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COMPARISON OF CLASSIFICATION METHODS AND CLUSTERING HYBRID DEEP NEURAL NETWORK DETECTION OF SENSITIVE INGREDIENTS IN FOOD PRODUCTS

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ABSTRACT

I.

Cases of Death of Indonesian People Due to Food Poisoning, Especially Packaged Foodstuffs are Assessed as High Enough. According to BPOM data, cases of food poisoning are more than 2000 cases per year. This is due to the lack of literacy received by the community about the composition of ingredients in food products. So that innovation is needed with an in-depth analysis of the design of a smart system that can be used by the public to identify certain compositions or ingredients shown in the composition table of a product. Before designing a smart system, an in-depth analysis will be carried out using the Hybrid Deep Neural Network method and comparing it with other methods in order to get the best method that can be implemented in the smart system later. This study aims to classify and cluster product image data and food composition data by developing a hybrid deep neural network and comparing with other methods, namely KNN, Tree, SVM, and linear regression as well as clustering using Hierarchical clustering and K-Means methods. a system designed from a combination of these methods can provide accurate, effective and efficient detection results. The stages of the research method are (1) Observation and Collection of Image Data and categorical composition of Food Composition, Nutritional Value, and Characteristics of food, (2) propocesing categorical datasets (3) Embedded Image data (4) Clustering data using Hierarchical Clustering and K-Means (5) classification of image data using Deep Neural Network (6) classification of image data using KNN, Tree, SVM, and linear regression (7) Training and testing models (8) Comparing and Evaluation Models. From the results of the analysis, it was found that for Categorical data, the RMSE value of the KNN model was 0.085, the MSE value was 0.007, the MAE value was 0.068 and the R2 value was 0.158. Furthermore, the Tree model has the RMSE value of 0.118, the MSE value is 0.014, the MAE value is 0.091 and the R2 value is 0.608. Furthermore, the SVM model, the RMSE value is 0.091, the MSE value is 0.008, the MAE value is 0.078 and the R2 value is 0.044. Furthermore, the Neural Network RMSE value is 0.117, the MSE value is 0.014, the MAE value is 0.089 and the R2 value is 0.574. and the last is linear regression, the RMSE value is 0.086, the MSE value is 0.007, the MAE value is 0.067 and R2 is 0.153. so that the best model in this case is KNN which is 0.915 or 91, 5% . Furthermore, for Categorical, the results are that the KNN precision value is 0.457, then the Tree precision value is 0.390, for the SVM method the precision value is 0.311, the Precision Neural Network value is 0.387, the nave Bayes precision value is 0.336 and the logistic Regression is 0.349 and the highest precision value is for this case is KNN. Furthermore, for Hierarchy clustering, very good results were found with the number of Clusters as much as 2 clusters, namely Sweet and Salty, and more Salty clusters were seen and for hypertension disease, the highest calorie content of sensitive ingredients was Fat and Salt 36.56%.

Keywords: *Deep Neural Network, Sensitive Ingredients, Food Products*

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1. INTRODUCTION

Cases of deaths of Indonesian people due to food poisoning, especially dangerous packaged food ingredients, are considered quite high. In 2021, 44 volunteers and refugees in East Java were suspected of having food poisoning and dozens of children in Papua were suspected of being poisoned after eating food from an event. According to BPOM (Food and Drug Administration) data, cases of food poisoning are more than 2000 cases per year. In 2019, the number of victims of food poisoning in Indonesia reached 3,637 people [1][2][3]

This is due to the lack of literacy received by coastal communities about the terms contained in food products and the composition of ingredients in food products, especially processed foods such as instant noodles, snacks. In addition, coastal communities do not understand and care less about the impact of health factors from consuming packaged food, so an innovation with in-depth analysis of a smart system that can be used by the community to identify certain compositions and ingredients is seen in the composition. packaged food table is needed easier to use It is a smart application, and it is hoped that this system can show the content, dosage, composition of packaged food products that are right for consumption, especially by coastal communities, and can identify the composition of ingredients that are halal and safe for consumption for the Muslim community in Indonesia.[4][5]

According to research data from the Ministry of Transportation of the Republic of Indonesia, currently almost 85% of coastal communities have used smartphones, so that with this data coastal communities have a good level of readiness to use application systems. this system. The specific objective of this research is the absence of an intelligent system to detect the composition of food ingredients that are good and safe for consumption based on images and barcodes using the hybrid deep neural network method. The neural network method is known as one of the artificial intelligence methods that can be used to detect based on image recognition, barcodes and text. [6][7][8]

However, currently there is no development of hybrid deep neural network, conventional neural network and recurrent neural network methods that can be combined in an intelligent system to detect sensitive food products which are expected to provide accurate, effective and efficient detection results.

2. PROBLEM STATEMENT

Furthermore, the formulation of the problem statement in this study is:
How to analyse sensitive food ingredients in food product samples using neural network method in hybrid and ow is the accuracy level of the Hybrid Deep Neural Network method analysis on sensitive food ingredients contained in Food Product Samples.

Feasibility study in this study requires in-depth research, testing methods.[1][9]

Development of a model so that it can be tested on an intelligent system to detect the composition, whether a food ingredient is good for consumption or bad.

3. RESEARCH OBJECTIVE

The scope of this research is to classify, and cluster sensitive food ingredients, as well as compare with other methods in order to obtain the best model, namely, SVM, Random Forest, KNN, Tree and others.

4. RESEARCH CONTRIBUTION

The contribution of this research is that this study aims to classify and cluster product image data and food composition data by developing a hybrid deep neural network and comparing it with other methods, namely KNN, Tree, SVM, and linear regression as well as clustering using the Hierarchy clustering method and K- Means, so it is hoped that the system designed from the combination of these methods can provide accurate, effective and efficient detection results.

5. RESEARCH HYPOTHESIS

The first hypothesis in this study is the classification and clustering model can classify and cluster sensitive food ingredients > 90%.

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6. PROPOSED METHODOLOGY

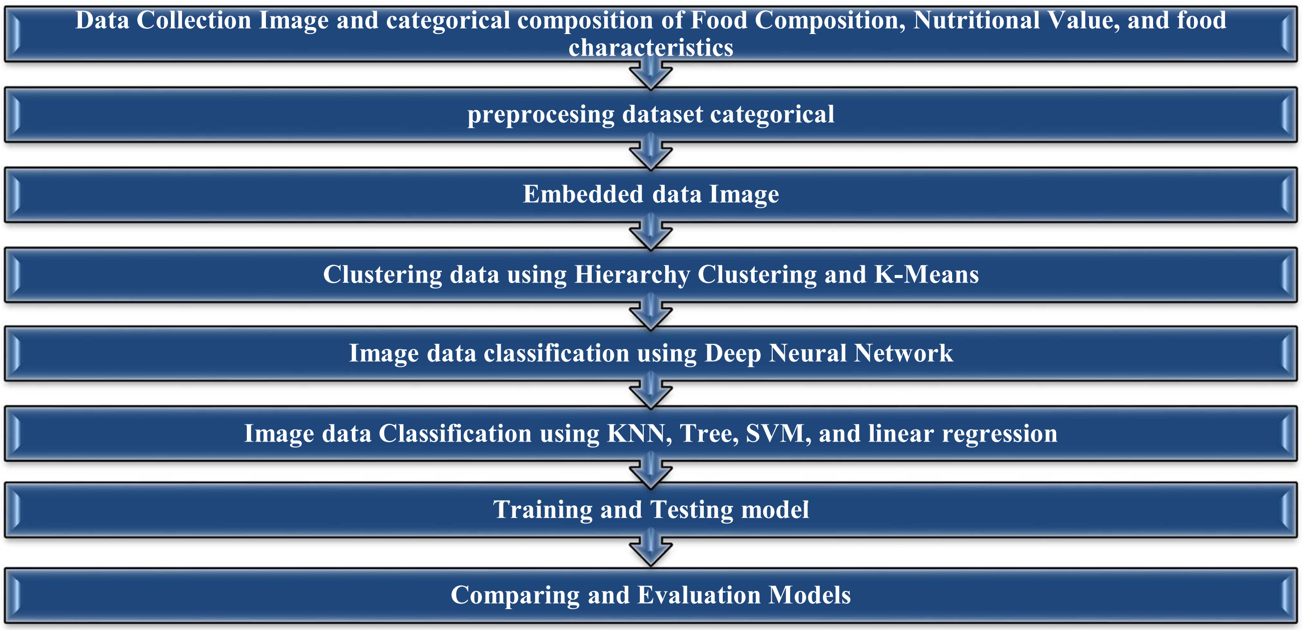

Fig 1. Proposed Methodology

7. Result And Discussion

a. Data Collection Image and categorical composition of Food Composition, Nutritional Value, and food characteristics

In this phase, observations will be made from literature, journals and previous research regarding the composition of sensitive food ingredients, nutritional values and people's diets. The data collected is as follows:

- Image data and barcodes on the composition of sensitive foodstuffs, especially instant noodles, snack foods, based on BPOM (Food and Drug Administration) data.
- Nutritional value standard data.
- Data on the characteristics of a healthy diet and the types of food often consumed by coastal communities are in accordance with BPOM (Food and Drug Administration) and Ministry of Health standards.
- Data on Dominant diseases that often suffer from coastal communities. Furthermore, image data analysis was carried out using the deep learning method.

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Energy /Calorie	Total Calories	Energy / Calorie (Gram)	Translation results Nutritional	Disease
Total fat	70 kkal	1.5	2	Diabetes
Saturated Fat	70 kkal	1.5	8	Hypertensi
Protein	70 kkal	1	3	Diarhhea
Carbohidrat	70 kkal	12	4	Diabetes
Sugar	70 kkal	1	5	hypertension
Salt	70 kkal	0.85	6	Diarrhea
Total fat	50kkal	1.5	2	Diabetes
Saturated Fat	50kkal	1.5	8	hypertension
Protein	50kkal	1	3	Diarrhea
Carbohidrat	50kkal	12	4	Diabetes
Sugar	50kkal	1	5	Diabetes
Salt	50kkal	0.85	6	Diabetes
Total fat	140kkal	1.5	2	hypertension
Protein	140kkal	1.5	8	Diarrhea
karbohidrat total	140kkal	1	4	hypertension
protein	140kkal	12	4	Diarrhea
Food Fiber	140kkal	1	6	Diabetes
Sugar	140kkal	0.85	7	Diarrhea
Salt	140kkal	0.85	7	hypertension

Fig 2. Dataset Categorical

b. Preprocecing dataset categorical

In this phase, preprocessing of data is carried out. For Categorical Data, there are 5 inputs, namely composition, energy, calories, nutrition and the target output is diseases. As for the image data used data from food product packaging as much as 155 data. The selection of critique criteria from (Food and Drug Administration) and Ministry of Health standards. In this phase, the data that has been collected will be preprocessed[10][11][12].

Data Reduction is used to handle missing values or missing and incomplete data in the database as well as cleaning data noise

c. Embedded data Image

Next is the embedded data image from 155 data to 2048 image data to facilitate a better clustering process. because the image will be seen from the right side, top left and bottom.

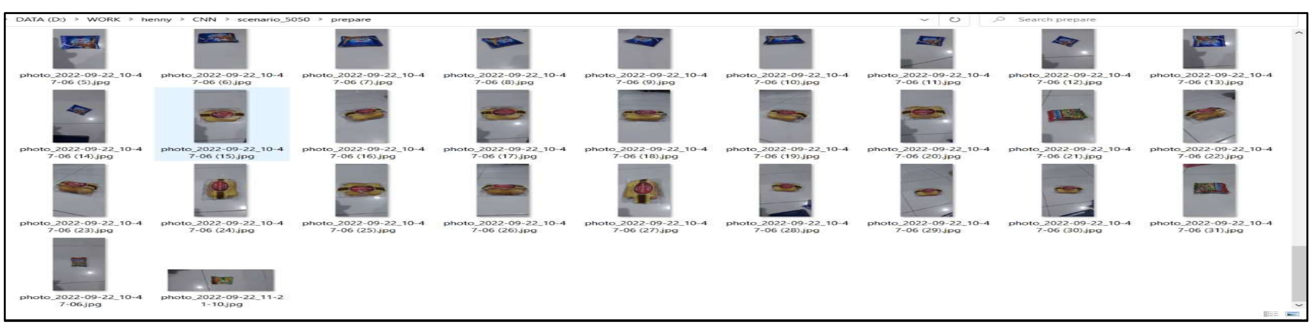

Fig 3. Dataset Image

a. Clensing data to form a balanced dataset according to the model and system to be tested.

b. Data Transformation where the data will be normalized and generalized.

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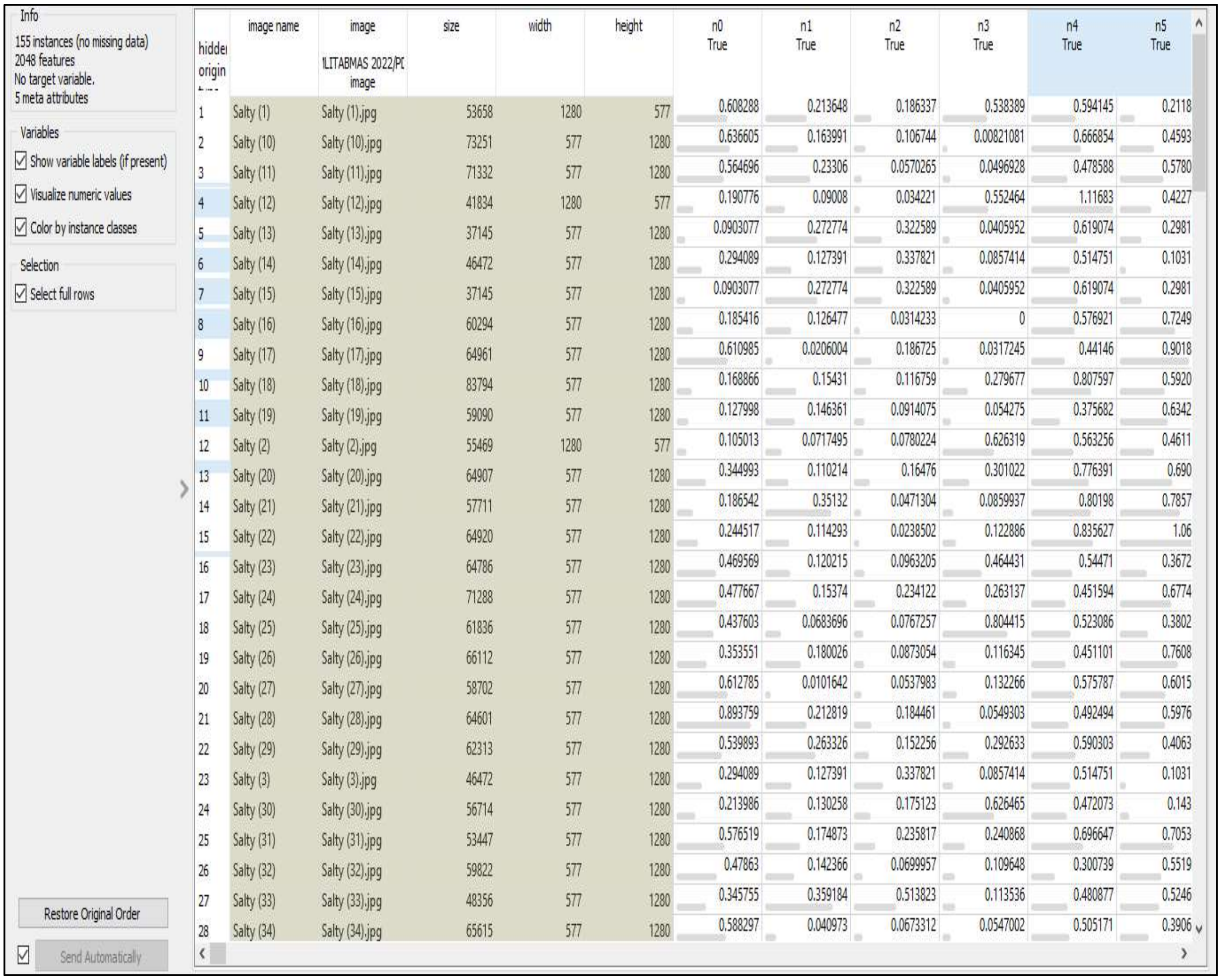


hidden origin	image name	image ILITABMAS 2022/PI image	size	width	height	n0 True	n1 True	n2 True	n3 True	n4 True	n5 True
1	Salty (1)	Salty (1).jpg	53658	1280	577	0.608288	0.213648	0.186337	0.538389	0.594145	0.2118
2	Salty (10)	Salty (10).jpg	73251	577	1280	0.636605	0.163991	0.106744	0.00821081	0.666854	0.4593
3	Salty (11)	Salty (11).jpg	71332	577	1280	0.564696	0.23306	0.0570265	0.0496928	0.478588	0.5780
4	Salty (12)	Salty (12).jpg	41834	1280	577	0.190776	0.09008	0.034221	0.552464	1.11683	0.4227
5	Salty (13)	Salty (13).jpg	37145	577	1280	0.0903077	0.272774	0.322589	0.0405952	0.619074	0.2981
6	Salty (14)	Salty (14).jpg	46472	577	1280	0.294089	0.127391	0.337821	0.0857414	0.514751	0.1031
7	Salty (15)	Salty (15).jpg	37145	577	1280	0.0903077	0.272774	0.322589	0.0405952	0.619074	0.2981
8	Salty (16)	Salty (16).jpg	60294	577	1280	0.185416	0.126477	0.0314233	0	0.576921	0.7249
9	Salty (17)	Salty (17).jpg	64961	577	1280	0.610985	0.0206004	0.186725	0.0317245	0.44146	0.9018
10	Salty (18)	Salty (18).jpg	83794	577	1280	0.168866	0.15431	0.116759	0.279677	0.807597	0.5920
11	Salty (19)	Salty (19).jpg	59090	577	1280	0.127998	0.146361	0.0914075	0.054275	0.375682	0.6342
12	Salty (2)	Salty (2).jpg	55469	1280	577	0.105013	0.0717495	0.0780224	0.626319	0.563256	0.4611
13	Salty (20)	Salty (20).jpg	64907	577	1280	0.344993	0.110214	0.16476	0.301022	0.776391	0.690
14	Salty (21)	Salty (21).jpg	57711	577	1280	0.186542	0.35132	0.0471304	0.0859937	0.80198	0.7857
15	Salty (22)	Salty (22).jpg	64920	577	1280	0.244517	0.114293	0.0238502	0.122886	0.835627	1.06
16	Salty (23)	Salty (23).jpg	64786	577	1280	0.469569	0.120215	0.0963205	0.464431	0.54471	0.3672
17	Salty (24)	Salty (24).jpg	71288	577	1280	0.477667	0.15374	0.234122	0.263137	0.451594	0.6774
18	Salty (25)	Salty (25).jpg	61836	577	1280	0.437603	0.0683696	0.0767257	0.804415	0.523086	0.3802
19	Salty (26)	Salty (26).jpg	66112	577	1280	0.353551	0.180026	0.0873054	0.116345	0.451101	0.7608
20	Salty (27)	Salty (27).jpg	58702	577	1280	0.612785	0.0101642	0.0537983	0.132266	0.575787	0.6015
21	Salty (28)	Salty (28).jpg	64601	577	1280	0.893759	0.212819	0.184461	0.0549303	0.492494	0.5976
22	Salty (29)	Salty (29).jpg	62313	577	1280	0.539893	0.263326	0.152256	0.292633	0.590303	0.4063
23	Salty (3)	Salty (3).jpg	46472	577	1280	0.294089	0.127391	0.337821	0.0857414	0.514751	0.1031
24	Salty (30)	Salty (30).jpg	56714	577	1280	0.213986	0.130258	0.175123	0.626465	0.472073	0.143
25	Salty (31)	Salty (31).jpg	53447	577	1280	0.576519	0.174873	0.235817	0.240868	0.696647	0.7053
26	Salty (32)	Salty (32).jpg	59822	577	1280	0.47863	0.142366	0.0699957	0.109648	0.300739	0.5519
27	Salty (33)	Salty (33).jpg	48356	577	1280	0.345755	0.359184	0.513823	0.113536	0.480877	0.5246
28	Salty (34)	Salty (34).jpg	65615	577	1280	0.588297	0.040973	0.0673312	0.0547002	0.505171	0.3906

Fig 4. Dataset Embedded Image

d. Clustering data using Hierarchy Clustering and K-Means

Furthermore, data clustering is carried out using Hierarchical Clustering and K-Means[13][10][14] with the number of clusters 2 and the number of iterations being 300 with 2048 data.

In the Clustering Process, it was found that the grouping results were very good, in the sense that the K – Means model could classify sweet and salty food products very well.

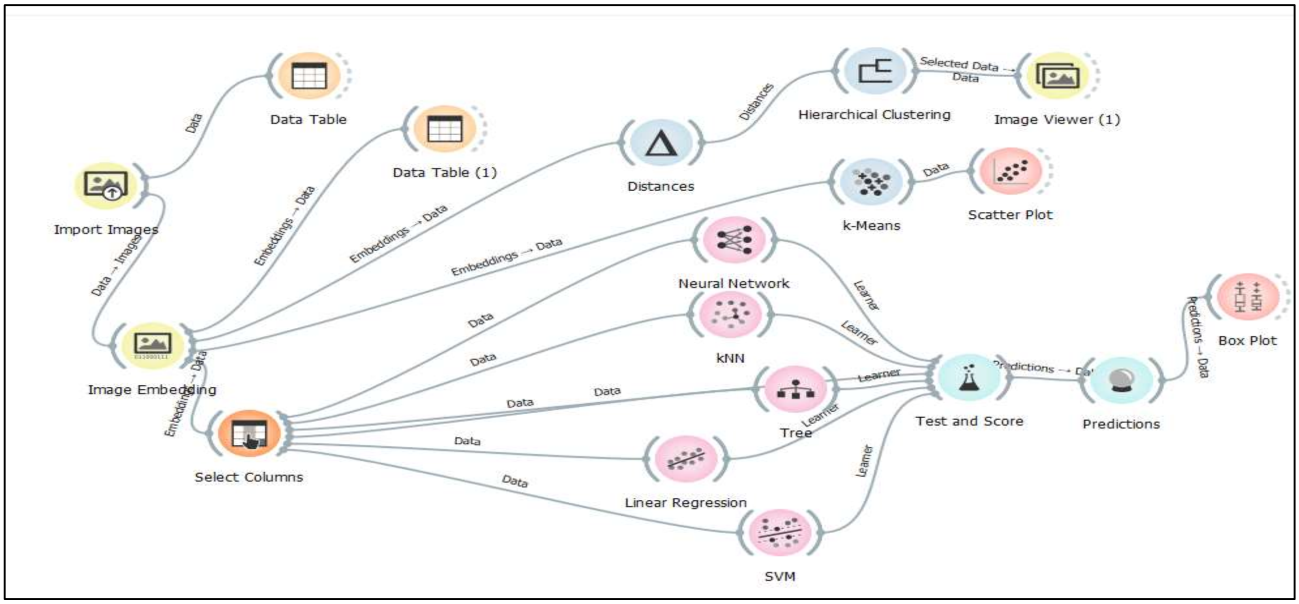
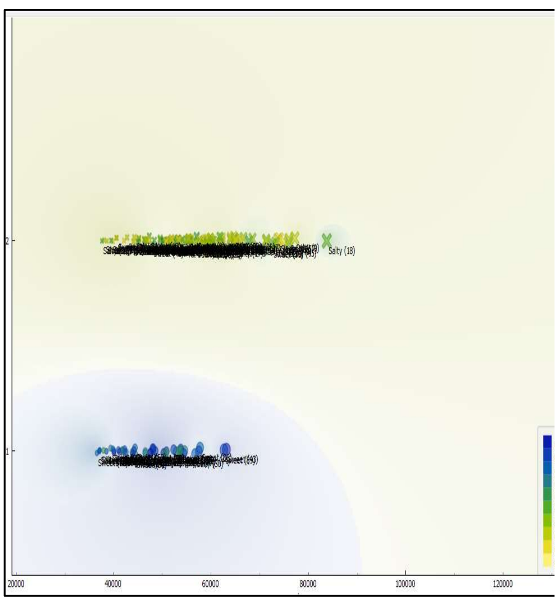
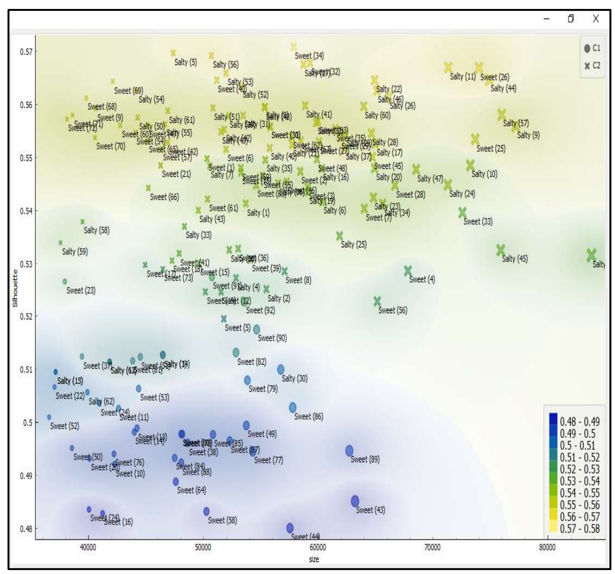


Fig 5. Clustering Models Using Hierarchical Clustering And K-Means





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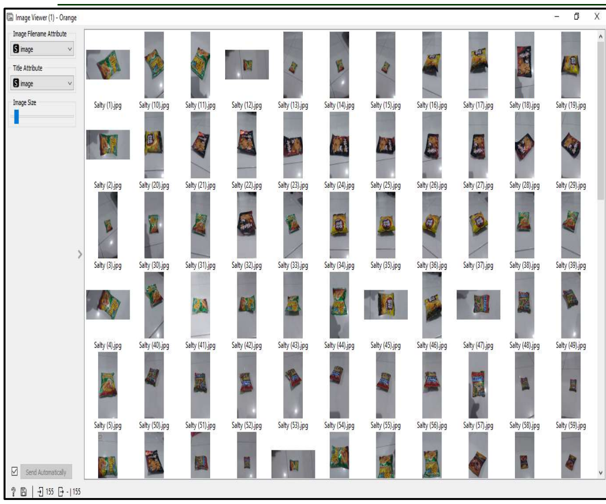

Fig 6. Clustering Models Of Sweet And Salty Products

e. Image data classification using Deep Neural Network

The next step is to classify the image data using a Deep Neural Network with 2048 image data as input. In the Neural Network method, the activation function tanh, adam, with hidden layers is 100, 100, 500.

Model	MSE	RMSE	MAE	R2
kNN	0.007	0.085	0.068	0.158
Tree	0.014	0.118	0.091	-0.608
SVM	0.008	0.091	0.078	0.044
Neural Network	0.014	0.117	0.089	-0.574
Linear Regression	0.007	0.086	0.067	0.153

Fig 7 . Image Data Classification Using Deep Neural Network

f. Classification of image data using KNN, Tree, SVM, and linear regression

Classification of image data uses other methods such as KNN, , SVM, Linear Regression, and Tree which will later train the Hybrid Deep Neural Network model on the system using hyperparameters, hidden layers and activation functions[15][16][6]. From the results of the analysis, it was found that for Categorical data, the RMSE value of the KNN model was 0.085, the MSE value was 0.007, the MAE value was 0.068 and the R2 value was 0.158. Furthermore, the Tree model has the RMSE value of 0.118, the MSE value is 0.014, the MAE value is 0.091 and the R2 value is 0.608. Furthermore, the SVM model, the RMSE value is 0.091, the MSE value is 0.008, the MAE value is 0.078 and the R2 value is 0.044. Furthermore, the Neural Network RMSE value is 0.117, the MSE value is 0.014, the MAE value is 0.089 and the R2 value is 0.574. and the last is linear regression, the RMSE value is 0.086, the MSE value is 0.007, the MAE value is 0.067 and R2 is 0.153. so that the best model in this case is KNN which is 0.915 or 91, 5%. [8][17][18].

g. Categorical data classification using neural Network, KNN, Tree, SVM , dan linear regression

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	Komposisi	Energy /Calorie	Total Calories	ergy / Calorie (Grar	AKG (21 / 5,000 Translation results ional Adequacy Rat	Disease
1	Minyak Nabati	protein	50kkal	12.00	5	Diabetes
2	Lesitin kedelai	Food Fiber	50kkal	1.00	2	hypertension
3	tepung Tapioka	Sugar	50kkal	0.85	4	Diabetes
4	Karamel	Salt	50kkal	0.85	2	hypertension
5	Perisa Vanila	Food Fiber	50kkal	3.00	3	Diarrhea
6	Perisa Susu	Sugar	50kkal	2.00	5	Diabetes
7	Perisa Pandan	Salt	50kkal	1.50	2	hypertension
8	Flour	Total fat	70kkal	3.00	4	Diarrhea
9	Sugar	Carbohidrat	70kkal	2.00	3	hypertension
10	Minyak nabati	Saturated Fat	70kkal	1.50	2	hypertension
11	Lemak nabati	protein	70kkal	1.00	1	Diarrhea
12	kakao bubuk	Carbohidrat	70kkal	11.00	1	Diabetes
13	Dekstrosa	Sugar	70kkal	5.00	2	Diabetes
14	Pati jagung	Salt	70kkal	0.55	2	hypertension
15	Sirup Tinggi Fru...	Total fat	70kkal	12.00	2	Diarrhea
16	Maltodekstrin	Carbohidrat	70kkal	1.00	4	hypertension
17	Pengembang N...	Saturated Fat	70kkal	0.85	3	hypertension
18	salt	protein	70kkal	0.85	2	Diabetes
19	Lesitin kedelai	Carbohidrat	70kkal	0.85	2	hypertension
20	Perisa Sintetik	Sugar	70kkal	0.85	2	Diarrhea
21	Flour Gluten	Salt	45kal	2.00	3	hypertension
22	Sugar	Saturated Fat	45kal	1.50	2	hypertension
23	Air	Protein	45kal	1.00	2	Diabetes
24	minyak Nabati	Carbohidrat	45kal	6.00	3	hypertension
25	Margarin pewar...	Sugar	45kal	2.00	1	Diarrhea
26	Ekstrak Anato	Salt	45kal	0.15	2	hypertension
27	Kurikumin	Protein	45kal	6.00	2	hypertension
28	Pengawet kaliu...	Carbohidrat	45kal	2.00	3	hypertension
29	Antioksidan	Sugar	45kal	0.15	1	Diabetes

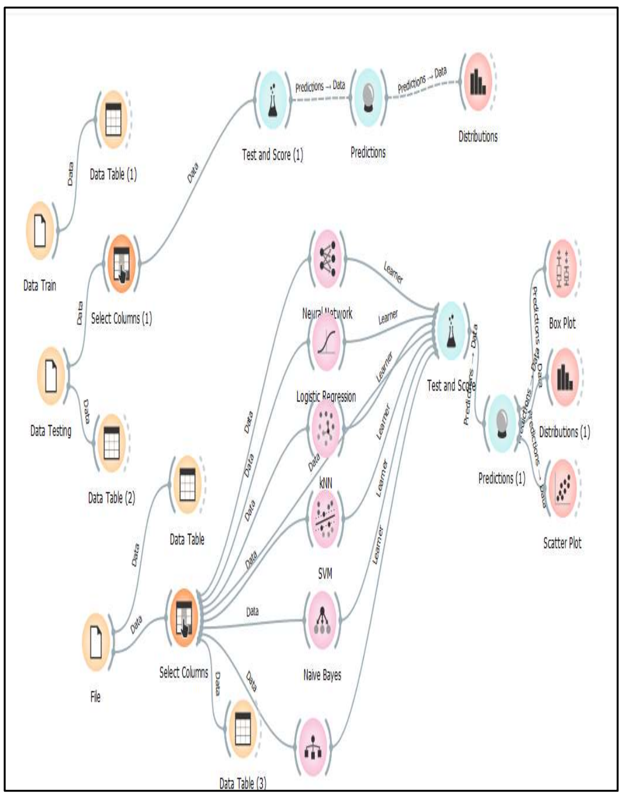
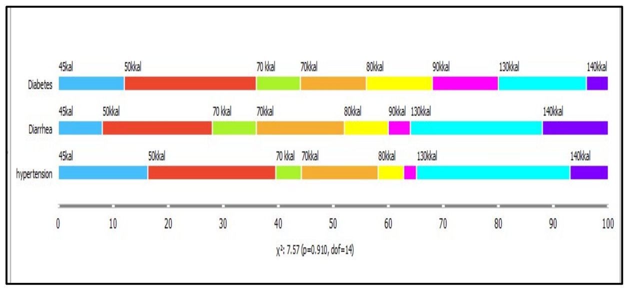


Fig 8 . Categorical Data Classification Using Deep Neural Network KNN, Tree, SVM , And Linear Regression

h. Training and Testing model

Furthermore, the training process is carried out on the Neural Network method and other models as well as Testing.

Disease	Komposisi	Neural Network	ogistic Regressior	kNN	SVM	Naive Bayes	Tree	ral Network (Diab	ral Network (Diarr	Network (hyperte	ic Regression (Dia	ic Regressic
Diarrhea	Bumbu Kecap	Diabetes	hypertension	hypertension	hypertension	hypertension	hypertension	0.829847	0.00237949	0.167773	0.251742	0.112637
Diabetes	Flour	hypertension	Diarrhea	Diarrhea	hypertension	Diarrhea	hypertension	1.10034e-05	0.00242738	0.997562	0.0913206	0.482911
hypertension	Sugar	hypertension	hypertension	Diabetes	hypertension	hypertension	hypertension	0.00035084	0.369688	0.629961	0.217453	0.135363
Diarrhea	salt	hypertension	hypertension	Diarrhea	hypertension	hypertension	Diarrhea	0.00298453	0.00385947	0.993156	0.273617	0.312756
hypertension	MInyak nabati	Diarrhea	Diabetes	hypertension	hypertension	Diabetes	hypertension	0.150646	0.618979	0.230376	0.352256	0.322231
Diabetes	Sirup Glukosa	hypertension	hypertension	hypertension	hypertension	hypertension	hypertension	0.00804745	0.00995485	0.981998	0.162769	0.306962



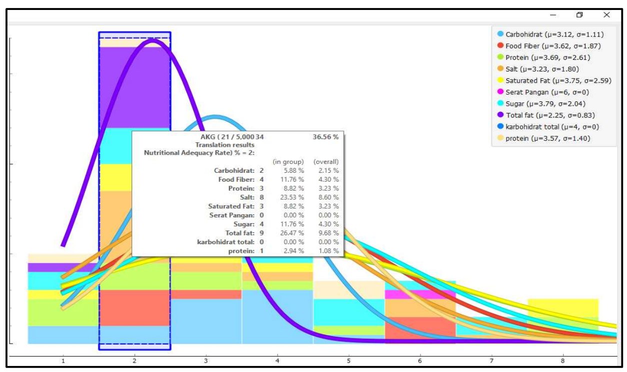


Fig 9. Classification Result Neural Network

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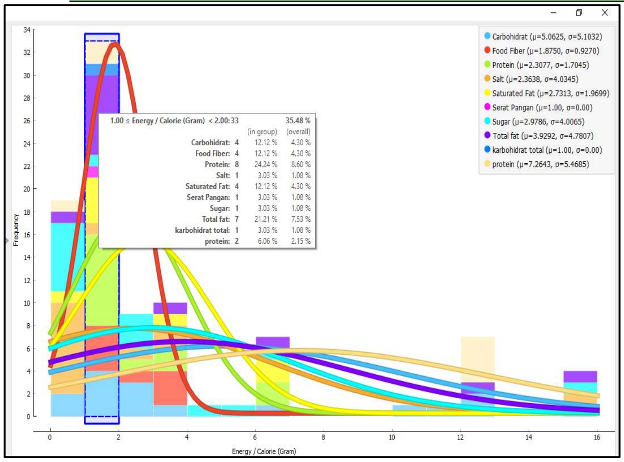

Fig 9. Classification Result Calori / Energy

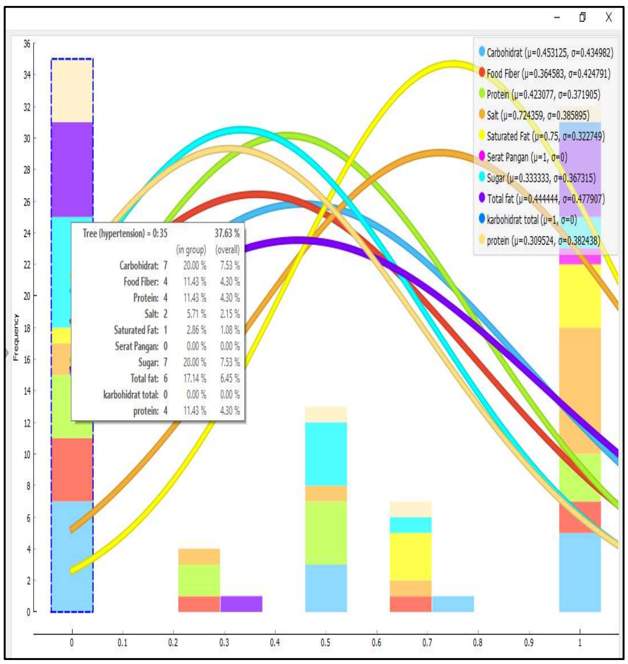

Fig 10. Classification Result Tree

Furthermore, for Hierarchy clustering, excellent results were found with the number of Clusters as much as 2 clusters, namely Sweet and Salty, and more Salty clusters were seen and for the results of disease classification, more results were found for Hypertension with the highest calorie content of sensitive ingredients being Fat and Salt 36,56 %.

i. Comparing and Evaluation Models

Furthermore, Comparing and Evaluation of the Model is carried out by looking at the RMSE, MSE, MAE, Precision, Recall, AUC values, CA values and F1 values

Model	AUC	CA	F1	Precision	Recall
kNN	0.573	0.452	0.454	0.457	0.452
Tree	0.548	0.376	0.382	0.390	0.376
SVM	0.497	0.419	0.337	0.311	0.419
Neural Network	0.540	0.398	0.392	0.387	0.398
Naive Bayes	0.429	0.323	0.329	0.336	0.323
Logistic Regression	0.493	0.409	0.365	0.349	0.409

Figure 11. Result And Comparing Research

8. CONCLUSION

From the results of the analysis, it was found that for Categorical data, the RMSE value of the KNN model was 0.085, the MSE value was 0.007, the MAE value was 0.068 and the R2 value was 0.158. Furthermore, the Tree model has the RMSE value of 0.118, the MSE value is 0.014, the MAE value is 0.091 and the R2 value is 0.608. Furthermore, the SVM model, the RMSE value is 0.091, the MSE value is 0.008, the MAE value is 0.078 and the R2 value is 0.044. Furthermore, the Neural Network RMSE value is 0.117, the MSE value is 0.014, the MAE value is 0.089 and the R2 value is 0.574. and the last is linear regression, the RMSE value is 0.086, the MSE value is 0.007, the MAE value is 0.067 and R2 is 0.153. so that the best model in this case is KNN which is 0.915 or 91, 5% . Furthermore, for Categorical, the results are that the KNN precision value is 0.457, then the Tree precision value is 0.390, for the SVM method the precision value is 0.311, the Precision Neural Network value is 0.387, the nave Bayes precision value is 0.336 and the logistic Regression is 0.349 and the highest precision value is for this case is KNN. Furthermore, for

Hierarchy clustering, very good results were found with the number of Clusters as much as 2 clusters, namely Sweet and Salty, and more Salty clusters were seen and for hypertension disease, the highest calorie content of sensitive ingredients was Fat and Salt 36.56%. It is known that the DeepNeural Network can analyze sensitive food ingredients in food product samples using the hybrid Neural Network method and the accuracy of the Hybrid Deep Neural Network method analysis on sensitive food ingredients contained in Food Product Samples is 91,5%.[19][20] . strengths and weakness from the result is Strengths of the Research are known that the Deep Hybrid Neural Network can classify with an accuracy rate of 91.5% by studying cases of sensitive material samples of food products and Weakness of the Research is that currently the number of criteria used still uses image data and categorical data and it is still possible to use other data and analysis methods.

9. FUTURE RESEARCH

For further research, more than 2 clusters can be used and increase the number of criteria to be able to further increase the accuracy value of this case. Furthermore, the implementation of this Hybrid Method can be carried out in applications such as mobile applications to make it easier for users to detect sensitive ingredients in packaged food products.

10. CONFLICTS OF INTEREST

The author declares that there is no conflict of interest in this study, both at the time of data collection and research results.

11. AUTHOR CONTRIBUTIONS

For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should.

12. ACKNOWLEDGMENTS

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