Development of Classification Model for Public Perception of Nuclear Energy in Social Media Platform using Machine Learning: Facebook Platform in Thailand

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Abstract: Due to the accident consequence of Fukushima Daiichi NPPs, the public acceptance of nuclear energy has decreased in many countries including Thailand. To overcome the public acceptance challenge in Thailand, it is important to understand the public perception in a wide range to improve the proper nuclear energy learning. Currently, analysis of social media is a significant approach to understanding public perception with large comments and expressions. Machine learning is a popular technique that was used to learn big data from social media platforms to create models to predict public perception. The authors applied machine learning to understand and predict the public perception of nuclear energy through social media in Thailand. The objective was to develop classification models for public perception of the nuclear energy of Thai people on social media platforms focusing on Facebook using machine learning in order to use the classification models to understand the public perceptions that people have a neutral opinion or biased opinion on nuclear energy news. The selected Facebook news related to the update of nuclear power plant technology was learned in the machine learning process to compare the ability of the classification models and select the proper model to be representative. In the authors' judgment, the majority (74%) of the comments on Facebook were the people who have neutral opinions. Thus, it is the opportunity of Thailand on behalf of the country not having NPPs to convince these people to understand the proper nuclear perception to support the direction of the future nuclear energy plan in Thailand. In the evaluation of the model, the accuracy of the selected classification model was only 58% of the author's judgments results. The improvement in the perception categorization step in the language translation was needed to improve the model accuracy for future work.

1. INTRODUCTION AND BACKGROUND

Since the severe accidents of Nuclear Power Plants (NPPs) of Fukushima Daiichi occurred in 2011, the radioactive consequences from the accident significantly affected people around the world [1]. The Fukushima Daiichi accident dramatically contributed to the changes in nuclear energy policy and the decrease in public acceptance in many regions including East and Southeast Asia countries that are geographically the closest neighboring countries to the situation of the Fukushima Daiichi accident. Thailand which is one of the Southeast Asia countries was affected by the nuclear consequences of the Fukushima Daiichi accident. In 2012, after happening the Fukushima Daiichi accident, the NPP project in Thailand was indefinitely postponed by the Thailand Government in order to study nuclear safety more [2]. In 2018, the NPP project was not contained as the official nuclear energy plan in the Power Development Plan for Thailand [3]. In the same way, the public acceptance of nuclear energy in

Thailand has also decreased significantly as in many countries [1]. Although Thailand has a public acceptance issue for NPPs, nuclear energy still has the potential to serve a carbon neutrality society. In 2022, the carbon neutrality society is the main goal under the National Energy Plan of Thailand [4]. Since nuclear energy is the dominant future source that possibly contributes to the goal of carbon neutrality in Thailand, the understanding of the public perception of nuclear energy became an important challenge to reinforce the public acceptance of the country.

Therefore, to overcome the public acceptance challenge in Thailand, it is important to understand the public perception in a wide range not only specific groups in order to improve the proper nuclear energy learning activities. In the past, a survey aiming to contribute to public acceptance was conducted using questionnaires to explore the people's opinions about nuclear energy in Thailand [5]. Though statistical results from the survey could somehow reflect some aspects of public perception towards nuclear power in Thailand, it is time-consuming and not cost-efficient. Moreover, if there are a number of questions to answer, people might feel troublesome and would not utterly express their feelings and opinions. Recognizing this issue, Thailand Institute of Nuclear Technology (TINT) decided to use a questionnaire with focus-group meetings to explore the public perception of a nuclear research reactor in order to prepare for the planned construction of the new Thailand Research Reactor in Ongkharak, Nakhon Nayok. Structural Equation Modeling (SEM) was employed for the analysis of the results which led to a significantly better understanding of the elements that contribute to the public acceptance of the research reactor [6]. However, this approach still requires significant investment to conduct focus group meetings. Social media, such as Facebook, YouTube, and Twitter, are influential to people around the world [7] and could potentially serve as a more cost-effective resource for the comprehension of public perception. There were large comments and expressions on these platforms. Thus, the surveys using data collections from these social media platforms are the possible approach in various fields directly and indirectly. Machine learning is a popular technique that was used to learn the existing data in order to help create a model to predict the trend of perception.

For years, artificial intelligence and machine learning technique have been applied in nuclear science and engineering in various areas such as the prediction of loss of flow accident progress in NPPs [8], the optimization of radiation detection and monitoring systems [9], as well as the study of the understanding of public perception [10]. In 2017, Korea proposed big data analysis using Bayesian statistics-based machine learning to identify the public attitudes toward nuclear power after the Fukushima Daiichi accident to develop nuclear businesses and improve public acceptance in the country [10]. In early 2022, there was a public sentiment analysis on nuclear energy in German-speaking countries in which the public comments on nuclear news on social media were collected and analyzed by automatic analysis by using machine learning algorithms to understand the public real opinions such as neutral sentiment, positive sentiment, and negative sentiment [11]. In 2022, due to Thailand still having the public acceptance challenge, it is important to apply the machine learning technique to understand and predict the public perception of nuclear energy in a wide range through social media platforms that contain big data from a lot of people's opinions and comments.

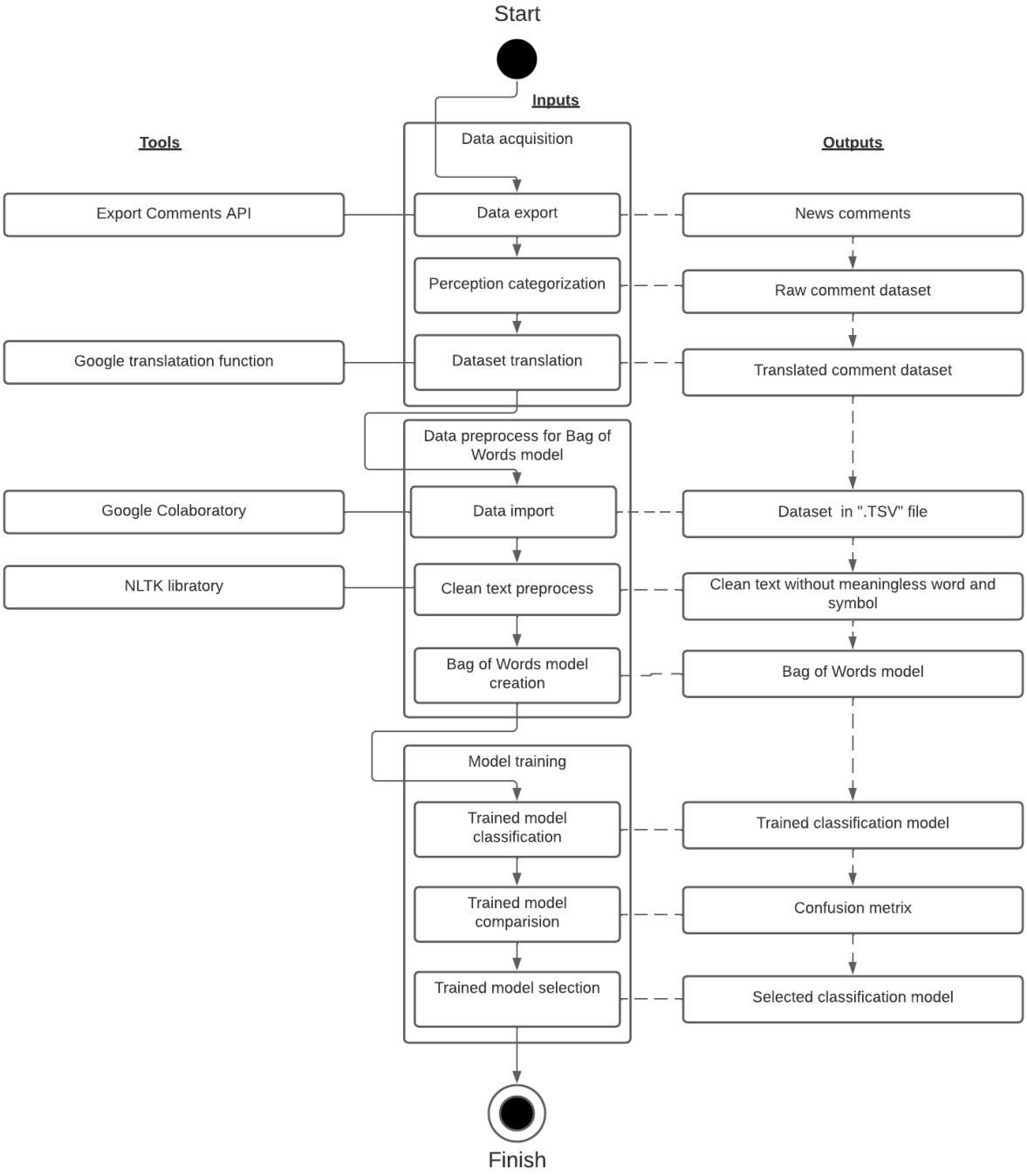
The objective of this paper was to develop classification models for public perception of the nuclear energy of Thai people on social media platforms using machine learning techniques in order to use the models to understand the trend of the public perception that people have a neutral opinion (non-biased opinions) or bias opinion on nuclear energy news. The scope of this work was focused on the Facebook platform in the starting step. This was because Facebook was the most popular in Thailand with the highest number of Thai people who play when compared with other social media platforms [12]. In the study, the comment data from six selected nuclear news on Facebook were extracted. The extracted data were classified and prepared for proper machine learning model inputs for creating the models to understand their neutral opinions and biased opinions. Moreover, the development of classification models is expected to use as a tool to understand the big data of nuclear public opinions fast and efficiently to identify the weak points that need to be improved on the public side in order to support the future nuclear power program of Thailand under the concept of carbon-neutral society.

The paper is divided into four main sections. The first section includes the introduction, background, and objective of the paper. The second section explains the framework and steps of the work including data selection, data extraction, and the machine learning process. The third section describes shows results and discussion of the classification models. The last section is the conclusion.

2. METHODOLOGY

Figure 1 shows the steps to design the classification model for public perception of nuclear energy in Thailand using machine learning. There are three main steps including (1) data acquisition, (2) data preprocess for Bag of Words model, and (3) model training [13]. Details were explained in the subsections below.

Figure 1: Steps to design the classification model for public perception of nuclear energy in Thailand using machine learning



2.1. Data Acquisition

2.1.1. Data export

In this study, the selected nuclear energy news in the Thai language was surveyed and collected from the international news agency on the Facebook platform. the basis to select the news based on the news that did not indicate people in the same direction. Thus, the news related to the update of nuclear power plant technology was selected as the main focus for understanding neutral opinions and biased opinions. A higher number of comments on the news would be the priority to be selected. Then Application Programming Interface (API) of Export Comments [14] was applied for extracting only comments from Facebook news in form of a Comma Separated Value (CSV) file as inputs. CSV file is suitable to process for machine learning and Natural Language Processing (NLP).

2.1.2. Perception categorization

After receiving all Thai comments, the comments were analyzed for justifying the perception of the sentences. Neutral opinions and biased opinions were classified by the author's evaluation. The methodology to classify the public opinions, whether neutral opinions or biased opinions, included three steps. First, non-related meaningless sentences, links, figures, and emotional symbols were screened out. Second, the comments related to the headlines that do not express any sentiments were cut off. Third, the remaining comments related to the headlines were discussed by the authors and were classified into neutral opinions or biased opinions. Basically, biased opinion was separated into positive and negative opinions but, in this case, the study would focus on only neutral opinions and biased opinions covering positive and negative opinions.

2.1.3. Dataset translation

All Thai comment inputs were translated into the English language using the Google translation function in the Google Sheet Platform for preparing data to appropriate input for model training. The translation process from Thai to English was required because the English algorithms developed for model training are widely used in the survey studies [15]. Nevertheless, Thai algorithms are still developing in the early stage of deployment [16].

2.2. Data Preprocess for Bag of Words Model

2.2.1. Data import

The translated data was imported to Google Colaboratory to write and execute arbitrary python code through the web browser suitably machine learning.

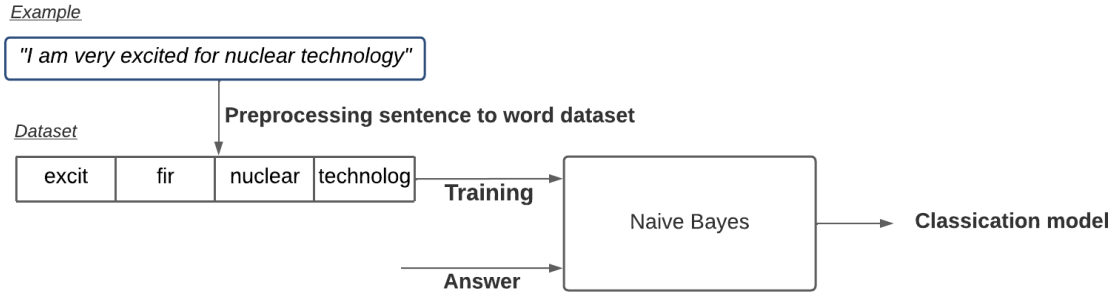
2.2.2. Clean text preprocess

The sentences of the dataset that have no meaning would be removed and lower characteristics using the function from the NLTK library. Poster Stemmer library was applied to generalize the wordings to the roots of their words.

2.2.3. Bag of Words model creation

All word datasets became input to create the bag of the word and were transformed into numeric in order to create the word representation in a matrix diagram with individual clean words.

Figure 2: Example of Naïve Bayes approach for the classification models



2.3. Model Training

2.3.1. Trained model classification

Figure 2 shows the example of Naïve Bayes approach for the classification models. The classification models were generated by the input bag of the word dataset. The well-known method of Naïve Bayes was selected for the machine learning analysis in this study. Naïve Bayes classifier is a statistical classifier based on the posterior hypothesis using the probability data for the large dataset [17]. The classification task is to provide the dataset of sample data to the determined classes using supervised learning algorithms. In this study, the number of the dataset were separated into two groups for train data and test data varying the proportion of them. The classification model helped classify neutral perception and bias perception.

2.3.2. Trained model comparison

Table 1 shows the confusion matrix to calculate the statistical values of accuracy, precision, recall, and F1-score. All word datasets became input to create the bag of the word and were transformed into numeric in order to create word representation in a matrix diagram with max word features. In this study, the neutral comment was determined as Positive (P), while the bias comment was determined as Negative (N). The statistical values of accuracy, precision, recall, and F1-score were calculated to compare the ability of classification models [18].

Table 1: Confusion matrix to calculate the statistical values of accuracy, precision, recall, and F1-score

Confusion Matrix		**Predicted Class**	
		Positive	**Negative**
Actual Class	**Positive**	**True Positive *(TP)***	**False Negative *(FN)***
	Negative	**False Positive *(FP)***	**True Negative *(TN)***
Accuracy	$\frac{TP + TN}{TP + TN + FP + FN}$		
Precision	$\frac{TP}{TP + FP}$		
Recall	$\frac{TP}{TP + FN}$		
F1-score	$\frac{2\ x\ Precision \times Recall}{Precision + Recall}$		

2.3.3. Trained model selection

The highest score of the statistical values would be considered for selecting the classification model. The selected classification model would be the representative to predict the public perceptions of nuclear energy on the Facebook platform to classify whether people have neutral opinions or biased opinions on nuclear energy news.

3. RESULTS AND DISCUSSION

3.1. Data Acquisition

In this study, nuclear energy news in the Thai language was surveyed and collected from the international news agency on the Facebook platform. It was found that normally the Facebook platform in Thailand included the news that could be divided into three categories namely (1) the news related to the update of nuclear power plant technology, (2) the news related to the nuclear accidents and radioactive contamination, and (3) the news related nuclear weapons and wars. Since this study focused on the understanding of the public perception of Thai people including their neutral opinions and biased opinions, only the news related to the update of nuclear power plant technology was selected as the main focus first consistently with the goal of the development of nuclear power plant technology in Thailand.

Table 2 shows the lists of the news related to the update of nuclear power plant technology from selected news agencies on the Facebook platform in Thailand. There were the three news agencies on the Facebook platform that concentrated on the news related to the update of nuclear power plant technology including China Xinhua New, TNN World, and BBC Thai. Due to the unpopularity of nuclear energy technology in Thailand, there were only people around tens to hundreds who were interested and commented on each Facebook news post. In this case, the six Facebook news posts with a total of 653 comments were selected for the study of the machine learning process. Then, all comments were extracted by the Export Comments Website. All comments were classified into neutral opinions or biased opinions by the author's judgments and they were translated into the English language using the Google translation function in the Google Sheet Platform for the machine learning process in English algorithm.

From the author's judgments, the evaluation of the neutral opinions and biased opinions of all nuclear news on Facebook news in Table 2 was that there were 74% (485 comments) of neutral opinions and 26% (168 comments) of biased opinions. This means that most of the comments on the Facebook platform related to the update of nuclear power plant technology are the people who have neutral opinions about nuclear energy. There were only less than 30 percent of people who have biased opinions about nuclear energy.

The finding of this work was that on the Facebook platform, there were main Thai people who have neutral opinions about nuclear energy. Thus, the reason affecting a lot of neutral opinions possibly is that Thailand has no NPP. This reason leads to the opportunity to convince the people who have neutral opinions to understand the proper and precise nuclear perception and activities to support and improve the direction of the nuclear energy plan in Thailand. Moreover, the strategy of neutral opinion developed based on this fact in Thailand is possible to be used as a NPP foundation for other countries not having NPPs.

However, generally biased opinions included both positive and negative opinions but the classification of positive and negative opinions is not the scope of this study, and it will be the future work. Moreover, the number of Thai people who used Facebook is quite varied [19]. Most of them were in the range of 25-34 years (33%) followed by 25-34 years (22%) and 35-44 years (17%). People's ages who used Facebook are possible to affect the ratio of answers in their ranges which should also be considered for the next step as the future work.

Table 2: Lists of the news related to the update of nuclear power plant technology from selected news agencies on the Facebook platform in Thailand

Facebook news headlines in translated English	News agency	Country of origin of the news agency	News date	Number of comments	Number of total individual clean words
A new world record, China's artificial sun lasts 1,056 seconds. [20]	China Xinhua New	China	2 Jan 2022	151	700
China contains fuel at the nuclear power plant of the 2nd place of Hualong-1.[21]	China Xinhua New	China	8 Nov 2021	39	250
China began to build a small commercial nuclear reactor in Hainan. [22]	China Xinhua New	China	14 July 2021	101	550
China's first nuclear power plant to use Hualong-1 technology, a Chinese-developed third-generation reactor design started filling fuel yesterday. [23]	China Xinhua New	China	5 Sep 2020	89	450
Chinese engineers revealed China's first floating nuclear power plant that may work even in extreme weather events. [24]	TNN World	Thailand	16 Dec 2021	96	450
The U.S. breaks a nuclear power record that almost reaches the point of igniting a sustained fusion reaction. [25]	BBC Thai	The UK	20 Aug 2021	177	600
Total				**653**	**1800**

Figure 3: Example of clean text code

Cleaning the texts

```
import re
import nltk
nltk.download('stopwords')
from nltk.corpus import stopwords
from nltk.stem.porter import PorterStemmer
corpus = []
for i in range(0, len(dataset)):
  pattern = re.compile('http[s]?://(?:[a-zA-Z]|[0-9]|[$-_@.&+]|[!*\(\),]|(?:%[0-9a-fA-F][0-9a-
  review = str(dataset['Comment english'][i])
  review = review.lower()
  review = pattern.sub('', review)
  review = re.sub('[^a-zA-Z]', ' ', review)
  review = review.split()
  ps = PorterStemmer()
  all_stopwords = stopwords.words('english')
  all_stopwords.remove('not')
  new_stopwords = ['http','photo']
  all_stopwords.extend(new_stopwords)
  review = [ps.stem(word) for word in review if not word in set(all_stopwords)]
  review = ' '.join(review)
```

Figure 4: Results of individual clean words' frequencies

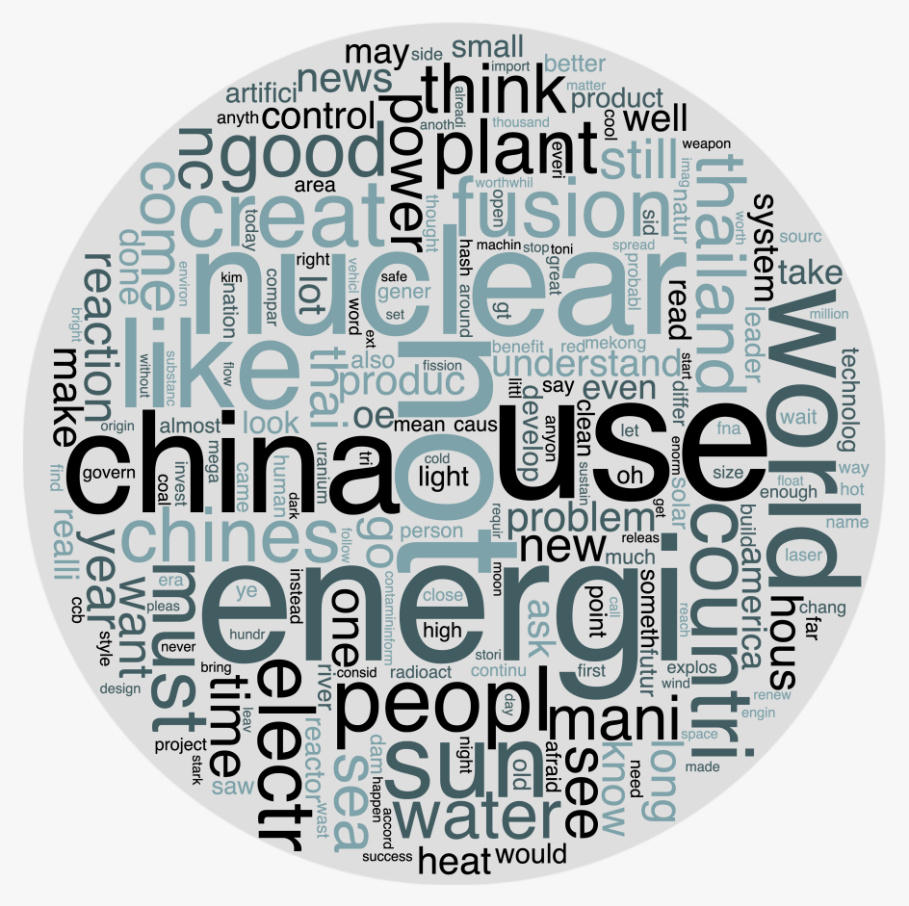
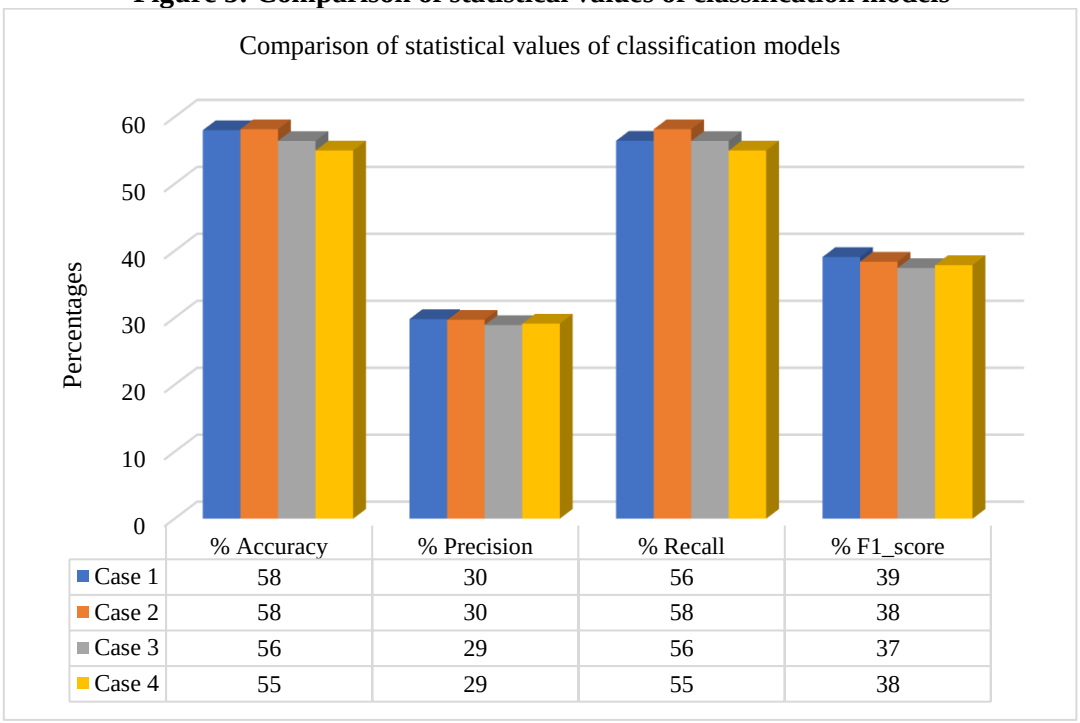


Figure 5: Comparison of statistical values of classification models



	% Accuracy	% Precision	% Recall	% F1_score
Case 1	58	30	56	39
Case 2	58	30	58	38
Case 3	56	29	56	37
Case 4	55	29	55	38

Table 3: Case studies of the training model.

Case	% Train data	% Test data
1	80	20
2	70	30
3	60	40
4	50	50

3.2. Data Preprocess for Bag of Words Model

Figure 3 shows the example of clean text codes. In the NLP process, all comments, that were extracted and translated into English, were reduced the complexity of the sentences to provide natural language understanding and natural language generation with clean words in the Tab Separated Values (TSV) file. Figure 4 shows the results of individual clean words' frequencies. It was found that the public perception of nuclear energy of Thai people on the Facebook platform mostly came from the Chinese news related to the update of nuclear power plant technology due to a lot of media from China Xinhua News in the Thai language.

3.3. Model Training

Table 2 shows the number of total individual clean words and Table 3 shows the case studies of the training model. All comments from six news with their natural language were extracted as individual clean words for the training process. In Table 3, there were four case studies of the training model in this paper varying in the proportion of train data and test data. The extracted data were classified and prepared for proper machine learning model inputs consisting of train data and test data. Train data were used to generate machine learning models to classify the public perception of nuclear energy of Thai people to understand their perceptions using Naïve Bays analysis. The results of generating machine learning models were validated by test data to suggest appropriate models for the public perception of nuclear energy of the Thai people to understand their neutral opinions and biased opinions.

Figure 5 shows the comparison of statistical values of classification models. In the learning and validation process, the statistical values of accuracy, precision, recall, and F1-score were calculated to compare the ability of classification models from the four cases. Overall, the results of the comparison of statistical values accuracy in Figure 5 tended to the close values. This meant that all of the classification models have the potential to use for the predictions of the public perception of nuclear energy of the Thai people. However, if comparing the accuracy and F1-value (the balance between the precision and the recall) of all classification models, it was found that the classification model in case 1 has the highest accuracy and F1-value. Thus, in this study, the classification model in case 1 was selected as an appropriate model for the public perception of nuclear energy of the Thai people to evaluate the neutral opinions and biased opinions of the selected nuclear news.

From the authors' judgments, the evaluation of Thai people's opinions of all nuclear news on Facebook news in Table 1 was 74% (485 comments) neutral opinions and 26% (168 comments) biased opinions. This means that the selected classification model in case 1 could be used to accurately predict the Thai people's opinions on the news of the update of nuclear power plant technology on the Facebook platform accurately around only 58% of the authors' judgments results. Although the accuracy of the classification model in case 1 was not quite high, the model is acceptable for the prediction of the case of nuclear news as the primary work. Thus, it was a crucial point for us to look back to NLP to improve the model accuracy. This is because, in the perception categorization step in Figure 1, Thai language comments were judged by the authors to identify their sentiments before the translation into English to use in the English algorithm to generate the classification models. In future work, the translation into English of the comments should be implemented before the process of the authors' judgment to compare and find the misjudged points to improve the accuracy of the classification models.

The development of classification models is expected to support the understanding of nuclear public opinions from the social big data, fast and efficiently. This will help identify the weak points that need to be improved in the public side of Thailand to support the future nuclear energy program in Thailand under the concept of a carbon-neutral society.

4. CONCLUSION

This study intended to develop classification models for public perception of the nuclear energy of Thai people on the Facebook platform using machine learning techniques in order to use the models to understand the trend of the public perceptions that people have neutral opinions or biased opinions on nuclear energy news. The six Facebook news posts with a total of 653 comments were selected for the study of the machine learning process to compare the ability of the classification models in the four cases.

From the authors' evaluation of the Thai people's opinions from the six Facebook news posts with a total of 653 comments, it was found that the majority (74%) of the comments on the Facebook platform related to the update of the nuclear power plant technology are the people who have neutral opinions for nuclear energy. Most neutral opinions about the nuclear energy of Thai people possibly came from no direct experience of operating NPP in the country. Thus, it is the opportunity to convince the people who have neutral opinions to have an understanding of the proper and precise nuclear perception to support the proper direction of the nuclear energy plan of Thailand in the future. Moreover, the strategy of neutral opinions in Thailand is possible to contribute to an NPP foundation on the public side for other countries not having NPPs.

Due to the highest accuracy and F1-value of the classification model in case 1, the classification model in case 1 was selected as an appropriate model for the public perception of nuclear energy of the Thai people on the selected news on Facebook. Although the accuracy of the classification model in case 1 was only 58% of the author's judgments results, the model is acceptable for the prediction of the case of nuclear news as the primary work. Thus, the improvement in the perception categorization step was an important point for us to improve the model accuracy in the next part.

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