Designing of Recommendation Engine for Recyclable Waste Mobile App

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Abstract. The objective of this research is to design a recommendation engine for Pilah Matur App. The recommendation engine in this research used a combination of CF (Collaborative Filtering) and LBS (Location Based Service). Collaborative filtering performs data filtering based on the similarity of user characteristics so that it is able to provide new information to other users because CF provides information based on a pattern of one user group that has a similarity. The preference for recycled material used the nearest neighbor similarity method based on GPS coordinates where the recycled material was uploaded by the recyclable waste donor or volunteer then compared to the location of the recyclable waste taker. The recommendations proposed by collaborative filtering methods could be measured for accuracy using Mean Absolute Error (MAE). The results of the MAE calculation in the user-based CF method, the App Maturity dataset has an MAE value of 0.33. While the item-based CF method gets an MAE value of 0.17 using the same dataset. The results of testing the CF method show that in user-based collaborative filtering the prediction errors are more than in item-based collaborative filtering. The results of the CF method recommendations then sorted based on the closest distance by the LBS method.

1. Introduction
The accumulation of garbage in landfills has become one of the consequences of city government policies that still adhere to the old paradigm in handling waste in cities in Indonesia. A study released in 2010 states that every year there are 3.22 million metric tons of plastic waste thrown into the sea. If one truck of garbage is loaded with a maximum of 8 tons, then at least 402 thousand garbage trucks are needed to transport all the plastic waste, which is wasted every year into the Indonesian sea. The accumulation of garbage in landfills to the sea has affected the perception of Indonesia as the second country with the worst waste management in the world, after China [1]. Recyclable waste is recyclable solid waste produced by urban residents or small business groups. Households or individual small businesses mostly own types of recyclable solid waste such as plastic, paper, metal, glass, paper, fabric, and wood. These wastes do not include hazardous industrial waste or construction material waste that requires special handling [2]. Pilah Matur App is a recyclable waste mobile app that can be used by recyclable waste donors or volunteers to inform the recycling waste that they have. Information of recyclable waste has been input into this application can be read by other users to exchange recyclable waste. Even Pilah Matur App users can get raw materials for making new handicraft products from plastic bottles or from recycled material. The wastes that recycled by craftsmen will not accumulate in landfills. So, the amount of waste that thrown into the landfill will decrease gradually [3].

The involvement of citizens and NGOs in the handling of household waste is realized in the form of waste banks. The public or private can understand waste banks as a recycled waste processing center that is managed independently. Citizens can have benefited from exchanging recyclable waste owned
or collected to waste banks. In return, citizens get a saving book containing records of recyclable waste every day, then the saving book can be cashed after accumulating a certain amount [4]. Research related to location-based service of waste has also been enforced through waste dumpsites mapping which aims to ensure that the landfill site is spread evenly and can be monitored from smart city center [5]. Data collection on the location of waste sources and landfill location can be a source of information for more coordinated waste management. In addition, segregation of waste should be done at the source so that it can be easily processed when wastes arriving at the landfill [6].

The aim of this paper is to design of recommendation engine for Pilah Matur App using a combination of CF (Collaborative Filtering) and LBS (Location Based Service) to help waste donors or volunteers to find recyclable waste that more correspond for them and the nearest location of recyclable waste. CF is a recommended method that uses rating data from many users to generate recommendations. CF assume that the user's choice for an item will tend to be the same from time to time. This assumption is strengthened by data of other users who like the same item, so it is assumed that the user will like the items that are liked by other users. Items recommended by CF then displayed sequentially by LBS according to the closest distance.

2. Method

Collaborative filtering method works by filtering data based on the similarity of user characteristics. CF can provide new information to other users because CF provides information based on a pattern of one user group that is almost the same. Differences in interest in some group members can be new sources of information that will be useful for other group members [7].

Collaborative filtering can be divided into two different classes: a) User-based collaborative filtering is the user-based nearest neighbor algorithm that uses statistical techniques to find a set of users, known as neighbors, as shown in Figure 1. This group of neighbors has a history of approval activities with targeted users. After a group of neighbors is formed, the system uses different algorithms to combine the likes of neighbors to produce Top-N predictions. b) Item-based collaborative filtering is a recommended method that works based on a similarity between rating a product and the product chosen. From the level of product similarity, then divided by the parameters of the user's needs to obtain the value of product use. Products that have the highest usability value then used as recommendations. This method appears as a solution to several problems in user-based collaborative filtering, namely the problem of limitations and scalability and problems of time and memory [8]. The principle behind collaborative and content-based filtering is shown in Figure 1.

![Collaborative Filtering and Content-Based Filtering](image)

**Figure 1.** The principle behind collaborative and content-based filtering [9]

Pilah Matur App accepts input from waste donors or volunteers be in the form of age data, gender, recycling information sharing activities or implicit user activity data, such as the number of frequency of application usage, the type of recyclable waste that is preferred or the choice of information that is
often opened. The data is then inputted into the recommendation engine, which is divided into two modules. The first CF module that functions to filter out the types of dry waste based on the age and user rating in one cluster. Second, LBS modules that function filter location data, based on the closest distance of the user’s position at that time with the distance of the location of the recyclable waste. The recommendation engine then generates a list of recyclable waste location from the CF module and LBS modules. These results are recommendations according to user preferences and the closest distance from the user.

3. Results and Discussion

Pilah Matur App is used by waste donors or volunteers to inform the recyclable waste they have or the recyclable waste that they have collected to other users. The location of waste donors or volunteers can be identified from the recyclable waste data uploaded into the application. Recyclable waste data that has been inputted can be known by type, weight, geolocation of Android devices, and waste description by other users. So that other users can see more details or give a like sign according to their preferences, as shown in Figure 2.

![Figure 2. Pilah Matur App for waste donors or volunteers](image)

Data of recyclable waste was uploaded by waste donors or volunteers consists photos of an object, details of the type specifications or dimensions of recyclable waste, and the location of recyclable waste that obtained from GPS, as shown in Figure 2. Photos of recyclable waste were upload can provide an overview of the condition of the item, whether it can still be reused or must be destroyed. Photos can also be considered by waste donors or volunteer about how they want the recycling process. Users who are interested in photos and information can respond by clicking the "like" button. The popularity of recyclable waste can be seen from the number of "likes" and the number of "views" that the item has. "Like" data provided by the user is recorded to describe the relationship between the item and the user. If there are two users who like recyclable waste the same can be grouped as adjacent neighbors.

The number of likes on the recyclable waste and who gives the likes will be the input for the CF method, as shown in Figure 3. Sample data for the design of recommendation engine was taken from the Pilah Matur App database contain 43 waste donors or volunteers and 159 recyclable wastes. Active
users who get recyclable waste recommendations from the system are only users who have given “like” at least 3 different items. These requirements are to ensure the formation of the neighborhood and improve the accuracy of the recommendations displayed by the recommendation engine. The design of the recommendation engine for Pilah Matur App is shown below (see Figure 3).

![Diagram of recommendation engine for Pilah Matur App]

Figure 3. Design of recommendation engine for Pilah Matur App

The interface display as shown in Figure 4, only be seen by users who have given "likes" to recyclable waste at least 3 items. If the active user has not provided the required number of "likes", the recommendation page will only display a popular list of recyclable waste. The recommendation page will display the top 5 items that match the user’s preferences and then sorted by the closest distance between the user and the recyclable waste location. Information on distance and address of the position of recyclable waste can make it easier for waste donors or volunteers to find items needed. Users can also use the hide button if they do not want items recommended by the Pilah Matur App, and then the hidden items will be replaced with other appropriate items with user preferences (see Figure 4).
Figure 4. Results of a recommendation engine for Pilah Matur App

The list of recyclable waste in the recommendations page as shown in Figure 4 needs to be tested to ensure the accuracy of the recommendations proposed. The recommendations proposed by collaborative filtering methods can be measured for accuracy using the standard method in statistics called Mean Absolute Error (MAE). MAE calculates the absolute error between the actual rating and the prediction result. Accuracy of collaborative filtering methods between the actual rating ($p_i$) and the prediction result ($r_i$) can be measured by [10]:

$$MAE = \frac{1}{n} \sum_{i=1}^{n} |p_i - r_i|$$

The proposed recommendations will be more accurate if the MAE value is getting smaller. Previous studies on collaborative filtering methods showed that accurate MAE values were not more than 1.00 [10]. The results of the MAE calculation in the user-based CF method, the App Maturity dataset has an MAE value of 0.33. While the item-based CF method gets an MAE value of 0.17 using the same dataset. The MAE results show that accuracy of item-based CF method predictions is more accurate than a user-based CF method. Existing studies show that item-based CF methods could achieve comparable or better recommendation accuracy compared with user-based CF methods. Meanwhile, item similarities can be calculated on a subset of user ratings, so that item-based CF methods are of better scalability. Moreover, user-based CF methods suffer from the “cold start user” problem, which is less of an issue in item-based CF methods. Overall, item-based CF methods play an important role in the recommender system, so that the design of privacy-preserving item-based CF algorithm in this paper is beneficial [11].

4. Conclusions
The design of the recommendation engine on the Pilah Matur App as a recyclable waste mobile app using the CF method has been able to provide recyclable waste location information shared by volunteers automatically to users according to the user’s preferences. The recommendation engine using the LBS method has been able to provide information on the location of recyclable waste based on the closest distance from the user’s location. Pilah Matur App is able to provide recommendations for recyclable waste by considering the criteria of user preferences and user location obtained from the
The active coordinates of the GPS of the device used. The item-based CF method produces better quality recommendations compared to the user-based CF method. The results of calculating the average probability of errors generated by the item-based CF method are lower than the user-based CF method. The closest distance determines the order of recommendations produced by the Recommendation Engine. The development of this research can be continued by combining CF method with other methods that can improve the accuracy of the recommendations.

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