A Systematic Literature Review on Hybrid Deep Learning Smart Recommendation Systems

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Keywords: Systematic Literature Review, Deep Learning, Hybrid Deep Learning, Smart Recommendation Systems, Recommendation Systems.

Abstract: The purpose of the research was to conduct a Systematic Literature Review (SLR) to understand about the hybrid deep learning model on smart recommendation system. SLR was held based on guidelines from Kitchenham & Charters. There were four research question about datasets, methods, programming language and also evaluation parameters that was used in hybrid deep learning smart recommendation system. The research started with 4931 articles from digital libraries namely ACM Digital Library, IEEE Explore, ScienceDirect and also SpringerLink. After third layer filtering, there found 50 articles became the data of the SLR. It can be concluded that the analysis result namely: (1) textual dataset was the most used dataset, (2) the combination of Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) was the most widely used as hybrid deep learning method, (3) python is widely used in experiments, and (4) accuracy, precision, recall, and F1-Score were the most often used as evaluation parameters in smart recommendation systems.

1 INTRODUCTION

Personalized recommendation system is not only providing items or products that meet the interests of different users according to their interests, but also recommend new items that meet their interests. Product recommendation systems can influence buying behaviour, consumer preferences, user experiences, and also sales (Zhang & Bockstedt, 2020) (Wu & Ye, 2020) (Turkut, Tuncer, Savran, & Yılmaz, 2020). Recommendation systems usually use predicting ratings or develop a list of product rankings for each user. In general, there are three types of recommendation systems, namely Content-based (CB) recommendation, Collaborative Filtering (CF), and Hybrid models (Benabderrahmane, Mellouli, & Lamolle, 2018) (Wang, Zhang, Xue, Lu, & Na, 2019). Content-based and collaborative filtering recommendation systems have evolved in the last ten years. Hybrid model is a collaboration of CB and CF models. The hybrid model in the recommendation system was developed with the aim of optimizing the recommendation results.

Some algorithms in artificial intelligence can be applied and combined to produce an optimal recommendation system model. The clustering algorithm can be applied to content-based recommendations. Clustering attempts to group large-scale data points into several categories according to their attributes. Various traditional clustering algorithms have been implemented including Gaussian Mixture Model, nearest neighbours, K-means, mean-shift, graph community detection, and DBSCAN (Wang, Zhang, Xue, Lu, & Na, 2019). In intelligent systems, the Self Organizing Maps (SOM) algorithm can be used in the clustering process to provide product recommendations. Self-Organizing Maps is an unsupervised neural network algorithm created by Kohonen. SOM is widely used in multidimensional data clustering (Dewi & Harjoko, 2010). A product can be recommended if it is in the same cluster.

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Collaborative Filtering (CF) is applied to the recommendation system to find groupings of things that usually occur together, such as pants and belts together in a market-basket analysis. In addition to the classical apriori algorithm, deep learning algorithms can be applied in this association pattern. Deep learning is a development of neural network learning. Deep learning is a specialized field in machine learning that focuses on the representation of data and adds successive learning layers to improve the representation of input data (Benabderrahmane, Mellouli, & Lamolle, 2018) (Djellali & Adda, 2020). Deep neural network architecture can be used to predict or recommend various things as in research (Benabderrahmane, Mellouli, & Lamolle, 2018) (Jha, Prashar, Long, & Taniar, 2020) (Xu Y. , et al., 2019). Based on (Wang, Zhang, Xue, Lu, & Na, 2019) (Dewi & Harjoko, 2010). The use of deep learning can make the recommendation system performance better.

Several previous studies have developed a hybrid recommendation system model with various methods. Research (Nilashi, Ibrahim, & Ithnin, 2014) used Adaptive Neuro-Fuzzy Inference Systems (ANFIS) and SOM methods. Then research about the tourism industry (Nilashi, Bagherifard, Rahmani, & Rafe, 2017) using a combination of SOM and Expectation Maximization (EM) methods for clustering and then predicting the recommendations using the ANFIS and Support Vector Regression (SVR) method. Research (Xu Y. , et al., 2019) used a modified RNN in the Slanderous User Detection Recommender System. Convolutional RNN was also used in research (Adiyansjah, Gunawan, & Suhartono, 2019) for the Music Recommender System.

The basic idea of this research is to conduct a systematic literature review to understand about the hybrid deep learning model on a smart recommendation system. There is no literature review that discusses the types of datasets used in hybrid deep learning smart recommendation systems, trend hybrid deep learning methods that used to build smart recommendation systems, trend frameworks used to build hybrid deep learning smart recommendation systems, and evaluation parameters used to measure the success of a hybrid deep learning smart recommendation system.

2 RESEARCH METHODOLOGY

The research was a systematic literature review research. A systematic literature review could be explained as a research method and process for identifying and critically appraising relevant research with purpose to identify all empirical evidence that fits the pre-specified inclusion criteria to answer a particular research question or hypothesis (Snyder, 2019).

The research setting was digital libraries, namely ACM Digital Libraries (from 2020-2021), IEEE Explore (from 2020-2021), ScienceDirect (from the last 5 year), and SpringerLink (from the last 5 years). The data collection technique used is the documentation of articles and journals. The research instrument was a check-list for the classification of research materials and research notes.

The data analysis technique was a Systematic Literature Review (SLR) according to the guidelines from Kitchenham & Charters (Kitchenham & Charters, 2007). The analysis divided into three big phase, which are planning, conducting and reporting the review.

Research question was built with purpose to maintain the focus of the literature review. This condition facilitates the process of finding data needed. The research question namely:

1. What kind of datasets are the most used for a hybrid learning smart recommendation system? (RQ1)
2. What kind of methods are the most used for a hybrid learning smart recommendation system? (RQ2)
3. What kind of programming languages are proposed for a hybrid learning smart recommendation system? (RQ3)
4. What kind of parameters are used for evaluating a hybrid learning smart recommendation system? (RQ4)

This study used several components, namely: (1) Background, (2) Research Questions, (3) Search terms, (4) Selection criteria, (5) Quality checklist and procedures, (6) Data extraction strategy, and (7) Data synthesis strategy. The research stated search string. The search string was **(hybrid learning AND (smart OR intelligent)) AND (recommend* OR classificat*) AND (systems).** Figure 1 is described about the studies selection strategy. Inclusion and exclusion criteria were used to select the main study. The results of the article from these criteria will be

reviewed by the researcher. The inclusion and exclusion criteria can be seen in Table 1.

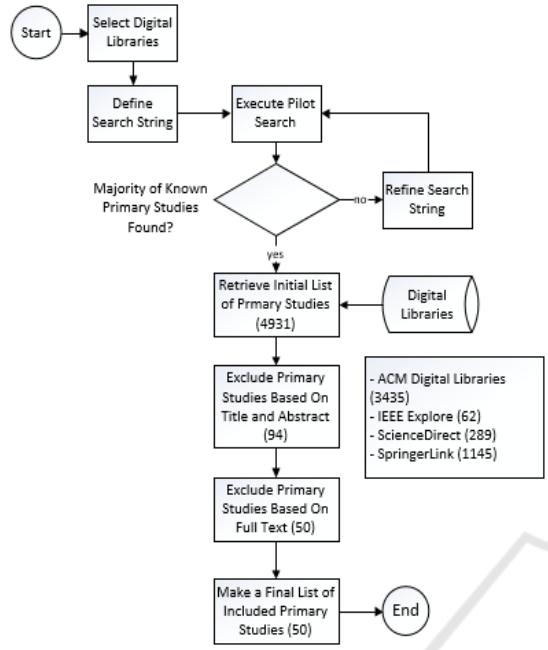

Figure 1: Studies Selection Strategy.

Table 1: The Inclusion and Exclusion Criteria.

Name	Description
Inclusion	Studies in academic and industry using large- and small-scale data sets
	Studies discussing and comparing modeling performance in the area of smart recommendation systems
	For studies that have both the conference and journal versions, only the journal version will be included
	For duplicate publications of the same study, only the most complete and newest one will be included
Exclusion	Studies without a strong validation or including experimental results of smart recommendation system
	Studies not written in English

Table 2, 3, 4 are shown the filtering process result. The research started with 4931 articles then after third layer filtering, there found 50 articles became the data of the SLR as shown in Table 5. The parameters used to extract the data include: (1) feature datasets, (2) hybrid deep learning method, (3) programming languages, and (4) evaluation parameters.

Table 2: Filtering Process Result of Step Retrieve Initial List Result.

Keywords	ACM	IEEE Explore	Science Direct	Springer Link
hybrid deep learning smart recommend* systems	1.716	15	152	615
hybrid deep learning smart classificat* systems	1.719	47	137	530

Table 3: Filtering Process Result of Step Exclude Based on Title and Abstract.

Keywords	ACM	IEEE Explore	Science Direct	Springer Link
hybrid deep learning smart recommend* systems	23	5	2	19
hybrid deep learning smart classificat* systems	16	14	8	7

Table 4: Filtering Process Result of Step Exclude Based on Full Text.

Keywords	ACM	IEEE Explore	Science Direct	Springer Link
hybrid deep learning smart recommend* systems	12	4	1	9
hybrid deep learning smart classificat* systems	4	11	5	5

Table 5: Filtering Process Recapitulation.

Phase	Amount
Retrieve Initial List Result	4.931
Exclude Based On Title and Abstract Result	94
Exclude Based On Full Text Result	50

3 RESULTS AND DISCUSSIONS

3.1 The Most Used Datasets

The analysis results of datasets that are widely used can be seen in Figure 2. Figure 2 shows that the most widely used dataset in hybrid deep learning smart

recommendation system research was textual dataset, which is 34 out of 50 total articles.

The research with textual dataset are (Wang & Cao, 2011), (Liu, Zhang, & Gulla, 2021), (Feng, Li, Ge, Luo, & Ng, 2021), (Jamal, Xianqiao, Al-Turjman, & Ullah, A Deep Learning–based Approach for Emotions Classification in Big Corpus of Imbalanced Tweets, 2021), (Aliannejadi, Zamani, Crestani, & Croft, 2021), (Cheng, Shen, Huang, & Zhu, 2021), (Kimmel, Brack, & Marshall, 2021), (Jawarneh, et al., 2020), (Vijayalakshmi, Vinayakamurthy, & Anuradha, 2020), (Gunjal, Yadav, & Kshirsagar, 2020), (Zou, Gu, Song, Liu, & Yao, 2017), (Chiu, Huang, Gupta, & Akman, 2021), (Benlamri & Zhang, 2014), (Motwani, A., Shukla, P.K., & Pawar, M., 2021), (Qadir, Ever, & Batunlu, 2021), (Anthony Jnr, 2021), (Li, Li, Zhang, Zhong, & Cheng, 2019), (Vora & Rajamani, 2019), (Torres-Ruiz, et al., 2020), (Jelodar, et al., 2021) (Karo, Ramdhani, Ramadhelza, & Aufa, 2020), (Ahmad Mahmud & Azuana Ramli, 2020), (Zhu, Wang, Zhong, Li, & Sheng, 2021), (Popoola, Adebisi, Hammoudeh, Gui, & Gacanin, 2021), (Liang, Zhu, Zhang, Cheng, & Jin, 2020), (Jahangir, et al., 2021), (Cuzzocrea, et al., 2020), (Mlika & Karoui, 2020), (Ibrahim, Saleh, Elgaml, & Abdelsalam, 2020), (Serano, 2020), (Fang, et al., 2021), (Shafqat, et al., 2021), and (Masud, et al., 2021).

Next is the image dataset totalling 11 articles, namely (Yue, et al., 2021), (Cui, Yu, Wu, Liu, & Wang, 2021), (Khosroshahi, Razavi, Sangar, & Majidzadeh, 2021), (Luo, Yang, Tang, & Zhang, 2020), (Rafi & Akthar, 2021), (Joshi & Sharma, 2021), (Su & Wei, 2020), (Anjna, Sood, & Singh, 2020), (Khan, Nazir, García-Magariño, & Hussain, 2021), (Louati, 2020), and (Kristiansen, et al., 2021).

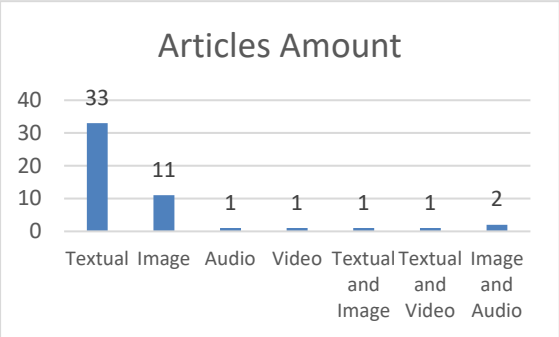

Figure 2: The Result of Research Question 1.

Only 1 article from (Mohammed, Elhoseny, Abdulkareem, Mostafa, & Maashi, 2021) used an audio-based dataset, as well as a video-based dataset. There are also studies that use two types of datasets. Research from (Wang, et al., 2021) used textual and video. Research from (Li, et al., 2021) and (Chintamani, Kumar, & Karan, 2021) used image and audio datasets.

3.2 The Most Used Methods

The analysis results of the most used methods can be seen in Figure 3. The most widely used hybrid deep learning method is a combination of the Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) which are the development of the Recurrent Neural Network (RNN) method. LSTM and CNN are also widely combined with other methods in building a hybrid deep learning smart recommendation system, but the amount is not as many as the combination of CNN and LSTM.

(Wang, et al., 2021) on their research leveraged hybrid deep learning to distill the textual contents for more distinguishable features. The research by (Yue, et al., 2021) used the hybrid deep learning model to extract discriminative spatial features (CNN) and to encode temporal information from the encrypted image sequences (leveraged LSTM).

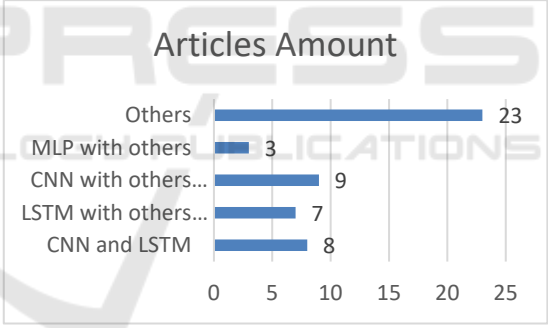

Figure 3: The Result of Research Question 2.

The combination of CNN and LSTM was also conducted by (Khan, Nazir, García-Magariño, & Hussain, 2021), they used CNN for the classification of spatial data while LSTM for temporal data. The same with (Liang, Zhu, Zhang, Cheng, & Jin, 2020), (Feng, Li, Ge, Luo, & Ng, 2021) and (Rafi & Akthar, 2021) they used CNN_LSTM for classification phase. (Louati, 2020) also used CNN for classification and CNN-LSTM for traffic prediction.

Different with (Kimmel, Brack, & Marshall, 2021), they utilized CNN and RNN to analyze cell motility data. RNN modified with CNN became RNN autoencoders and the research stated that it capable of learning motility features in an unsupervised manner and capturing variation between myogenic cells in the latent space.

3.3 The Most Proposed Programming Language

Based on the analysis of 50 articles, there are 9 papers that use python as the programming language and 3 combined python with other languange. The research was conducted by (Liu, Zhang, & Gulla, 2021), (Su & Wei, 2020), (Kristiansen, et al., 2021), (Joshi & Sharma, 2021), (Yue, et al., 2021), (Rafi & Akthar, 2021), (Liang, Zhu, Zhang, Cheng, & Jin, 2020), (Khosroshahi, Razavi, Sangar, & Majidzadeh, 2021), (Chiu, Huang, Gupta, & Akman, 2021), (Popoola, Adebisi, Hammoudeh, Gui, & Gacanin, 2021), (Motwani, A., Shukla, P.K., & Pawar, M., 2021), and (Jawarneh, et al., 2020). Python is widely used because it has modules that strongly support machine learning, such as NumPy, TensorFlow, Keras, Pandas, PyTorch, Matplotlib, Scikit-learn. Based on the data in Figure 4, there are also Matlab, R, and PHP programming language that are proposed for a hybrid learning smart recommendation system.

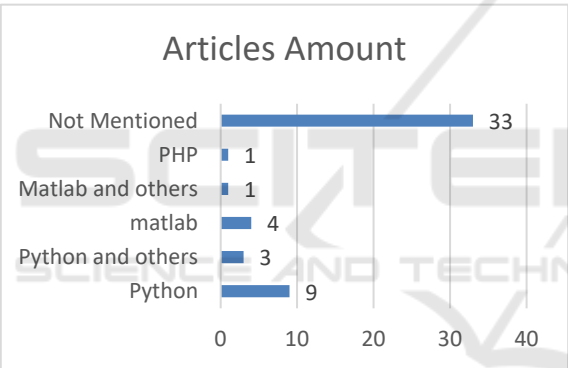

Figure 4: The Result of Research Question 3.

3.4 The Most Used Evaluation Parameters

There are several parameters used in evaluating the performance of the hybrid deep learning smart recommendation system. The analysis result showed that accuracy, precision, recall, and F1-Score parameters are most often used as evaluation parameters in smart recommendation systems.

4 CONCLUSIONS

The research was a Systematic Literature Review (SLR) research. The research started with 4931 articles from digital libraries namely ACM Digital Library, IEEE Explore, ScienceDirect and also SpringerLink. After third layer filtering, there found 50 articles became the data of the SLR. It can be conluded that the analysis result, namely:

1. The most widely used dataset in hybrid deep learning smart recommendation system research was textual dataset.
2. The most widely used hybrid deep learning method was a combination of the Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM)
3. Python is widely used because it has modules that strongly support machine learning, such as NumPy, TensorFlow, Keras, Pandas, PyTorch, Matplotlib, Scikit-learn.
4. Accuracy, precision, recall, and F1-Score parameters are most often used as evaluation parameters in smart recommendation systems.

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