientific processes in agricultural and industrial systems, Also traditional, multispectral and hyperspectral computer vision systems are currently widely used to evaluate the quality of fruits and vegetables, so color, size, shape, texture and defects are common features inspected by traditional computer vision systems (TCVS).

Anjali N et al [22], discusses the current state-of-the-art imaging and collection of recent defect area counting methods using RGB images to detect defects on the surface of fruits and vegetables and classify whether the fruit is defective or fresh, whereas the system developed to identify fruit or vegetable samples using visual sensing techniques is one of the most effective and efficient methods available.

Mahdieh Mostafidi et al [23], discusses the main means of contamination of fruits and vegetables with pathogens, also the main means of preventing contamination in all parts of the food chain and microbial load, edible coatings, bacteriocins, radiation, gamma-rays, UV-C, and chemicals. Reduces high hydrostatic pressure, and conserves radiation, whereas ultrasonic, acid-electrolyzed water, ozone, modified atmosphere packaging (MAP), and cold plasma are mentioned in microbial safety of fruits and vegetables. In the context of addressing microbiological risks in fresh fruits and vegetables, there are five main risks associated with primary production, which are environmental and wildlife factors, fertilizer and pesticide use, irrigation water, worker and equipment hygiene, and contact levels.

Renuka N et al [24], works on the architecture of an automatic orange fruit classification system coded using VHDL language and implemented using SPARTAN 6 FPGA. And to get optimized hardware architecture, filter, feature extraction and matching blocks are optimized for hardware usage. Whereas in fruit extraction to maintain fruit characteristics, Q-point numbers are noted and the results are compared, as a result, they proved that the proposed architecture is efficient and gives 88% success rate to detect fruit state effectively with fewer hardware resources.

V. G. Narendra & Ancilla J. Pinto [25], works to detect external defects in vegetables and fruits

based on morphology, color, and texture. Whereas they propose algorithms for quality inspection such as external defects that RGB to L*a*b* color conversion and defective area calculation methods used to detect defects in both apples and oranges, also in vegetables, K-means clustering and defect area calculation methods are used to identify defective tomatoes on their color. And they claim an overall accuracy of 87% (apples: 83%; oranges: 93%; and tomatoes: 83%) in quality analysis and defect detection for defective fruits

(apples and oranges) and vegetables (tomatoes).

## III. RESEARCH METHODOLOGY

Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections A-D below for more information on proofreading, spelling and grammar.

Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

### A. *Propose System*

i) Hardware part

MQ4 Methane Gas Sensor detects the concentration of methane gas in the air and outputs its reading as an analog voltage. The concentration sensing range of 300 ppm to 10,000 ppm is suitable for leak detection.

HCI-2 Hydrometer digital temperature and humidity meter and clock, where the purpose of a hygrometer is for monitoring or measuring the moisture content of the air to decipher humidity. The calculations of the various measurements of humidity can be quite complex. As such, we aim to keep our instruments as simple to use as possible. Temperature and humidity sensors are among the most commonly used environmental sensors. Humidity sensors are also sometimes referred to as hygrometers. These devices are used to provide the actual humidity condition within the air at any given point or in any given place.

The ESP8266 WIFI Module is a self-contained SOC with an integrated TCP/IP protocol stack that can give any microcontroller access to your WIFI network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. The ESP8266 module enables microcontrollers to connect to 2.4 GHz Wi-Fi, using IEEE 802.11 bn. It can be used with ESP-AT firmware to provide Wi-Fi connectivity to external host MCUs, or it can be used as a self-sufficient MCU by running an RTOS-based SDK. The module has a full TCP/IP stack and provides the ability for data processing, reading, and controls of GPIOs.

RP2040 is the debut microcontroller from Raspberry Pi. It brings our signature values of high performance, low cost, and ease of use to the microcontroller space. With a large on-chip memory, symmetric dual-core processor complex, deterministic bus fabric, and rich peripheral set augmented with our unique Programmable I/O (PIO) subsystem, it provides professional users with unrivaled power and flexibility. With detailed documentation, a polished Micro Python port, and a UF2 bootloader in ROM, it has the lowest possible barrier to entry for beginner and hobbyist users. RP2040 is a stateless device, with support for cached execute-in-place from external QSPI memory. This design decision allows you to choose the appropriate density of non-volatile storage for your application, and to benefit from the low pricing of commodity Flash parts. RP2040 is manufactured on a modern 40nm process node, delivering high performance, low dynamic power consumption, and low leakage, with a variety of low-power modes to support extended-duration operation on battery power.

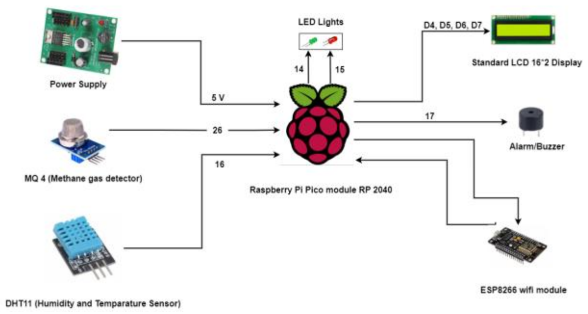


Fig: 1

In Fig:1, Raspberry pi connected with methane gas sensor mq4. The connection is such that one connection is grounded and another is connected with input. Where connected the power supply for the power and buzzer and all are used for the indication of decay and ripeness. Pi is also connected with dh11 which is used to send data to the WIFI module and Lcd display is to show the data. The main process on the backend the purpose of is to show if it is working or not. The WIFI module is connected for sending data to the database with the help of the WIFI module.

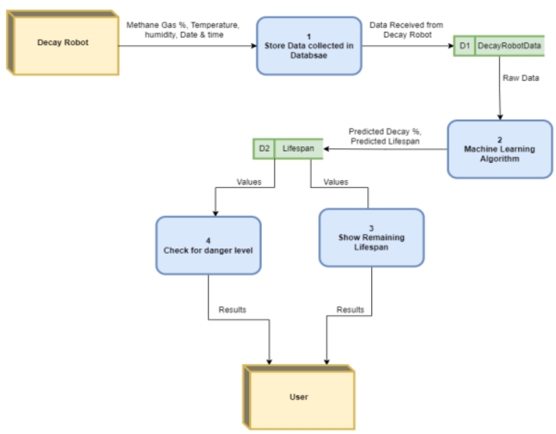


Fig: 2

In Fig: 2, Methane gas, temperature, humidity, and time data are collected by the Decay robot and stored in the database. Machine learning algorithms are applied to the data from the database, resulting in predicted Decay % and predicted lifespan. From this life span the danger level and remaining life span are shown.

Data Table - 1:

| *Timestamp* | *Temperature* | *Humidity* | *Methane* |
|---|---|---|---|
| 2023-03-24 00:12:09 | 24 | 78 | 870 |
| 2023-03-24 16:18:57 | 31 | 37 | 900 |
| 2023-03-24 21:55:18 | 24 | 70 | 1200 |
| 2023-03-25 00:14:49 | 22 | 75 | 1300 |
| 2023-03-25 00:41:09 | 23 | 74 | 1378 |

Methane gas, temperature, humidity, and time data collected by the Fig-2 Decay robot are presented in Table 1.

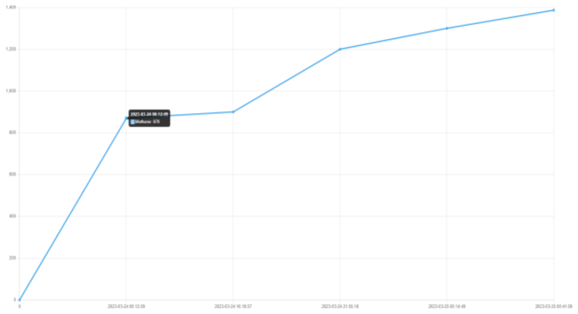

Fig: 3

In Fig: 3, data collected by the Decay robot shows the increase of methane gas along the y-axis with time along the x-axis.

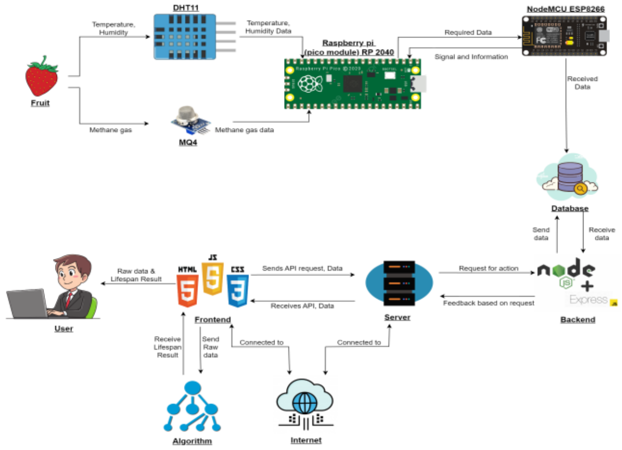


Fig: 4

In Fig: 4, This is the whole proposed system, where by sending a signal to Raspberry Pi Pico through NodeMCU-ESP8266, temperature with humidity data is collected by a DHT11 sensor and methane gas data is collected by an MQ4 sensor, and all the data is stored in the database.

## B. *Units*

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive".
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Number equations consecutively. Equation numbers, within parentheses, are to position flush right, as in (1), using a right tab stop. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen Data Table for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \tag{1}$$

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- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum $\mu_0$, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o".
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
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- The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

An excellent style manual for science writers is [7].

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**The template is designed for, but not limited to, six authors.** A minimum of one author is required for all conference articles. Author names should be listed starting from left to right and then moving down to the next line. This is the author sequence that will be used in future citations and by indexing services. Names should not be listed in columns nor group by affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization).

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*2) For papers with less than six authors:* To change the default, adjust the template as follows.

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TABLE I. TABLE TYPE STYLES

| Table Head | Table Column Head | | |
|---|---|---|---|
| | ***Table column subhead*** | ***Subhead*** | ***Subhead*** |
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[a.] Sample of a Table footnote. (*Table footnote*)

Fig. 1. Example of a figure caption. (*figure caption*)

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## Acknowledgment *(Heading 5)*

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.


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