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THE BEST METHOD OF MUSIC RECOMMENDATION SYSTEM

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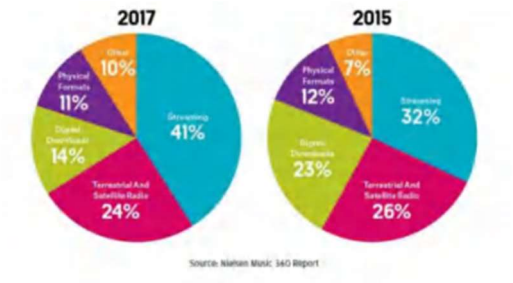
ABSTRACT

The discussion in this paper is about music applications. The development of music applications that have many features, especially the music recommendation system. In this paper, we will compare several methods that can be used in forming a music recommendation feature and the best method will be determined. The methods we have picked have their own advantages and disadvantages. With this comparison, the best method we get is to use the Collaborative Filtering method.

Keywords: *music recommendation system, recommender system, collaborative learning, item-based method, user-based method*

1. INTRODUCTION

Music is one of the entertainment that is needed by many people. For some people listening to music can soothe the heart, feelings, and soul, especially if we listen to music according to our own taste. In the development of this technology, music also experienced quite a significant development. Nowadays many people can listen to music online through music streaming applications and social media which available on smartphone and computer. Based on a survey conducted by the JakPat Mobile Survey Platform from the territory of Indonesia, it is stated that from 1955 respondents, there are 85% of respondents listen to online music streaming regularly every day. This has certainly made several companies, especially those engaged in digital content, to create their own streaming music applications. For example like Spotify, Joox, Youtube, AppleMusic, and SoundCloud.



Data from Nielsen RAM shows that streaming music users from 2015 were only 32% and increased in 2017 by 41%. Survey from daily social in 2018 said that as many as 88% listen to music via streaming and 12% do not listen to music via streaming. The amount of data and information from the list of music or song, users, and music history from all users can be utilized as a reference for the recommendation system which is one way to improve the user experience of the application and please the user. These data and information have a recommendation system can be made that provides a list of recommendations in accordance with preferences and behavior of each user. This will make it easier for users to find music that suits their individual tastes.

For example, one of the biggest applications in the world of streaming music services is Spotify which is a start-up company founded in October 2008 by Daniel Ek in Sweden. He has a passion for leveraging technology and building a better business model by providing 70% of revenue from song

screening and able to become the second largest digital service revenue contributor in Europe by offering more than 20 million songs for more than 60 million users in 58 countries around the world including Indonesia and 15 million of its users are users with paid services which account for 90% of its revenue. The increase in the number of users leads to an increase in Spotify's revenue and an increase in the desire to increase customer retention, one of which is by implementing a recommendation system that makes it easier for users to find suitable music among tens of millions of choices available.

The recommendation system has been widely used by all music applications. There are two approaches which are generally used in making recommendation systems, namely content based filtering and collaborative filtering. Content based filtering is a method that works by finding the proximity of an item to be recommended to users with items that have been picked up by previous users based on the similarity between the contents. However, this recommendation system still has weaknesses. All information is selected and recommended based on content, users do not get recommendations on different content types. In addition, this recommendation system also less effective for novice users because users do not get input from previous users. Another method to cover this weakness was developed by collaborative filtering method. This method is a method used to predict the usefulness of an item based on previous user ratings. Collaborative filtering can be used to create a recommendation system, but all computational systems in the algorithm depend on the results of the recommendation.

The application that enjoys the results of utilizing a recommendation system with Collaborative Filtering is Spotify which has successfully implemented a personalized playlist which is formed from a recommendation system developed from studying user behavior in interacting with the music of each user's choice. One of its famous features is "Discovery Weekly" which was introduced in July 2016 and provides 30 new playlists that are customized based on personal similarities and recommended to users every Monday morning. Now "Discovery Weekly" is one of Spotify's successful achievements is that it is able to create playlists of more than 40 million users and more than 5 billion songs are played through these recommendation intermediaries.

2. LITERATURE PAPER REVIEW

With online music services, namely music applications on electronic devices, it is very easy for all music lovers to listen to music and can be accessed globally [3]. The music that each person listens to is varied and numerous, so it may be difficult to survey the songs that users listen to frequently. This is where the music recommendation system plays a role. The music recommendation system will help to analyze the songs that the user might be interested in so that the system can recommend songs that the user might like. Over time, more and more models are used and each has its own advantages and disadvantages.

In the papers and journals that we have collected, they discuss the methods used, the models used, algorithms, several hypotheses, evidence using datasets, and the conclusions obtained after doing the proof. The paper is taken from the internet and has paper criteria published in 2013 - 2021. We chose to take 10 papers with research or the journal of a music recommendation system that has different models and methods, so we can compare each method. All the methods collected, one of the method will be chosen which is the best to become a music recommendation system. The selection of the method is based on the method algorithm, speed system, and the accuracy of the data result.

2.1 Proposed Method

Based on the journal entitled "*Music Recommendation System based on Fusion Deep Learning Models*", it is said that there are two most commonly used methods for a music recommendation, namely the content-based approach and the collaborative approach. The content-based approach uses a bayesian network and utility theory [4] . They conducted research using Fusion Deep Learning Model.

Based on the journal entitled "*Music Recommender System Based on Genre using Convolutional Recurrent Neural Networks*", they said that according to them, the method that might be suitable for this music recommendation system is content-based using Convolutional recurrent neural networks (CRNNs) which is a combination of Convolutional Neural Networks and Recurrent Neural Networks [5].

Based on the journal entitled "*Deep content-based music recommendation*", they researched that the deep convolutional network method is effective in predicting latent factors of music audio [6].

Based on the journal entitled "*Music Recommendations Based On Real-Time Data*", they researched using three methods, namely Deep Neural Network, Contextual Bandit, and Linear Regression. Each is proven by using a dataset [3].

Based on the journal entitled "*Implementasi Machine Learning dalam Penentuan Rekomendasi Musik dengan Metode Content-Based Filtering*", they researched using Machine Learning and Content-Based Filtering methods in implementing music applications as recommended music [7].

Based on the journal entitled "*Music Recommendation System using Content and Collaborative Filtering Methods*", they researched with the Content and Collaborative Filtering Methods [8].

Based on the journal entitled "*Music Recommendation System with User-based and Item-based Collaborative Filtering Technique*", they use user-based and item-based collaborative filtering methods [9].

Based on the journal entitled "*Music Recommendation System*", they researched using the Artificial Neural Networks and Regression Algorithm Method [10].

Based on the journal entitled "*Music Recommendation using Collaborative Filtering and Deep Learning*", they used the Collaborative Filtering and Deep Learning method [11].

Based on the journal entitled "*Analysis of Music Recommendation System using Machine Learning Algorithms*", they use Machine Learning, Convolutional Neural Networks, and Collaborative Filtering [12].

Please note that some journals may apply the same method as other journals, but the algorithms, datasets, and output results are different.

3. METHODOLOGY

In this section will be stated about the test, the algorithm process that used, and the results of the test.

3.1 Collaborative Filtering

Collaborative Filtering is a filtering process for information and technical patterns that involve collaboration among multiple agents, viewpoints, and data sources. This method usually involves very large data sets such as sensing and monitoring data, financial data, and data on users. This method is used as a recommendation system for an application.

3.1.1 Algorithm

The first test of Bertin Mahiux T et al [13] who purposed the million song dataset challenge in terms of personalized and large scale music recommendations. It aims to predict the song that the user will listen to by considering the user's history music and complete information (including metadata and content analysis) for all available songs.

The second test of Shlok Gilda et al [14] who purposed an effective cross platform music player and EMP recommendations music based on user's real time. EMP provides intelligent mood based music recommendations by incorporating emotional context reasoning capabilities in a music recommendation system. The music player contains three modules, the first is emotion module, the second is music classification module, and the recommendation module.

At the early stages of testing, Bertin will use 3 algorithms with Collaborative Filtering Method. The first is recommendation based on global popularity without personalization. The second is simple recommendations that predict songs by artists already in the user's taste profile. The third is talent factor models. All the results are based on similar test and exercise separations but there are differences in the distributions used. A training set consists of a full profile for 1 million users and a partial profile for 10 thousands tested users.

At the early stages of testing, Shlok will use 3 algorithms with Collaborative Filtering Method. The emotion module will take a picture of the user's face as input to identify their mood with 90,23% accuracy. The music classification module will take advantage of the audio feature to classify songs into 97,96% and 4 different mood classes. The recommendation module will suggest songs to users by mapping their emotions to the type of mood of the song taking into account the user's preferences.

3.1.2 Datasets

There are 10.000 songs and listeners have recommended and the best songs available based on mood, genre, artist, history, and top charts for the year. Through the interactive user interface, the top most played songs and the top charts of this year will be displayed. Listeners will have the option to

choose their favorite artists and recommended song genre for them.

3.1.3 Results

The testing through this method can play and recommend songs in 4 languages covering more than 40 artists. The system has been tested by 20 users and the results are quite promising. This datasets received an accuracy of 96% on the music recommendation system using Collaborative Filtering. [8]

3.2 Fusion Deep Learning

Deep learning is learning done by the system like the way the human brain works. This deep learning implemented fusion method.

3.2.1 Algorithm

The step is to collect data because the system is data-driven. The data is taken by downloading the open-source dataset feature analysis, audio information, lyrics data for one million songs, and listening history that have several users. The songs are classified into 3 groups, namely pop music, classic music, and country music. The retrieved data is contained in the database and the data is too large to be processed quickly so it is reduced to a spectrogram image so that it can be implemented in a deep learning model. The lyric has the same problem which is the length of the lyrics was too long to utilized. To reduce the length of the lyric while keeping the emotional expression, the script is written to analyze the best emotion in the songs. In the experiment, it defines six emotions, happy, sad, creepy, exciting, energetic, and melancholic. In the spectrogram that has been formed, the Convolutional Neural Network (CNN) is used which is part of the fusion model. The spectrogram is processed by CNN to extract feature map. Feature map's output is used to reflect the rhyme insight of the input songs

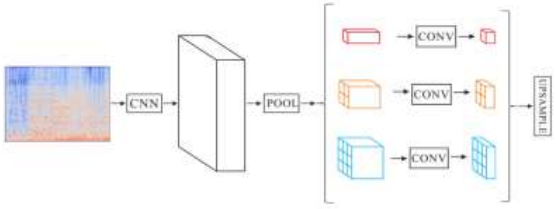


Figure 1. The Detailed Structure Of The CNN Based Model.

Figure 1 is the structure of CNN model. Using the unsampling process, the output of the feature map size is 4x4 which is enough to represent the information of the song [4].

3.2.2 Datasets

The dataset consists of a database of music objects such as feature analysis, audio information, lyrics data for one million songs, and listening history. Songs are divided into 3 groups, namely pop music, classic music, and country music.

3.2.3 Results

The results obtained through experiments with fusion deep learning, uses number of iteration which is 3000, 6000, and 9000. When the iteration get bigger, more accurate it becomes. The result got an overall highest accuracy of 90.2% with 9000 iteration.

Table 1. Effect of iteration on accuracy.

Iteration	Pop music	Classic music	Country music	Overall
3000	75.3%	62.9%	70.6%	69.6%
6000	94.3%	83.4%	90.5%	89.4%
9000	95.3%	85.1%	90.1%	90.2%

The table above show results of each iteration based on the experiments from the fusion deep learning method. [4]

3.3 Convolutional Recurrent Neural Networks

Convolutional Recurrent Neural Networks is a combination of Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) [5]. CNNs is a type of neural network that is used in image data to detect and recognize objects in an image. RNNs is a type of artificial neural network architecture that requires it to be called repeatedly to process sequential data input.

3.3.1 Algorithm

The stages that are passed in the formation of the system are the Beginning stage (identifying problems and literature review), collecting music data, data selection, audio preprocessing, neural network modeling, recommender system modeling, implementing design and evaluation of recommended music applications. In the formation of a music recommender, it can be said that this system uses content-based because the way it works is to compare features on audio signals.

The relevant data is taken by downloading the existing dataset. Raw data will be cleaned and selected by identifying song quality and music genre. Songs that have low song quality and mixed music genres will be deleted. After completion, the signal from the data is converted into a spectogram.

The process of this system is to calculate the similarity of one music to another. First, one music from each genre will be selected. Then, the

calculation will be done based on the neural network. This application system was developed with Python and several key libraries, namely Tensorflow, Keras, Librosa and Kivy [5].

To evaluate the music recommender that has been formed, it was tested with 30 participants. Participants will respond to the music recommendations that have been given by telling dislike or like recommendations.

3.3.2 Datasets

The dataset used is from the Free Music Archive (FMA). The total downloaded size is 22 GB, there are 25000 music in mp3 format, 16 music genres, and the duration of the music is 30 seconds. The dataset is cleaned and reprocessed into 7 genres, namely classical, electronic, folk, hip-hop, instrumental, jazz, and rock. Each genre has 1000 song data.

3.3.3 Results

The results received from the experiment are CRNNs that consider both the frequency features and time sequence patterns have overall better performance. To increase accuracy, you can use gram tempo to capture local tempo.

3.4 Deep Convolutional Network

Deep Convolutional Neural Network is useful for predicting latent factors of audio music. Latent factors will form a description of the difference to the user's tastes.

3.4.1 Algorithm

Algorithm used in this Deep Convolutional Neural Network is Weighted Matrix Factorization which will be detected if the user has ever listened to a song, then the user is interested in the song. If the number of users playing the song is quite a lot, then the user is more interested in the song. If the user has never listened to the song, then the user is not interested in the song.

$$p_{ui} = I(r_{ui} > 0), \quad (1)$$

$$c_{ui} = 1 + \alpha \log(1 + \epsilon^{-1} r_{ui}). \quad (2)$$

Rui is the play count for user u and song i. For each user item-pair, define pui as preference variable and cui as confidence variable, I(x) is the indicator function, α and E are hyperparameters. The preference variable define whether user has ever listened to song i. if the result is 1, it means the user enjoy the song. Confidence variable means how certain it is to be preferred. We can get the value by the play count. Songs with higher play count means it is more likely to be preferred. If the song has never been played, confidence variable will show a low value. Overall objective function :

$$\min_{x_*, y_*} \sum_{u,i} c_{ui}(p_{ui} - x_u^T y_i)^2 + \lambda \left(\sum_u ||x_u||^2 + \sum_i ||y_i||^2 \right), \quad (3)$$

λ is a regularization parameter, Xu is latent factor for user u, yi is latent factor for song i.

This algorithm is used to learn the latent factor. The intended formula will be used on the downloaded dataset. In addition, the algorithms used include Linear Regression, A multi-layer perceptron, and a convolutional neural network to minimize the mean squared error (MSE) in a prediction. Each algorithm is used and compared with the mean average precision (MAP) [6] .

3.4.2 Datasets

The dataset is taken from The Million Song Dataset (MSD) which contains lyrics, cover songs, tags and user listening data. The datasets taken from MSD are The Echo Nest Taste Profile Subset collected from 1 million users and the last.fm dataset which provides tags for more than 500,000 music. However, due to a problem with MSD , another dataset was taken from 7digital.com with 99% music clips of 29 seconds [6].

3.4.3 Results

There is a combination where deep learning and deep convolutional networks can work quite well , but There are still many characteristics of the song that are not detected from the audio signal but it is enough to provide a reasonable song recommendation [6].

3.5 Content Based Filtering

Content Based Filtering is a method to provide recommendation based on the similarity of the attributes of the item or items that are liked. In the song recommendation system, similarity is based on the attributes possessed by the song such as genre, beat, and information from the artist.

3.5.1 Algorithm

There is a music that separated based on a vector of its constituent components. Then the user will give a value like or dislike the music. The system will form

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a user profile based on the vector weight of the components that build a music. User profiling can use the TF-IDF algorithm (Term Frequency Inverse Document Frequency). TF is the number of terms in a document while IDF calculated based on the formula :

$$\text{idf}_i = \log(\frac{n}{dfi})$$

where the value of n is the number of all music and df is the number of documents that have term - i.

The system will make an assessment based on the analysis of the similarity of the user profile with the vector components that build up the music. If the music will be liked by the user, then the music will be recommended by the user.

3.5.2 Datasets

There are 2 users with the names **User 1311537** and **User 1775549**. [7] Each of them has 10 history of songs ever played with them. Each song history generates a list of recommended songs with different score on comfort score between songs. The recommended songs displayed are recommendation with the highest score, but the song will be checked whether the user has listened to it or not. If yes, a recommendation will be taken with a score below it.

3.5.3 Result

The results based on datasets get the average value of song equations such as **User 1311537** has an average of 0.8036 and **User 1776649** has an average of 0.8470. The average value of the equation obtained from the two users is 0.8253 and the average value means that the algorithm for finding similarities between songs is quite good.

3.6 User-based and Item-based Collaborative Filtering

In Collaborative Filtering, there are 2 types of approaches namely User-based Collaborative Filtering and Item-based Collaborative Filtering. User-based CF is a method that calculates the similarity between users as a parameter to generate recommendations. Item-based CF is a method that calculates the similarity between items seens from the rating given by the user for the item.

3.6.1 Algorithm

The method will calculate the similarity between one item and another item. The formula used is the cosine similarity measure which calculates the similarity between two items from the cosine made between the two items. If the cosine result is 1, then the items are absolutely identical. If the value of cosine is 0, then both items they have absolutely no resemblance.

$$sim(x,y) = cos(\vec{x},\vec{y}) = \frac{\vec{x}\cdot\vec{y}}{||\vec{x}||_2 \times ||\vec{y}||_2} = \frac{\sum_{i\in I_{xy}} r_{x,i} r_{y,i}}{\sqrt{\sum_{i\in I_{xy}} r_{x,i}^2}\sqrt{\sum_{i\in I_{xy}} r_{y,i}^2}}$$

Rumus cosine similarity measure

The next step is to predict the rating of these items. Rating calculation is done by comparing the rating that has been given by the user on an item with the similarity between the item and other items. The formula used the formula weighted sum. If rating predictions have been calculated, then item recommendations will be generated.

$$A_i^{\text{WSM-score}} = \sum_{j=1}^{n} w_j a_{ij}, \text{ for } i = 1, 2, 3, \ldots, m.$$

Rumus Weighted Sum

3.6.2 Datasets

Initialization Bij = { 1 if Rij > 0 || if Rij = 0 } where Rij is the rating of a user Ui for an item Ij and second step in pre-processing is normalization [9].

Table 2. Binary user-item rating matrix

	Item$_1$	Item$_2$	Item$_3$	Item4
User$_1$	0	0	1	0
User2	1	0	0	1
User$_3$	1	1	0	1
User$_4$	1	0	0	0
User$_5$	0	1	1	0
User$_6$	0	1	1	0
User$_7$	1	0	0	1
User$_8$	1	0	0	0
User$_9$	1	0	0	1
User$_{10}$	1	0	0	0

Length normalization and Root Mean Square Normalization is used to normalize binary User-based CF and Item-based CF rating matrix. This table 3 shows the user-item matrix with length normalization and Table 4 shows user-item matrix with RMSN normalization.

Table 3. Length normalized user-item rating matrix

	Item1	Item2	Item3	Item4
User1	0	0	1	0
User2	0.5	0	0	0.5
User3	0.33	0.33	0	0.33
User4	1	0	0	0
User5	0	0.5	0.5	0
User6	0	0.5	0.5	0
User7	0.5	0	0	0.5
User8	1	0	0	0
User9	0.5	0	0	0.5
User10	1	0	0	0

Table 4. RMSN normalized user-item rating matrix

	Item1	Item2	Item3	Item4
User1	0	0	0	0
User2	0.707	0	0	0.707
User3	0.408	0.408	0	0.408
User4	0	0	0	0
User5	0	0.707	0.707	0
User6	0	0.707	0.707	0
User7	0.707	0	0	0.707
User8	0	0	0	0
User9	0.447	0.447	0.447	0.447
User10	1	0	0	0

3.6.3 Result

The datasets was carried out on a benchmark data set obtained by Last.fm which is a website that allows users to listen to music online. The data taken care the last 50 hearings from 2006 - 2009 with a record number of 2,20,338 samples.

3.7 Deep Neural Network, Contextual Bandit, and Linear Regression

This system is created by combining two systems, namely a recommendation system that predicts a number of song features for users and a device system that finds the most suitable track. There are 3 implementation methods for the recommendation system, namely Deep Neural Network, Contextual Bandit, and Linear Regression.

3.7.1 Algorithm

In Deep Neural Network (DNN), the implemented model is DNNClassifier Estimator in Tensorflow. This is where predictions, calculations, and training are carried out. Linear Regression is implemented with Tensorflow as the LinearClassifier estimator. Contextual Bandit is used to predict the value in the song and give rewards by calculating the following formula:

$$y(x) = \begin{cases} 1 & \text{if rating} \geq 0.8 \\ -1 & \text{else} \end{cases}$$

The songs contained in the database are given a ranking or referred to as a ranking system with certain calculations carried out [3].

3.7.2 Datasets

There are 2 datasets, the first is a collection of songs where each song is paired with its respective tempo, mode, and loudness which will be associated with the selected feature as a variable for content-based filtering. The first step will select 1124 songs from a variety of different playlists to get a broad mix of artists and genres (tempo, mode, loudness).

The audio features for all selected songs will be downloaded from Spotify on April 17, 2018 using their API and then saved to the server database.The second data is their data which has 233 data points from 2 real life users that have been collected several months before.(userID, heartRate, timeValue,songID,rating) [3].

3.7.3 Results

The results of this experiment are able to acquire knowledge even though there is no certainty, able to generalize and extract from a certain data pattern so as to create a pattern of knowledge through self-regulation or self-organizing ability, have fault tolerance, disturbance can be considered as noise only and the ability to calculate in parallel so that the process is shorter but less able to perform numerical operations with high precision, less able to perform arithmetic algorithm operations, logical and symbolic operations, and the length of the training process that may occur in a very long time for large amounts of data [3] .

3.8 Collaborative Filtering and Deep Learning

Deep Learning is one part of a variety of Machine Learning methods that using Artificial Neural Networks (ANN) and the types of learning in Deeo Learning can be supervised, semi-supervised, and unsupervised. Deep Learning methods are becoming one of the most popular methods for the recommendation system because it is more efficient and on target.

3.8.1 Algorithm

The first approach is to create a recommendation system using text analysis. First task is to extract a dataset that is suitable for prediction. Here have taken FMA and millions of song datasets from columbia.edu and Github. The recommendation system with the approach a hybrid between Collaborative Filtering and Deep Learning. The dataset has been preprocessed using R and Python.

The packages used for R are readr, dplyr, and caTools while Python used the Pandas and Numpy packages [11].

The first stage will create Collaborative Filtering using text analysis from datasets that have been processed previously. The initial data set consists of 2 parts namely songs_data.csv and metadata.txt which will combined. The merged dataset has attributes like song_id, user_id, count, title, release, artist_name, and year. Song_id attribute is the unique id that assigned to each song, user_id attribute is the unique id that assigned to each user, count attribute is the count of each song listened by each user, title attribute is the title of the song, release attribute is the album with which the song was released, artist_name attribute is the singer of the song, and year attribute is the year of the song that was released.

3.8.2 Datasets

The dataset is divided into training data and test data in a ratio of 75:25. From 500.000 tuples will take 1.000 tuples at random and divide them in training and test data.

3.8.3 Result

The first part was able to generate the songs using Collaborative Filtering that shown in the figure. On passing the album art to the model, it was able to detect face band name "Pink Floyd". If user trying to make new album then detect the face band, the accuracy result was not good. But with the Collaborative Filtering and Deep Learning methods, the accuracy continues to increase as the amount of raw data increases.

4. CONCLUSION

There are many methods that can be used to develop music recommendation features. The method are Fusion Deep Learning, Convolutional Recurrent Neural Networks, Deep Convolutional Network, Deep Neural Network, Contextual Bandit, Regresi Linier, Machine Learning with Content Based Filtering, Collaborative Filtering, User-based and Item-based Collaborative Filtering, Artificial Neural Networks, Regression Algorithm Method, Deep Learning, and Machine Learning.

Methods	Algorithm	
	Simple	Complex
Fusion Deep Learning	✓	
Convolutional Recurrent Neural Networks		✓
Contextual Bandit		✓
Regresi Linier		✓
Machine Learning with Content Based Filtering		✓
Collaborative Filtering	✓	
User-based and Item-based Collaborative Filtering		✓
Artificial Neural Networks		✓
Regression Algorithm Method		✓
Deep Learning	✓	
Machine Learning		✓

Methods	Accuracy	
	Not Accurate	Very Accurate
Fusion Deep Learning		✓
Convolutional Recurrent Neural Networks	✓	

Contextual Bandit	✓	
Regresi Linier	✓	
Machine Learning with Content Based Filtering	✓	
Collaborative Filtering		✓
User-based and Item-based Collaborative Filtering	✓	
Artificial Neural Networks	✓	
Regression Algorithm Method	✓	
Deep Learning		✓
Machine Learning	✓	

FILTERED METHODS	Fusion Deep Learning
	Collaborative Filtering
	Deep Learning

Based on the testing of the data and the results that came out, it can be determined that Fusion Deep Learning, Collaborative Filtering, and Deep Learning method are the best method for implementing the recommendation system based on algorithm and accuracy progress. But if we look deeper into the difference, the Collaborative Filtering is the best method for recommendation system music because itself doesn't depend on other users or items and builds a profile by exploiting it based on ratings provided by active users. The way the system works can also be by bringing up relevant items based on exiting content. In addition, Collaborative Filtering can also generate recommendations that have not been rated by every user.

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