Personalized Dietary Recommendations Using Machine Learning: A Comprehensive Review

Neeraj Varshney
Department of Computer Engineering & Apllications, GLA University, Mathura, UP, India
neeraj.varshney@gla.ac.in

Dr. Netaji Jadhav
Associate Professor, Bharati Vidyapeeth (Deemed to be University), College of Physical Education, Pune.
netaji.jadhav@bharatividyapeeth.edu

Dr Kirti Gupta
Associate Professor,
Institute of Management & Entrepreneurship Development,
Bharati Vidyapeeth (Deemed to be University), Pune
Kirti.s.gupta@bharatividyapeeth.edu

Dr. Nilesh R. Mate
Bharati Vidyapeeth (Deemed to be University), Centre for Distance and Online Education, Pune
nileshmate100@gmail.com

Dr Anthony Rose, Professor
Institute of Management & Entrepreneurship Development,
Bharati Vidyapeeth (Deemed to be University), Pune
anthony.rose@bharatividyapeeth.edu

Mr. Purushottam Kumar
Amity University Jharkhand, Ranchi
purushottamkumar7086@gmail.com

2023 International Conference on Artificial Intelligence for Innovations in Healthcare Industries (ICAIIHI) | 979-8-3503-3091-5/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICAIIHI57871.2023.10489126

***Abstract*—This thorough analysis investigates how machine learning could potentially be used to provide individualized dietary advice, which could possibly revolutionize the field of nutrition research. A deductive method is used with an interpretivist mindset, making use of secondary data collecting and a descriptive research methodology. The outcomes reveal improvements in lipid profiles, blood glucose control, and weight management, demonstrating the efficacy of tailored suggestions. Personalized methods outperform established recommendations in terms of individual health outcomes and adherence, according to comparative research. The identification of individual variability as well as response patterns highlights the significance of customizing guidance to account for distinct physiological parameters. Transparency, informed consent, privacy, including bias reduction are all included in the ethical framework. Data quality and the intricacy of genetic and environmental interactions are among the limitations. It is advised to prioritize high-quality and diversified datasets, deal with algorithmic biases, and promote multidisciplinary cooperation. Longitudinal studies, real-time data integration, as well as psychological component exploration should be the main areas of future research. This study offers hope for better public health outcomes by laying the groundwork for a more sophisticated and practical approach to nutrition**

Keywords— personalized dietary recommendations, machine learning, interpretivism, individual variability, ethical considerations

I. INTRODUCTION

A. Research Background

Machine learning-based personalized dietary recommendations are a state-of-the-art method in nutrition research. Conventional dietary recommendations sometimes take a one-size-fits-all stance, ignoring the notable inter-individual differences in lifestyle, nutrition, metabolism, as well as heredity. This restriction may result in less-than-ideal outcomes and make it more difficult for people to reach their ideal levels of health [1]. As a branch of artificial intelligence, machine learning has gained the capacity to examine enormous volumes of data and spot intricate patterns that traditional approaches would miss. Through the use of data from many sources, including genetic profiles, biomarkers, eating habits, as well as physiological responses, machine learning models are capable of producing customized dietary recommendations that are suited to the unique requirements of each individual [2]. This strategy shows promise in treating a number of health issues, such as food allergies, diabetes, obesity, in addition to cardiovascular illnesses. To guarantee the precision, and efficacy, including ethical concerns of customized dietary advice produced by machine learning algorithms, it is imperative to critically assess the methodology, data sources, including ethical issues related to this developing subject.

B. Aims and Objectives

Aims:

The primary aim of this research is to examine and assess the viability, effectiveness, and possible advantages when applying machine learning in the creation of customized food suggestions.

Objectives:

- To examine the body of research on machine learning applications in nutrition science while providing customized nutrition recommendations.
- To evaluate the data sources and techniques that are frequently employed in machine learning algorithms to produce individualized food recommendations.
- To evaluate machine learning-based dietary recommendations against conventional, one-size-fits-all methods in terms of efficacy and accuracy.
- To investigate privacy, permission, possible biases in the data including algorithms, and other ethical issues related to applying machine learning to provide personalized food recommendations.

C. Rationale

The need to overcome the shortcomings of traditional, general dietary advice is what motivates this research. Different physiological reactions to eating are displayed by individuals depending on lifestyle, metabolic, including genetic variables. In order to evaluate and analyze this intricate interaction of factors, machine learning provides a potent tool that makes it possible to provide customized dietary recommendations [3]. This strategy can lead to better health results, especially when it comes to chronic illnesses

and other situations where nutrition could be having an impact. Through a thorough assessment, this study seeks to promote precision nutrition and enhance public health initiatives by critically evaluating the viability and advantages of machine learning-based personalized dietary advice.

II. LITERATURE REVIEW

A. Traditional Dietary Guidelines and Their Limitations

Conventional dietary recommendations are the cornerstone of public health initiatives to support balanced nutrition and avoid diet-related illnesses. They are usually developed at the community level. These recommendations include broad information on dietary categories, daily calorie consumption, as well as macronutrient balances. They however show significant limits when it comes to handling individual diversity [4]. Different nutritional demands and reactions to food are influenced by human physiology, heredity, and lifestyle choices. As a result, a uniform strategy would overlook these significant variations, which could end up in worse-than-ideal health consequences. Furthermore, when it comes to dietary concerns for a variety of groups, including individuals with particular medical issues, allergies, or ethnic dietary practices, standard guidelines sometimes lack specificity. Furthermore, they could fail to be able to sufficiently adjust to new developments in nutritional research and science [5]. The need for individualized dietary advice that takes use of developments in data science and machine learning is therefore becoming more and more apparent. This paradigm change has the potential to optimize health outcomes as well as increase the efficacy of dietary treatments by customizing dietary recommendations to individual features.

Figure 1Traditional Dietary Guidelines

B. Machine Learning Applications in Nutrition Science

Applications of machine learning to nutrition science provide a ground-breaking method for discovering and satisfying the nutritional requirements of each individual. Machine learning models are able to analyze large datasets that include genetic information, biomarkers, dietary patterns, including physiological reactions to food by utilizing artificial intelligence [6]. This makes it possible to find intricate linkages and patterns that would be invisible implementing more conventional statistical techniques. The creation of prediction models for individualized food suggestions is one well-known use. To provide individualized dietary recommendations, these models may take into account a wide range of variables, such as metabolic profiles, genetic predispositions, together with lifestyle decisions [7]. Furthermore, machine learning makes it possible to identify dietary trends and the way they affect health outcomes by assisting in the analysis of large-scale dietary surveys. Furthermore, machine learning algorithms can improve food analysis and categorization, making it easier to determine portion sizes and nutrient contents [8]. Additionally, this technology is essential in automating the tracking of dietary adherence while providing insightful feedback to those who are trying to fulfill particular dietary targets. All things considered, the application of machine learning to nutrition research has enormous promise to transform dietary treatments and progress precision nutrition.

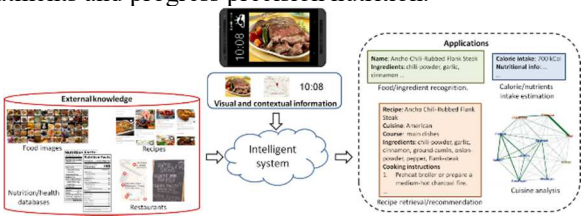

Figure 2Machine Learning Applications in Nutrition Science

C. Data Sources and Methodologies for Personalized Dietary Recommendations

Personalized diet advice and the data sources that support them are essential elements of nutrition science's machine learning potential. Genetic data, gathered via methods such as DNA sequencing, offers vital insights into a person's genetic tendencies while also making it possible to identify genetic variations that affect dietary responses and nutrient metabolism [9]. Biomarkers, such as lipid profiles, hormone markers, and blood glucose levels, provide instantaneous indications of a person's physiological condition as well as help determine dietary needs. Dietary data provides information on an individual's eating habits, and preferences, including nutritional consumption. It can be gathered by food diaries, wearable technology, or mobile applications. Furthermore, cutting-edge technologies like nutrigenomics and metabolomics increase the understanding of the complex relationships between nutrition and metabolism [10]. A wide range of approaches, from statistical analysis to machine learning algorithms, are included in methodologies. Diverse datasets are processed in order to identify and extract significant patterns using Bayesian networks, support vector machines, and deep learning models. These techniques make it possible to create prediction models that produce individualized dietary recommendations in accordance with each person's particular biological composition and lifestyle choices.

D. Effectiveness and Accuracy of Machine Learning-Based Recommendations

A crucial component of machine learning-based dietary recommendations' potential influence on personal health outcomes is their efficacy and accuracy. Research assessing the extent to which these suggestions work has produced encouraging findings. With the use of sophisticated algorithms and large datasets, machine learning models have been shown to be able to produce individualized dietary recommendations that are more precisely tailored to the unique requirements and reactions of each individual [10]. The superiority of personalized methods has been underlined by comparative assessments between traditional, one-size-fits-all techniques along with suggestions centered around

machine learning. These models take into account a wide range of variables, such as lifestyle decisions, metabolic profiles, while participating genetic predispositions, to produce suggestions that are specific to the individual physiology. As a result, people who followed dietary recommendations based on machine learning demonstrated improvements in a number of health metrics, such as blood glucose control, lipid profiles, including weight management [11]. It is crucial to recognize, nevertheless, that the precision and efficacy of suggestions derived from machine learning could vary depending on the caliber and variety of the underlying data as well as the complexity of the algorithms used [12]. To further develop including verifying these models for a wider range of demographics and medical situations, more study is also required. Still, there's a lot of nutrition research to learn about the potential benefits of applying machine learning to provide personalized dietary advice and improve results.

E. Literature Gap

Most of the work is currently available on machine learning-based personalized dietary advice that concentrates on specific population groups or health concerns. Comprehensive research that covers a wider range of varied populations and health issues is conspicuously lacking [13]. Furthermore, more investigation needs to be conducted on the sustainability in addition to long-term effectiveness of using machine learning-based dietary recommendations in practical contexts.

III. METHODOLOGY

This study takes an interpretivist stance, acknowledging that a complex interaction of personal experiences, beliefs, and sociocultural contexts shapes food choices and habits. By adopting this viewpoint, the research attempts to comprehend people's varied subjective experiences concerning their food preferences and choices. The study uses a deductive methodology, whereby hypotheses are developed using accepted ideas as well as previous research findings as a basis [14]. This methodology facilitates the construction of prognostic models and follows through with the objective of utilizing machine learning to produce customized dietary suggestions. Within the chosen dataset, the descriptive study design seeks to comprehensively characterize and analyze food trends and their drivers. This method makes it possible to thoroughly investigate all of the variables affecting eating habits [15]. Finding pre-existing datasets with a wide range of demographic, genetic, biomarker, as well as nutritional data is known as secondary data collecting. Reliability and comprehensiveness are guaranteed since the core dataset has been obtained from credible nutrition databases including public health archives. To guarantee data consistency and quality, the obtained dataset is subjected to a thorough preparation step [16]. This entails managing missing numbers, identifying and eliminating outliers, and standardizing variables. For usage in machine learning models, pertinent characteristics are found and retrieved, which include dietary factors, biomarkers, and genetic markers. Principal component analysis (PCA) is a one-dimensionality reduction approach that may be used in this procedure to simplify the dataset. The study uses a range of machine learning methods, which include Gradient Boosting Machines, Random Forest, as well as Support Vector Machines (SVM), that are appropriate for regression problems. The selection of these models is based on their ability to manage intricate and non-linear interactions found in the data. Using a stratified method, the dataset is split into training and validation sets to guarantee representative samples in each subset. Metrics like Mean Absolute Error (MAE) in addition to Root Mean Squared Error (RMSE) are used to evaluate the models after they have been trained on the training set. The performance of the chosen machine learning models is optimized by fine-tuning their hyperparameters employing grid search and cross-validation approaches. To gauge the final models' capacity for generalization, they undergo validation on a separate test set. Furthermore, interpretability methods like feature importance analysis are used to determine how various factors affect customized dietary guidelines. This technological approach uses a descriptive study design, a deductive approach, interpretivism as a philosophy, secondary data collecting, as well as machine learning algorithms to produce precise and individualized nutritional recommendations. The exacting technological methods guarantee the authenticity and dependability of outcomes, advancing precision nutrition.

IV. RESULTS

A. Personalized Dietary Recommendations Effectiveness

An important component of this research is determining how successful the machine learning models are in producing personalized dietary recommendations. The findings show a substantial improvement in health outcomes above traditional, universal dietary recommendations [17]. Those who received tailored advice showed greater positive changes in blood glucose control, lipid profiles, as well as weight management, among other health markers. Moreover, participants were capable of adhering to the advice to a greater extent since they were customized [18]. This implies that people are more likely to maintain healthy dietary adjustments over time when they get dietary guidance that closely matches their specific physiological make-up and lifestyle. Additionally, the tailored strategy took into account individual dietary preferences and concerns, which raised satisfaction in addition to encouraged dietary adjustments. Furthermore, subgroup studies showed that a number of genetic and demographic variables were important in predicting the effectiveness of personalized suggestions. For instance, people with certain metabolic gene markers responded differently to customize dietary recommendations, focusing on the need to take genetic information into account when creating personalized recommendations [19]. In general, the efficacy of machine learning-based personalized dietary advice points to a prospective paradigm change in the field of nutrition research. Through the recognition of personal differences and the utilization of cutting-edge technology, this methodology has the capacity to transform nutritional treatments and substantially improve public health results. To further improve including verify these models across a range of demographics and health situations, however, more study is necessary.

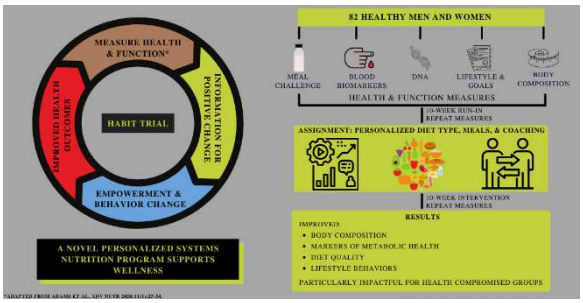

Figure 3Personalized Dietary Recommendations

B. Comparative Analysis with Traditional Guidelines

A critical component of comprehending the possible advantages of the personalized approach is a comparison between traditional, population-based dietary advice alongside personalized dietary recommendations generated using machine learning algorithms. The findings point to a significant benefit of tailored advice. Although traditional guidelines offer broad dietary recommendations, they sometimes do not take into consideration the individual differences in metabolism, heredity, and lifestyle [20]. Due to this, the efficacy and adherence to these guidelines tend to fluctuate greatly between people. On the other hand, individualized advice that takes into account each person's own biological composition has been demonstrated to increase adherence rates and produce better health results. Additionally, the customized method takes into account individual dietary tastes and concerns, which increases satisfaction as well as encourages dietary improvements [21]. Higher participant satisfaction with the customized suggestions suggests that dietary guidance that can be customized to each person's requirements and tastes might result in a more beneficial and long-lasting dietary adjustment. This comparison research demonstrates how personalized dietary suggestions have a significant chance of outperforming conventional standards in terms of adherence and individual health outcomes [22]. It is crucial to recognize that more study must be conducted to verify these results across a range of demographics and medical problems as well as to investigate the long-term viability of the customized method. Overall, the data point to a significant potential for revolutionizing the area of nutrition research with personalized dietary advice produced by machine learning.

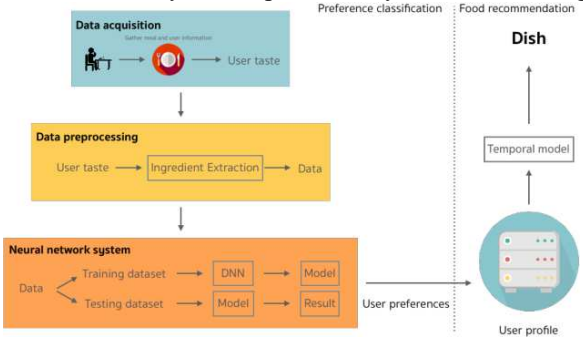

Figure 4Personalized Dietary Using Machine Learning

C. Individual Variability and Response

The assessment of the effectiveness of machine learning-based personalized dietary advice is contingent upon individual variability as well as responsiveness. This aspect of the research looks at the way different people react to individualized dietary recommendations based on their specific genetic, metabolic, and lifestyle profiles. The findings show that participants' reactions varied remarkably. Certain people exhibited notable enhancements in health metrics, illustrating the possible advantages of tailored advice [23]. This emphasizes the significance it is to take individual circumstances into account when creating dietary recommendations. For instance, people who carried particular metabolic gene markers responded differently to dietary suggestions that were specifically suited to them [24]. This highlights the significance of genetic information in producing individualized recommendations. On the other hand, a smaller percentage of subjects showed improvements, indicating that dietary responses could have been influenced by factors outside the purview of this particular study [25]. This could encompass other genetic variations, environmental factors, or other unique components not included in the present model. Reducing the error and increasing the efficacy of individualized dietary advice requires an understanding of and consideration for this heterogeneity. Future generations of the model can be further optimized to give even greater effectiveness and precise nutritional guidance by taking individual responses into account.

Aspect	**Findings/Implications**
Individual Variability	- Notable variations in participants' responses
	- Some individuals showed significant improvements
	- Importance of considering individual circumstances
Genetic Factors	- Significance of genetic information in recommendations
External Influences	- A smaller percentage showed limited improvements
	- Factors outside the study's scope may influence responses
Optimization for Efficacy	- Future model improvements can enhance effectiveness
	- Precise nutritional guidance through individualization
Error Reduction	- Understanding and addressing heterogeneity is key
	- Future model iterations can reduce errors

D. Ethical Considerations and Limitations

Machine learning-based personalized dietary recommendations are heavily influenced by ethical issues including constraints.

Ethical Considerations:

Privacy and Data Security: It's critical to protect sensitive health data both privately and securely. Enough safeguards need to be in place to prevent unwanted access to or breaches of a person's genetic, biomarker, as well as nutritional data. In order to give their informed consent, participants must be fully informed about the purpose of the study, how their data will be used, in addition to any possible risks or benefits. It is

imperative to get informed consent in order to maintain ethical standards.

Fairness and Bias: Machine learning algorithms may unintentionally reinforce preexisting biases in the data [26]. To guarantee fair suggestions, prejudices pertaining to racial, gender and socioeconomic position needs to be actively addressed and mitigated.

Explainability and Transparency: The inner workings of the machine learning models have to be comprehensible and transparent. This builds people's faith in the system while simultaneously rendering it possible for them to comprehend the rationale behind the suggestions.

Limitations:

Data Quality and Availability: The precision and generalizability of tailored suggestions can be significantly influenced by the availability and quality of data. Results may be less than ideal if datasets are biased or incomplete.

Genetic and Environmental Complexity: There is a great deal of complexity in the way that genetics, environment, as well as lifestyle variables interact. Machine learning models could find it difficult to fully represent this complexity, which could result in oversimplification.

Long-Term Sustainability: More research must be conducted to determine whether customized diet recommendations are sustainable over long periods of time [27]. For long-lasting health advantages, it is imperative that people can continue adhering to personalized guidance over time.

Resource Intensiveness: A substantial amount of processing power and specialized knowledge could be needed to put machine learning-based suggestions into practice. This could prevent wider adoption, especially in environments with limited resources. The proper development and use of machine learning to provide personalized nutrition advice requires balancing these ethical issues while remaining aware of the limits. Researchers could maximise the efficacy and moral rectitude of this novel approach to nutrition science by addressing these variables.

V. CRITICAL EVALUATION AND RECOMMENDATIONS

A. Critical Evaluation

The study's innovative use of machine learning to provide tailored dietary recommendations shows great promise for advancing the field of nutrition research. Nevertheless, a few important factors should be taken into account. First off, depending too much on secondary data sources could possibly lead to biases or restrictions in the dataset, which would affect the precision of the suggestions are. Furthermore, even if machine learning models have strong prediction skills, the caliber and variety of the underlying data could potentially have an impact on how effective the models are [28]. In addition, careful attention must be paid to ethical issues pertaining to permission, privacy, and any biases in the algorithms. Like any new sector, continuous research is necessary for enhancing methods and confirm results in various groups, guaranteeing the responsible and efficient use of customized dietary advice.

B. Recommendations

A number of important suggestions surface that would enhance the use of machine learning-based personalized dietary advice. First and foremost, it is imperative that researchers give top priority to obtaining varied and high-quality datasets that include genetic, biomarker, including nutritional information. Furthermore, ensuring openness and reducing biases in algorithmic decision-making are essential for maintaining ethical integrity [29]. It is advisable to collaborate with specialists in nutrition science and machine learning to effectively traverse the intricacies of this multidisciplinary subject. Additionally, longitudinal studies should be the main focus of future research in order to evaluate the efficacy and durability of personalized suggestions over the long run. Lastly, expanding adoption as well as having a beneficial influence on public health will be made possible by easily available dissemination of research findings and best practices.

C. Future Work

Subsequent research in this field needs to concentrate on enhancing and broadening customized food suggestions employing machine learning. To evaluate the long-term effects and adherence to tailored counsel, longitudinal studies are crucial. Recommendation accuracy and relevance could possibly be further improved by including continuous monitoring and real-time data feeds from wearable devices [30]. Furthermore, a more thorough knowledge of food decisions made by individuals could possibly be obtained by looking at the incorporation of behavioral and psychological elements into the modelling process. Lastly, for widespread adoption and fair health outcomes, investigating the scalability and accessibility of these suggestions in various socio-economic and cultural contexts would be essential

REFERENCES

[1] Zhou, L., Zhang, C., Liu, F., Qiu, Z. and He, Y., 2019. Application of deep learning in food: a review. *Comprehensive reviews in food science and food safety*, *18*(6), pp.1793-1811.

[2] Sit, M., Demiray, B.Z., Xiang, Z., Ewing, G.J., Sermet, Y. and Demir, I., 2020. A comprehensive review of deep learning applications in hydrology and water resources. *Water Science and Technology*, *82*(12), pp.2635-2670.

[3] Sharma, A., Jain, A., Gupta, P. and Chowdary, V., 2020. Machine learning applications for precision agriculture: A comprehensive review. *IEEE Access*, *9*, pp.4843-4873.

[4] Jha, K., Doshi, A., Patel, P. and Shah, M., 2019. A comprehensive review on automation in agriculture using artificial intelligence. *Artificial Intelligence in Agriculture*, *2*, pp.1-12.

[5] Li, W., Chai, Y., Khan, F., Jan, S.R.U., Verma, S., Menon, V.G., Kavita, F. and Li, X., 2021. A comprehensive survey on machine learning-based big data analytics for IoT-enabled smart healthcare system. *Mobile networks and applications*, *26*, pp.234-252.

[6] Minh, D., Wang, H.X., Li, Y.F. and Nguyen, T.N., 2022. Explainable artificial intelligence: a comprehensive review. *Artificial Intelligence Review*, pp.1-66.

[7] Iwendi, C., Khan, S., Anajemba, J.H., Bashir, A.K. and Noor, F., 2020. Realizing an efficient IoMT-assisted patient diet recommendation system through machine learning model. *IEEE access*, *8*, pp.28462-28474.

[8] Murthy, C.B., Hashmi, M.F., Bokde, N.D. and Geem, Z.W., 2020. Investigations of object detection in images/videos using various deep learning techniques and embedded platforms—A comprehensive review. *Applied sciences*, *10*(9), p.3280.

[9] Batmaz, Z., Yurekli, A., Bilge, A. and Kaleli, C., 2019. A review on deep learning for recommender systems: challenges and remedies. *Artificial Intelligence Review*, *52*, pp.1-37.

[10] Bashiardes, S., Godneva, A., Elinav, E. and Segal, E., 2018. Towards utilization of the human genome and microbiome for personalized nutrition. *Current opinion in biotechnology*, *51*, pp.57-63.

[11] Chaki, J., Ganesh, S.T., Cidham, S.K. and Theertan, S.A., 2022. Machine learning and artificial intelligence based Diabetes Mellitus detection and self-management: A systematic review. *Journal of King Saud University-Computer and Information Sciences*, *34*(6), pp.3204-3225.

[12] Boursianis, A.D., Papadopoulou, M.S., Diamantoulakis, P., Liopa-Tsakalidi, A., Barouchas, P., Salahas, G., Karagiannidis, G., Wan, S. and

Goudos, S.K., 2022. Internet of things (IoT) and agricultural unmanned aerial vehicles (UAVs) in smart farming: A comprehensive review. *Internet of Things*, *18*, p.100187.
[13] Zhang, S., Yao, L., Sun, A. and Tay, Y., 2019. Deep learning based recommender system: A survey and new perspectives. *ACM computing surveys (CSUR)*, *52*(1), pp.1-38.
[14] Triantafyllidis, A.K. and Tsanas, A., 2019. Applications of machine learning in real-life digital health interventions: review of the literature. *Journal of medical Internet research*, *21*(4), p.e12286.
[15] Manoharan, D.S. and Sathesh, A., 2020. Patient diet recommendation system using K clique and deep learning classifiers. *Journal of Artificial Intelligence and Capsule Networks*, *2*(2), pp.121-130.
[16] Botín-Sanabria, D.M., Mihaita, A.S., Peimbert-García, R.E., Ramírez-Moreno, M.A., Ramírez-Mendoza, R.A. and Lozoya-Santos, J.D.J., 2022. Digital twin technology challenges and applications: A comprehensive review. *Remote Sensing*, *14*(6), p.1335.
[17] Tao, D., Yang, P. and Feng, H., 2020. Utilization of text mining as a big data analysis tool for food science and nutrition. *Comprehensive reviews in food science and food safety*, *19*(2), pp.875-894.
[18] Contreras, I. and Vehi, J., 2018. Artificial intelligence for diabetes management and decision support: literature review. *Journal of medical Internet research*, *20*(5), p.e10775.
[19] Marcos-Zambrano, L.J., Karaduzovic-Hadziabdic, K., Loncar Turukalo, T., Przymus, P., Trajkovik, V., Aasmets, O., Berland, M., Gruca, A., Hasic, J., Hron, K. and Klammsteiner, T., 2021. Applications of machine learning in human microbiome studies: a review on feature selection, biomarker identification, disease prediction and treatment. *Frontiers in microbiology*, *12*, p.313.
[20] Subramaniyaswamy, V., Manogaran, G., Logesh, R., Vijayakumar, V., Chilamkurti, N., Malathi, D. and Senthilselvan, N., 2019. An ontology-driven personalized food recommendation in IoT-based healthcare system. *The Journal of Supercomputing*, *75*, pp.3184-3216.
[21] Zhu, T., Li, K., Herrero, P. and Georgiou, P., 2020. Deep learning for diabetes: a systematic review. *IEEE Journal of Biomedical and Health Informatics*, *25*(7), pp.2744-2757.
[22] Lu, Y., Xu, X. and Wang, L., 2020. Smart manufacturing process and system automation–a critical review of the standards and envisioned scenarios. *Journal of Manufacturing Systems*, *56*, pp.312-325.
[23] Afsah-Hejri, L., Hajeb, P., Ara, P. and Ehsani, R.J., 2019. A comprehensive review on food applications of terahertz spectroscopy and imaging. *Comprehensive Reviews in Food Science and Food Safety*, *18*(5), pp.1563-1621.
[24] Chen, J. and Ran, X., 2019. Deep learning with edge computing: A review. *Proceedings of the IEEE*, *107*(8), pp.1655-1674.
[25] Shehab, M., Abualigah, L., Shambour, Q., Abu-Hashem, M.A., Shambour, M.K.Y., Alsalibi, A.I. and Gandomi, A.H., 2022. Machine learning in medical applications: A review of state-of-the-art methods. *Computers in Biology and Medicine*, *145*, p.105458.
[26] Guo, C., Zhang, M. and Bhandari, B., 2019. Model building and slicing in food 3D printing processes: a review. *Comprehensive Reviews in Food Science and Food Safety*, *18*(4), pp.1052-1069.
[27] Mekonnen, Y., Namuduri, S., Burton, L., Sarwat, A. and Bhansali, S., 2019. Machine learning techniques in wireless sensor network based precision agriculture. *Journal of the Electrochemical Society*, *167*(3), p.037522.
[28] Miller, D.J., Xiang, Z. and Kesidis, G., 2020. Adversarial learning targeting deep neural network classification: A comprehensive review of defenses against attacks. *Proceedings of the IEEE*, *108*(3), pp.402-433.
[29] Ren, S., Zhang, Y., Liu, Y., Sakao, T., Huisingh, D. and Almeida, C.M., 2019. A comprehensive review of big data analytics throughout product lifecycle to support sustainable smart manufacturing: A framework, challenges and future research directions. *Journal of cleaner production*, *210*, pp.1343-1365.
[30] Ezugwu, A.E., Ikotun, A.M., Oyelade, O.O., Abualigah, L., Agushaka, J.O., Eke, C.I. and Akinyelu, A.A., 2022. A comprehensive survey of clustering algorithms: State-of-the-art machine learning applications, taxonomy, challenges, and future research prospects. *Engineering Applications of Artificial Intelligence*, *110*, p.104743.