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Personalized Natural Fruit Prescription System: Considerations and Methodologies

IYAMAH, B. E. [1,*], ***ALLENOTOR, D.*** [1]

[1]*Department of Computer Science, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria*

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ABSTRACT

In recent years, natural fruit prescription has gained popularity due to the growing interest in natural and organic foods. This trend led to increased demand for data on the nutritional and medicinal properties of fruits. Existing sources on fruits are often incomplete, and difficult to retrieve. Thus, hinders effective decisions to natural fruit prescription. Our study uses the generative adversarial network k-means cluster to develop a fruit ontology-based semantic retrieval system for natural fruit prescription. In the context of fruit ontology, it generated new fruit images or natural language text descriptions from existing ontology. Results confirmed system successfully implemented the fruit ontology semantic retrieval and delivers intelligent recommendations based on user-defined criteria. Thus, contributes to natural fruit prescriptions.

1. INTRODUCTION

Fruits have long been a rich source of nutrients and bioactive compounds that can prevent and treat diseases. Research has also shown that certain fruits have specific health benefits (Spoladore et al., 2022). Blueberries are rich antioxidants and improve cognitive function and reduce the risk of heart disease. Cranberries prevent urinary tract infections, while pomegranates have been shown to have anti-inflammatory and anti-cancer properties (Agapito et al., 2018). However, there is a lack of comprehensive and easily accessible information on the health benefits of specific fruits – making it a bit difficult for healthcare professionals to prescribe fruits as part of a treatment plan and for consumers to make informed choices about their diet (Aghware et al., 2023a, 2023b; Al-Bashiri et al., 2017).

Natural fruit prescription, also known as fruit therapy, is the practice of using fruits for their nutritional and medicinal properties to promote health and prevent or treat diseases. The use of fruits for their health benefits dates back to ancient times and has been practiced by various cultures worldwide (Akazue et al., 2022, 2023; Malasowe et al., 2023). In recent years, fruit prescription has gained popularity due to the growing interest in natural and organic foods. This trend has led to increased demand for information on the nutritional and medicinal properties of fruits. However, existing knowledge sources on fruit crops are often scattered, incomplete, and difficult to retrieve, hindering effective decision making in natural fruit prescription (Ananda et al., 2020; Tantawi, 2023). Ontologies have been proposed as a solution to organise and share knowledge in various domain (Allenotor et al., 2015; Ojugo, Akazue, Ejeh, Odiakaose, et al., 2023; Ojugo,

*Corresponding author, e-mail: *iyamahboyce@gmail.com*

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Allenotor, et al., 2015; Ojugo & Eboka, 2014).

An ontology is a formal representation of knowledge that specifies a set of concepts, their attributes, and the relationships between them. Ontologies enable the integration and interoperability of heterogeneous knowledge sources, making it possible to retrieve and present information in a structured and coherent manner (Eboka & Ojugo, 2020; Ibor et al., 2023; Yoro, Aghware, Akazue, et al., 2023; Yoro, Aghware, Malasowe, et al., 2023). In the context of fruit crop production, several ontologies have been developed to represent the knowledge of fruit crops, including crop ontology, plant ontology, and fruit ontology. These, provide a formal representation of the domain knowledge, making it possible to retrieve and present information on fruit crops in a structured and coherent manner (Allenotor & Ojugo, 2017; García et al., 2011; Okobah & Ojugo, 2018; Wu et al., 2019).

The fruit crop ontology-based Semantic Retrieval System requires the integration of data on the taxonomy and biology of fruits, its nutritional cum medicinal properties, and their cultural and historical relevance. The use of ontologies enables the integration of diverse data onto a standardized form that can be easily accessed (Smith et al., 2020). The system has the potential to provide healthcare professionals and consumers with a valuable tool for accessing and sharing information on the therapeutic properties and values of these fruits. It requires an cross-cutting integration and collaboration of diverse knowledge sources, making it a complex and challenging endeavour (Kakhi et al., 2022; Khaki et al., 2020; Manickam et al., 2022).

Fruit crop ontologies are the formal representations of knowledge or concepts related to different types of fruit crops that are used to organize and classify information about them. There are many decision support systems that aids in treatment decisions and other areas of application (Arlati et al., 2019; James et al., 2018). The development of fruit prescription decision support system will be of immense benefit in health sector. The development of fruit crop ontologies involves collecting and analysing data on different types of fruits, including their properties, uses, and effects on human health. The ontology is designed to be standardized so that it can be used across various platforms and by different researchers in the same way, ensuring consistency in the classification of information (Al-Bashiri et al., 2017). The development of fruit crop ontologies also faces several challenges.

One of the biggest challenges is the lack of standardized vocabulary and terminology used to describe different types of fruits and their properties. Another challenge is the dynamic nature of fruit crop research, which requires ongoing updates and revisions to the ontology. Despite these challenges, the development of fruit crop ontologies is an essential area of research that has significant implications for healthcare and natural remedies. By enabling the efficient and accurate retrieval of information about fruit crops and their medicinal properties, these ontologies can help to promote the use of natural remedies in healthcare and contribute to a better understanding of the properties and uses of different types of fruits. Several fruit crop ontologies based semantic retrieval systems are discussed in this section. These systems use fruit crop ontologies, which are formal representations of knowledge or concepts related to different types of fruits, to organize and classify information about fruits and their medicinal properties (Collins et al., 2019; Costa et al., 2014).

1.1 Prescription Web-based System

They are software that allow healthcare providers to manage and track prescriptions online, by integrating the retrieval of natural fruit remedies into the prescribing process (Hamad et al., 2021;

James et al., 2018). It integrate the retrieval system can provide a valuable resource for healthcare providers who want to explore natural remedies as complementary or alternative treatments for their patients (Ismail & Soye, 2018; Ismayilova & M.Klassen, 2019; Ojugo & Eboka, 2018b, 2019, 2021). By incorporating the retrieval system into the prescribing process, healthcare providers can offer patients a comprehensive treatment plan that considers both conventional and natural remedies (Borgonovi & Ferrara, 2022; Ferrari et al., 2012; Ojugo, Eboka, et al., 2015a, 2015b; Ojugo & Ekurume, 2021b; Roehrs et al., 2019).

However, there are potential challenges associated with the integration of ontology semantic retrieval systems into prescription web systems. A major challenge is to ensure the accuracy and reliability of the information retrieved. It is essential, healthcare providers can trust the data received from the system and based on rigorous research (Verdonck et al., 2020). Another challenge is ensuring the privacy and security of patient information. Prescription web-based systems must comply with strict privacy regulations to protect patient data from unauthorized access or disclosure. Integrating an ontology retrieval system into the system must also meet these standards to ensure the security of patient record (Ojugo & Ekurume, 2021a; Oyemade et al., 2016; Oyemade & Ojugo, 2021).

Overall, the integration of a Fruit Crop Ontology-based Semantic Retrieval System into prescription web-based systems has the potential to revolutionize the way healthcare providers approach natural remedies. By providing easy access to accurate and reliable information about natural fruit remedies, healthcare providers can offer patients a more comprehensive treatment plan that considers both conventional and natural remedies. However, it is essential to address potential challenges related to accuracy, reliability, privacy, and security to ensure the success of these systems in the healthcare industry (Agapito et al., 2018).

1.2 Machine Learning Algorithms

Machine-learning algorithms are used in developing fruit ontology retrieval system (Charan et al., 2020; Chevalier et al., 2003; Datta et al., 2021; Ojugo et al., 2021a, 2021b; Ojugo & Otakore, 2018a, 2018b) are:

1. **Decision Trees:** Decision trees can be used to classify different types of fruit based on its features (Hamad et al., 2021)
2. **Random Forest:** Random Forest is an extension of decision trees that combines multiple decision trees to improve the accuracy of the classification. Each tree is trained on a different subset of the dataset, and the final classification is determined by aggregating the results of all the trees.
3. **Support Vector Machines** helps to find best boundary between different classes of data points in a high-dimensional space and can be used to classify different types of fruit based on their characteristics (James et al., 2018).
4. **K-Nearest Neighbours** helps in finding the k-nearest data points in the dataset to the input data and then classifying the input data based on the majority class of its k-nearest neighbour as a result can be used to classify different types of fruit based on their characteristics.
5. **Neural Networks:** Neural networks as a powerful class of machine learning algorithms that are particularly effective for complex classification problems, can be used to extract features of fruits that captures the important characteristics of the fruit and help in finding the most relevant matches in the ontology.

Ontology-based systems that enable more accurate and precise retrieval of data, can be easily extended to include new concepts and relations and provide a common vocabulary and terminology for different stakeholders to communicate and collaborate (Ismail et al., 2017). These methods have been applied by some researchers.

Espín et al. (2016) used an ontology-based recommender system called NutElCare for older adults that desire to create their own diet plan based on their aging process. The system has the ability to learn from user's behaviour pattern which enables it to present a tailored recommendation to a new user. Subramaniyaswamy et al. (2019) used ProTrip with user preference and interest in recommending healthy food. System learns from previous knowledge to make a new recommendations and contributions.

Bianchini et al. (2017) proposes PREFer that leverages prescription and nutritional behaviour to propose a set of menus to users. Each recipe's features are filtered to generate user menu, refines and ranks them based on the healthiest menu.

Spoladore et al., (2021) proposed a comprehensive methodology for developing a tele-healthcare system called HeNuALs to promote healthy behaviours among older adults. The system reuses knowledge helps it in limiting the number of information needed to retrieve nutritional recommendation. The system is limited to only two use cases. Also, the system lacks the ability to automatically acquire new information.

Critical analysis of the difficulty experienced in retrieving relevant information on specific fruits and their medicinal properties in the existing system shows the following issues;

i. Lack of standardized fruit crop ontology
ii. Limited availability of reliable data
iii. Lack of user-friendly interface

2. MATERIALS AND METHODS

The aim of the fruit ontology-based semantic retrieval system prescription is to provide a user-friendly system that eases the access accurate information on natural fruit remedies. The system is designed to retrieve information based on user queries, making it easier for people to find information on specific fruits and their medicinal properties.

The specific objectives: (a) develop a standardized ontology for fruit, (b) gather and analyse reliable data sources, (c) design a user-friendly interface, and (d) evaluate the system (Pradeepa & Parveen, 2020).

2.1. Proposed Methodology

Study develops a fruit ontology-based semantic retrieval system prescription which leans on Spoladore et al., (2021) for telecare system to promote healthy behaviours among older adults. It fuses a top-down and bottom-up approach using a high-level ontology that included concepts such as food and physical activity, and refined the ontology via a series of iterations based on feedback from domain experts and user testing. The ontology listed 358-concepts yielding over 1000-relations to provide a rich and detailed representation of the domain.

The ontology was modelled as a system architecture to ease porting on to a mobile application for users, a web-based dashboard for healthcare providers, and a knowledge management system for managing it. The mobile application allows users to track their diet and physical activity, connect with other users, and receive personalized feedback and recommendations. The dashboard provides healthcare czars with access to user data and allows them monitor/manage their patient's health remotely. The knowledge management system serves as a central repository for the ontology, ease updates and modifications as at when needed.

To implement, we combined the open-source technologies of Django framework, the Apache Jena semantic framework. We used the unit testing and user evaluation to ensure system was easy to use and effective in promoting healthy behaviours among older adults. Our method incorporates both domain expertise and user feedback to develop a tele-healthcare system that addresses the complex needs of older adults. The use of an ontology-based approach provides a common language for communication and allows for integration of data from multiple sources; while the combination of top-down and bottom-up approaches ensures that the system is both flexible and detailed. Figure 1 shows the data flow of the existing system.

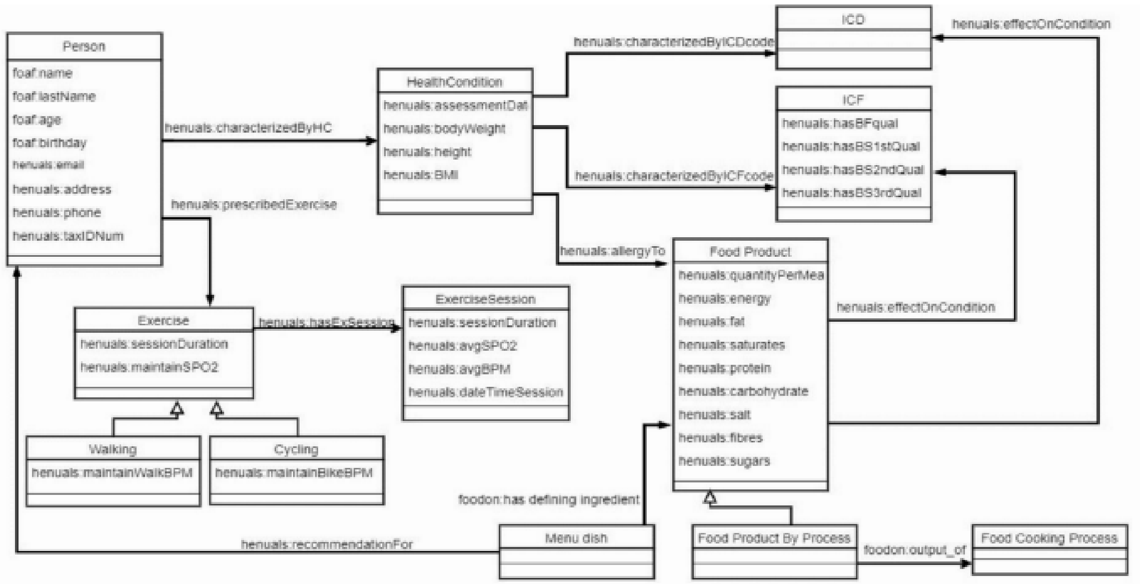

Figure 1: Existing system object Model

2.2. Proposed System methodology

First, we retrieved the dataset of fruit images and natural language text descriptions is collected, which is used to train K-Means Cluster (Nassar & Al-Hajri, 2013; Ojugo, Yoro, et al., 2013; Ojugo & Otakore, 2020; Suleiman & Nachandiya, 2018).

Secondly, we used the k-mean cluster to train the dataset, and learn the underlying distribution of the features that define fruit images and natural language text descriptions. This involves feeding the dataset into the k-mean cluster, consisting a generator network and a discriminator network (Ojugo et al., 2015; Ojugo, Oyemade, et al., 2013; Ojugo & Eboka, 2018a). Its generator network yields synthetic fruit images or natural language text descriptions based on the learned distribution; While, discriminator evaluates authenticity of generated data (Leira et al., 2021; Ma et al., 2020). Using an iterative process, the k-means cluster K-means cluster learns to generate evolved realistic data that represents the fruit ontology (Ojugo, Ugboh, et al., 2013; Ojugo & Yoro, 2020a, 2020c, 2020b).

Thirdly, the synthetic data generated by the K-means cluster is used to augment the original dataset and expand the ontology. Table 1 shows the fruit ontology (Tarafdar & Zhang, 2005; Yuan & Wu, 2021; Zardi & Alrajhi, 2023; Zawislak et al., 2022).

Table1: Fruit crop ontology

Class Hierarchy	Properties and Attributes	Relationships
Fruit Crop	Nutritional Composition	Subclass of: Fruit Crop
Citrus Fruit	Health Benefits	Citrus Fruit is a subclass of Fruit Crop
Berry	Cultivation Information	Berry is a subclass of Fruit Crop
Tropical Fruit	Culinary Uses	Tropical Fruit is a subclass of Fruit Crop
Stone Fruit	Culinary Uses	Stone Fruit is a subclass of Fruit Crop
Apple	Crisp texture	Apple is a subclass of Fruit Crop
Banana	Nutritional content	Banana is a subclass of Fruit Crop

Grape	Culinary preparations	Grape is a subclass of Fruit Crop
Orange	Nutritional content	Orange is a subclass of Citrus Fruit
Lemon	Health benefit	Lemon is a subclass of Citrus Fruit
Grapefruit	Tartness	Grapefruit is a subclass of Citrus and Fruit
Strawberry	Sweetness	Strawberry is a subclass of Berry
Blueberry	Juicy & flavorful	Blueberry is a subclass of Berry
Raspberry	Sweet & Tart flavor	Raspberry is a subclass of Berry
Mango	Nutritional Value	Mango is a subclass of Tropical Fruit
Pineapple	Distinct texture and Nutritional benefit	Pineapple is a subclass of Tropical Fruit
Papaya	Health benefits and nutrition	Papaya is a subclass of Tropical Fruit
Peach	Sweetness, slight tartness,nutrition	Peach is a subclass of Stone Fruit
Plum	Sweet, Juicy	Plum is a subclass of Stone Fruit

The data can train other machine learning models, and be used to generate new fruit prescriptions based on user feedback. Figure 2, shows the data flow of the proposed system.

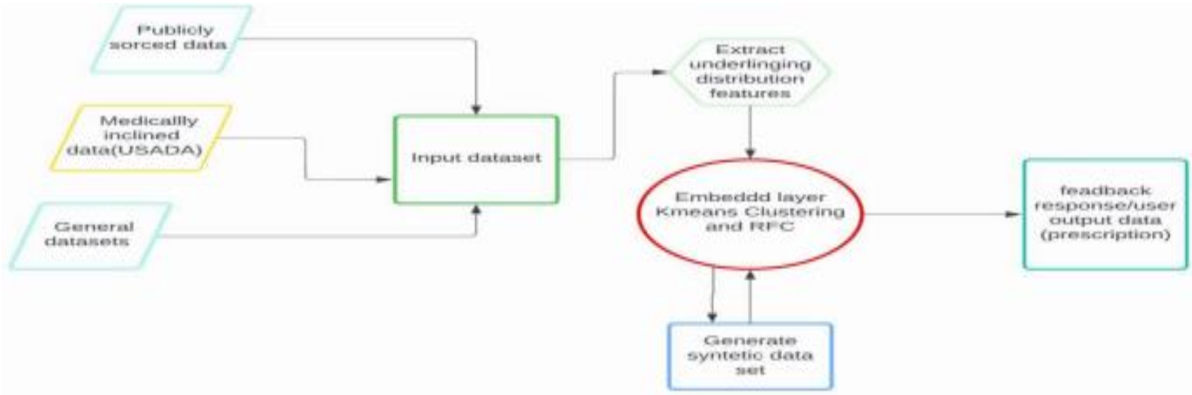

Figure 2: Data flow diagram of the proposed system

We used the k-mean cluster generative adversarial network as unsupervised learning such that K-means is not explicitly trained on labelled data; Instead, it learns to underlying features that define fruit images and natural language text descriptions based on a dataset of unlabelled data. Its generator net generates synthetic data samples of fruit images as its natural language text descriptions; while, the discriminator net evaluates the authenticity of the generated data and provide feedback to improve the quality of the generated data.

3. RESULT AND DISCUSSION

A comprehensive dataset of fruit crop data with its nutritional data, health benefits, and other relevant features was pre-processed to clean the data, handle missing values, and format it for further analysis as in Figure 4 we used the Python programming language and relevant libraries and frameworks. The Fast API framework was utilized to create web-based interface for user interaction. Natural Language Processing (NLP) techniques were employed for data pre-processing and feature extraction as shown in Figure 5, and the K-means clustering algorithm was implemented for efficient grouping and recommendation (Drummond et al., 2003; Filippi et al., 2019; Guntur et al., 2018; Joloudari et al., 2022).

Figure 6 shows user interface where the users is allowed to specify their criteria or conditions for fruit prescription based on nutritional data, health benefits, and other attributes. User is presented with an interface to collect the required input from the users.

The user input interface includes fields for entering nutritional data such as calories, fibre, carbs, protein, fat, vitamins (A, B6, E), and minerals like calcium, iron, potassium, and magnesium. Furthermore, users can also provision the system with the specific health benefits they wish and seek for, vide the fruit prescription. This interface ensures that users can easily enter their criteria and preferences, guiding them via selection process effectively. This agrees with (Ojugo & Okobah, 2017).

	Fruit Crop	Nutritional Data	Health Benefits	Other Attributes
0	Apple	Calories: 52 Carbs: 14g Fiber: 2.4g	High in antioxidants Rich in dietary fiber	Red, Green, Yellow Varieties
1	Banana	Calories: 96 Carbs: 23g Fiber: 2.6g	Excellent source of potassium Boosts energy...	Cavendish, Lady Finger
2	Orange	Calories: 62 Carbs: 15g Fiber: 3.1g	High in vitamin C Supports immune system	Navel, Valencia
3	Strawberry	Calories: 29 Carbs: 7g Fiber: 2g	Packed with antioxidants Supports heart health	Sweet, Fragaria Vesca
4	Pineapple	Calories: 50 Carbs: 13g Fiber: 1g	Contains bromelain for digestion support	Sweet, Smooth Cayenne

Figure 4: Data Collection Preparation

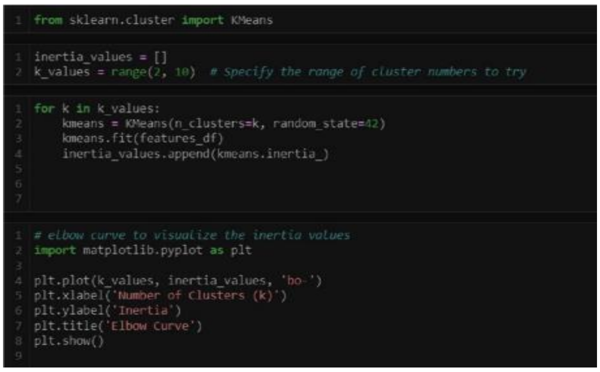

Figure 5: Data pre-processing and feature extraction

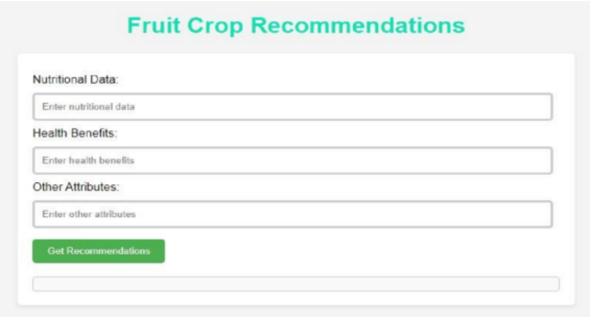

Figure 6: user interface

Figure 7 are generated recommendation from its output design, which retrieves several fruit prescriptions based on a user's input criteria to meet specified conditions and preferences, leveraging on semantic relationships encoded in the Fruit Crop Ontology. This agrees with (Ojugo, Abere, et al., 2013; Ojugo, Aghware, et al., 2015; Ojugo, Akazue, Ejeh, Ashioba, et al., 2023; Ojugo, Odiakaose, & Emordi, 2023; Ojugo, Odiakaose, Emordi, et al., 2023).

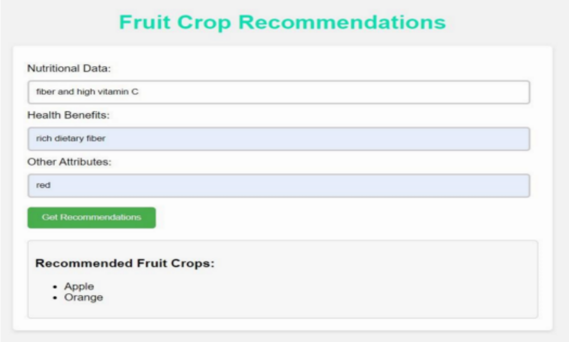

Figure 7: Sample system fruit crop recommendation

To ensure the functionality and performance of the Fruit ontology-based semantic retrieval system, rigorous testing is conducted to yield the table 2 – as results of various parameters.

Table 2: Overall Performance Evaluation

Metric	Value	Description
Response Time	<500 ms	Time taken to retrieve and recommend fruit crops
Latency	<100 ms	The delay between user input and system response
Throughput	>100 requests/s	Number of requests served per second
Scalability	High	The ability of the system to handle increasing user load
Resource Usage	Optimal	Efficient utilization of hardware resources (CPU, memory, etc.)
Error Rate	<1%	Percentage of erroneous responses or system errors

The performance evaluation of the fruit crop Ontology-based Semantic Retrieval System demonstrated favourable outcome, features and characteristics. These include lower-time response, minimal latency, high throughput, scalability, optimal resource usage, and a low error rate. These evaluations provide insights into the system's efficiency and effectiveness, ensuring that it meets required performance expectations for retrieving fruit prescriptions based on user specified criteria (Akpoyibo et al., 2022; Bhavani & Mangla, 2023; Borgonovi & Ferrara, 2022; Hurt, 2019; Li et al., 2017; Tingfei et al., 2020).

4. CONCLUSION

Our fruit crop ontology-based semantic retrieval system offers a valuable solution for natural fruit prescription

recommendations. We explore the fruit crop ontology, semantic retrieval techniques, and machine learning algorithms, the system effectively matches user specified criteria with the appropriate fruit prescriptions. Its implementation is via data pre-processing, feature extraction, K-means cluster, training and prediction – to successfully provides users with personalized fruit prescriptions based on nutritional data, health benefits, and other relevant attributes encoded in the ontology. It demonstrates the potential of integrating an ontology-based semantic retrieval system with machine learning approach in fruit recommendations.
Our study unveils the significance of harnessing semantic relations and machine learning for intelligent fruit-crop prescription recommendations to promote healthier living choices with support for the elderly. This will in turn, help achieve their health goals.

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