

Using Case Based Reasoning, in the Student Graduation Prediction System (CBR)

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Abstract

The performance of an educational institution is considered to have a negative impact due to the high percentage of students who do not graduate on time. Therefore, the number of students must be calculated and anticipated, so this paper needs to propose a model for predicting student graduation rates and predicting the time of graduation for each student. The K-Nearest Neighbor (KNN) method and algorithm were developed using Case-Based Reasoning (CBR). The research was conducted with training data taken from data from students who had graduated, and as a trial, the sixth-semester student data was used. The research attributes required to consist of the grade 1 to semester 5 of the achievement index (IPS) and the students' age. Model testing is carried out with four scenarios where the distribution of training data and testing data is also needed as support. The experimental results show that the stability of the data accuracy value on CBS using the KNN algorithm is found in the 90% training data scenario and 10% test data, namely 90.24% with the closest neighbors $K = 5$, $K = 7$, and $K = 9$. It can be concluded that the model. The resulting prediction system can predict whether students will graduate on time or not. This research will be helpful if implemented in higher education performance to increase student achievement to graduate on time.

Keywords: prediction, case-based reasoning, k-nearest neighbor



1. Introduction

Graduation is an expression of graduation from a university about the completion of an educational program that must be followed by all students. The student will later get a certificate as a sign of graduation after completing all educational programs at educational institutions. In this case, there are also several study programs that have students who are not on time to graduate. In tertiary institutions the number of students who have completed the education program on time does not affect the ratio of lecturers to students, as well as the ratio of lecturer readiness. In the process of fulfilling the lecturer ratio, it has an impact on lecturer recruitment, the lecturer ratio for students has also affected the superior quality of the study program. In addition, students who do not graduate on time will be subject to drop out sanctions or dismissal if they pass the predetermined learning time limit. This will have a negative impact on the relationship between the teaching and learning process in a university. In addition, the high number of students who graduate on time is not expected for accreditation of study programs.

On the other hand, there are several reasons why students do not graduate on time. The causes are, the student's employment status, student interest in the course, and the distance of students from campus to their place of residence. Therefore, this problem needs to pave the way for reducing the student graduation rate that is not on time. This problem can actually be solved by improving the prediction model. This prediction model has been used in various problems. This predictive model is also used in diagnosis, assessing performance, failure to diagnose, targets, construction costs, differentials, infectious diseases, progress, and predicting hypoglycemia. This prediction model is also extended by determining various methods.

And, this paper discusses the expansion of the student graduation prediction model. The graduation prediction model that will later be generated is expected to help the study program to solve the problem of student graduation that is not on time. This graduation prediction model can also be used to help study programs and improve student quality of learning, as well as improve student graduation rates on time.

2. Research Method

The study was conducted through five stages, namely data collection, data transformation, development of prediction models, testing of models, and evaluation of predictive results. First, data collection was carried out on 2009 to 2012 student data. Student data came from one university in Indonesia. Student data that has been collected is then selected and cleaned. The selection and cleaning of the data is done to get the data that suits the research needs. Data cleaning is intended to select data that is noise or incomplete data and then discarded.

Second phase, data transformation. This activity is carried out by transforming several forms and initial data values into data with formats and values that are appropriate to the needs of model development. The third stage is developing a student graduation prediction model. In making models, the data used are the data of students who have graduated. Next, the fourth step is to test the developed prediction models. Testing is done by predicting student graduation using testing data and training data. The fifth stage, predicts the graduation of students who are still actively studying.

2.1 The Data and Scenario

Data used in the study were 878 alumni data. Data were analyzed using Case Based Reasoning based on K-Nearest Neighbor. Alumni data are used to form models. The model was developed with 4 scenarios. Every scenario there are 5 tests. The four scenarios are: scenario 1: 25% of training data and 75% of testing data with the closest neighbor values $K = 1, K = 3, K = 5, K = 7, K = 9$; scenario 2: 50% training data and 50% testing data with the nearest neighbor value $K = 1, K = 3, K = 5, K = 7, K = 9$; scenario 3: 75% training data and 25% testing data with the nearest neighbor value $K = 1, K = 3, K = 5, K = 7, K = 9$; scenario 4: 90% training data and 10% testing data with the nearest neighbor value $K = 1, K = 3, K = 5, K = 7, K = 9$.

In addition, there was a second testing used to predict student graduation, the data referred to is the sixth semester student data of 282 data. In table 1, some training data displayed are used to develop the model. The training data used to form a model as much as 75% of the data of alumni from 2009 to 2012.

Table 1. The Data Training for Develop the Model

#	Student-ID	Name	Age	IPS 1	IPS 2	IPS 3	IPS 4	IPS 5	Classification
1	11209018	Edoardo	20	3,27	2,50	2,42	2,00	2,75	No
2	11209228	Muhmad	21	3,09	2,80	2,90	3,00	2,32	No
3	11210007	Arief Julianto	21	2,00	3,00	3,10	3,50	2,75	No
4	11210264	Ahmad	23	3,66	3,00	3,60	3,10	3,10	No
5	11211177	Sandi	20	2,95	3,37	3,11	2,40	2,67	No
6	11211185	Syukron	20	3,55	3,45	3,26	3,24	3,14	No
7	11211232	Ali Mustofa	21	3,23	2,82	2,43	2,38	3,07	No
8	11211233	Chandra	20	3,14	2,51	2,74	2,94	2,71	No
9	11211247	Leo Hardians	20	3,09	3,11	3,07	2,79	2,36	No
10	11212001	Badri Iskandar	24	3,05	2,80	2,73	3,05	3,11	Yes

Some of the testing data will be displayed which will be used to form the model shown in Table 2. The data testing one for the formation of the model is as much as 25% of the data of students who have graduated from the class of 2009 to 2012. It was to evaluate the accuracy of the model. And, Table 3 shows some of the testing data two. The data testing two is used to predict graduation from the established model. The data used are the 6th semester student data of 2014.

Table 2. The Data Testing for Develop the Model

#	Student-ID	Name	Age	IPS 1	IPS 2	IPS 3	IPS 4	IPS 5	Classification
1	11212097	Jaenudin	24	2,95	3,04	2,96	3,17	3,31	Yes
2	11212103	Wijaya	20	3,11	3,37	3,41	2,99	3,21	Yes
3	11212104	Rihaldi	20	3,18	3,63	3,42	3,92	3,69	Yes
4	11210193	Andri	20	3,73	3,00	3,26	3,51	2,85	No
5	11210203	Dossy	21	3,41	2,00	2,88	2,88	2,79	No

Table 3. The Data Testing for Prediction Graduation of Students

#	Student-ID	Nama	Age	IPS 1	IPS 2	IPS 3	IPS 4	IPS 5
1	11214001	M. Ramdona	24	3,33	3,15	3,2	2,44	2,75
2	11214003	Afitriana	20	3,33	3,46	3,63	3,7	3,29
3	11214005	M. Hidayatul	23	3,62	3,33	3	2.23	2,75

Finally, the system testing is carried out with the approach of calculating the distance measurements of the neighbor members of the K-nearest Neighbor process. The size of a neighbor's close or far distance is calculated using Euclidean Distance with Equation (1). Where $D(x, y)$ is the scalar distance of the two data vectors x and y in the form of a matrix measuring d dimensions.

$$d(x,y)= \sqrt{(\sum_{i=1}^n [(x_i-y_i)]^2)} \quad (1)$$

In addition, the predicted results which are the outcomes of the model are tested by calculating the value of Accuracy, Precision, and Recall. Accuracy values describe how accurately the system can classify data correctly. In other words, the Accuracy value is a comparison between correctly classified data and the whole data. Accuracy values can be obtained by equation 2. Precision values describe positive categories that are correctly classified with total positive classified data. Precision can be obtained by equation 3, while Recall shows what percentage indicates what percentage of positive category data is correctly classified by the system. Recall value is obtained by equation 4

$$Precision = \frac{TP}{TP+FP} \dots\dots\dots(2)$$

$$Recall = \frac{TP}{TP+FN} \dots\dots\dots(3)$$

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \dots\dots\dots$$

2.2 Literature Review

Prediction models have been developed in many fields and using many approaches. It was in education, health, financing, and risk. In the education sector, prediction models have developed to predict student performance[1], graduation success[2], student retention[3], online discussion performance[4], critical course[5], and interactive volume[6]. In the health sector, there are models predicting diabetes[7], disease diagnosis[8], risk of infectious disease[9], and hypoglycemia[10]. There are also prediction models of performance areas[11][12][13], predicting targets[14], and predicting progress[15]. In addition, predictive models are also developed to predict the degree of difference[16]. Based on the prediction models that have been developed, it is known that education is a field that requires predictive models.

Development of prediction models in general is done using one approach. Among them are the neural network approach, k-nearest neighbor, interaction network, knowledge representation, fusion models, classification, support vector machines, association rules, hybrid models, latent class growth analysis, statistical models, Gaussian process regression, support vector regressors, numerical modeling, multivariate adaptive regression, and nonlinear dynamics. Prediction models have also been developed using case based reasoning methods[17], statistical models[18], Gaussian process regression[19], support vector regressors[20], and numerical modeling[21], multivariate adaptive regression[22], and nonlinear dynamics[23][24].

There are several models developed using more than one approach. For example, combining multi-objective and neural network approaches, naïve bayes, decision trees, and combining classification and k-means clustering approaches[25]. However, based on the results of literature studies conducted it is known that the prediction model developed by combining the case-based reasoning approach and k-nearest neighbor is still limited[26]. Therefore, the method of merging case-based reasoning and k-nearest neighbor that was developed is a form of contribution in this study[27].

3. Findings

3.1 Analysis Result

3.1.1 Model of Case Based Reasoning with K-nearest neighbor

The student graduation prediction model with case-based reasoning using the K nearest neighbor algorithm developed is shown in Figure 1. The developed model consists of input, case-based reasoning using k nearest neighbor and output.

3.1.2 Input

In the Input section, there is 6th semester student data where the variables used are age, Semester Performance Index (IPS) 1, IPS2, IPS3, IPS4, IPS5. Student data for the 6th semester will be used as input[28]. This is due to students' consideration. The student has attended lectures for 5 semesters and still has 3 more semesters for the student to arrive at the graduation level on time. If the prediction results show that the student graduated not on time then the academic can provide information and motivation to the student in order to graduate on time.

3.1.3 Combining Case based reasoning with K-nearest neighbor

One of the important stages in the Case based reasoning (CBR) cycle is retrieval of previous cases which can be used to resolve new problems[29]. The fundamental questions are on the basis or consideration of what the retrieval was carried out. It was taken into consideration in many studies as the assessment of similarity, namely Similarity Assessment.

In many studies about CBR, it was sufficient to assess the similarity of stored cases based on apparent features. It is meant by the characteristics that appear from a case are the explanation it has and the form of presentation using attribute value pairs. In this study, the data in the input process will enter the new case which will then be retrieved. The retrieve process is carried out in the form of presentation using attribute value pairs, while the attribute values paired in the form of age, IPS1, IPS2, IPS3, IPS4, IPS5 are juxtaposed between old cases and new cases and determine the number of K to be used[30].

For a retrieval approach based on apparent features, the similarity of each case with a new problem is presented as a real number that is calculated according to the given measure of similarity. Usually the recalled case is the K-case which has the highest similarity with a new problem. The Retrieved case is taken from the previous case in this study, the previous case contains data of students who have graduated and have a classification value, this data will be juxtaposed with the new case in this case the data of semester 6 students. After that enter the reuse process.

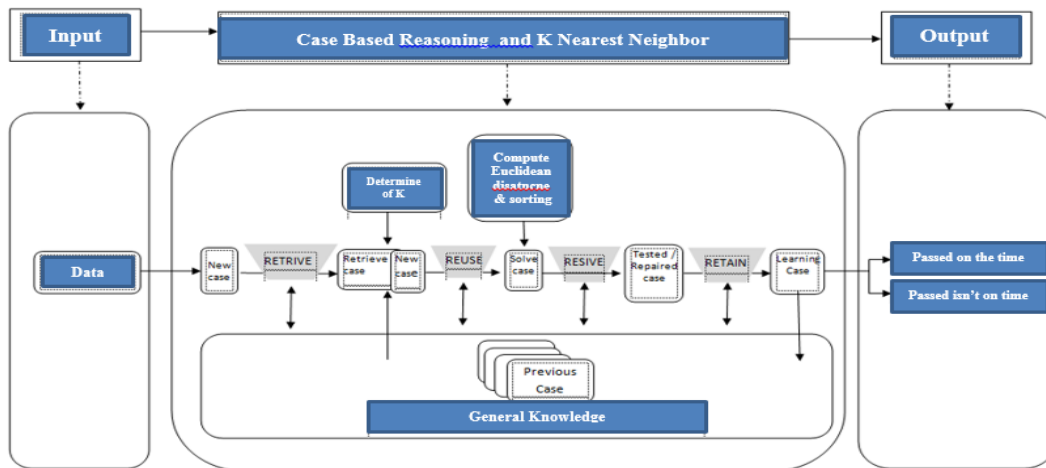


Figure 1. Combining Case based-reasoning and K-nearest Neighbor for Prediction Model

The reuse process in the CBR cycle is responsible for providing a solution (solve case) of a new case based on the resolutions of the case taken back. Solve cases are obtained by calculating the proximity between old cases and new cases using Euclidean distance then sorting the smallest Euclidean distance. After that, it is sought which has the highest similarity with new cases. From the smallest Euclidean distance it can be seen whether the problem solving (solve case) whether entered into the classification passes on time or not on time.

While in the reuse process the problem is found, the revision process can be skipped. But if the reuse stage has not yet been found, the revision process is carried out with a tested/repaired case and repeats the retrieve step. Then, we will retain and enter the learning case and enter the general knowledge.

3.1.4 Output

The output of this process is in the form of information about the prediction of the data that was inputted at the beginning of which the 6th semester students will graduate on time or not on time.

3.2 Research Implementation

3.2.1 Testing of Model

Testing the model using accuracy, matrix confusion, precision, and recall. In this study, testing the model with 4 Scenarios where scenario 1 consists of 25% training data and 75% testing data, scenario 2 consists of 50% training data and 50% testing data, scenario 3 consists of 75% training data and 25% data testing, scenario 4 consists of 90% of training data and 10% of testing data.

Based on journal that the optimal k for K-Nearest Neighbor is $K = 5$ then in each scenario there are 5 tests namely $K = 1$, $K = 3$, $K = 5$, $K = 7$, and $K = 9$. With the confusion matrix tables can be calculated with accuracy, precision, recall. The value of accuracy, precision, and recall of each scenario will be compared and then it can be seen in which scenario has the most accurate values.

Table 4. Confusion Matrix for Testing with Scenario 1, and $K = 1$

		Value of Classification	
		True	False
True of values	True	310	14
	False	130	164

The accuracy value generated by the prediction model with the test and training data in Table 5 with K = 1, is calculated using Equation (2). The precision value is calculated using Equation (3), and the recall value is calculated using Equation (4). The resulting accuracy, precision and recall values are:

$$accuracy = \frac{310 + 164}{310 + 14 + 130 + 164} = \frac{474}{618} = 76,70\%$$

$$Precision = \frac{310}{310 + 130} = \frac{310}{440} = 70,45\%$$

$$Recall = \frac{310}{310 + 14} = \frac{310}{324} = 95,68\%$$

The accuracy, precision and recall values calculated based on the data in Table 4 are values with the condition K = 1. Then the test and calculation of the accuracy, precision and recall values are repeated by replacing the value of K. Where, the test is done for K = 3, K = 5, K = 7, and K = 9. The results of the confusion matrix from five tests with different K values are shown in Table 5. While the accuracy, precision, and recall values for the 5 test scenarios are shown in Table 6.

Table 5. Data of confusion matrix for 25% data training and 75% data testing

Table of Confusion Matrix	25% data training and 75 % data testing									
	K1		K3		K5		K7		K9	
	Values of prediction		Values of prediction		Values of prediction		Values of prediction		Values of prediction	
	T	F	T	F	T	F	T	F	T	F
True of values (True)	310	14	312	12	315	9	316	8	320	4
True of values (False)	130	164	153	141	152	142	149	145	154	140
TOTAL	618		618		618		618		618	

Table 7. Values of Accuracy, Precision and Recall for All Scenario Testing

Scenario 1	Keterangan	25% data training and 75 % data testing				
		K=1	K=3	K=5	K=7	K=9
	Correctly Classified	76.70 %	73.30 %	73.95 %	74,60 %	74,43 %

	<i>Incorrectly Classified</i>	23.30 %	26.70 %	26.05 %	25,40 %	25,57 %
	<i>Precision</i>	0.705	0.671	0.675	0,680	0,675
	<i>Recall</i>	0.957	0.963	0.972	0,975	0,988
Scenario 2	Label of information	50% data training and 50 % data testing				
		K=1	K=3	K=5	K=7	K=9
	<i>Correctly Classified</i>	85.19 %	86.89 %	84.22 %	79.13 %	77,67 %
	<i>Incorrectly Classified</i>	14.81 %	13.11 %	15.78 %	20.87 %	22.33 %
	<i>Precision</i>	0.775	0.795	0.759	0.699	0.685
	<i>Recall</i>	0.975	0.980	0.985	0.995	0.990
Scenario 3	Label of information	75% data training and 25 % data testing				
		K=1	K=3	K=5	K=7	K=9
	<i>Correctly Classified</i>	89.32 %	91.26 %	93.20 %	93.69 %	93.20 %
	<i>Incorrectly Classified</i>	10.68 %	8.74%	6.80%	6.31%	6.80%
	<i>Precision</i>	0.845	0.872	0.901	0.908	0.915
	<i>Recall</i>	0.982	0.982	0.982	0.982	0.964
Scenario 4	Label of information	90% data training and 10 % data testing				
		K=1	K=3	K=5	K=7	K=9
	<i>Correctly Classified</i>	89.02 %	89.02 %	90.24 %	90.24 %	90.24 %
	<i>Incorrectly Classified</i>	10.98 %	10.98 %	9.76%	9.76%	9.76%
	<i>Precision</i>	0.780	0.795	0.800	0.800	0.800
	<i>Recall</i>	1.000	0.969	1.000	1.000	1.000

The results of testing in Table 7, inform that in scenario 1, the highest accuracy value is at K = 1 (76.70%), but the accuracy rate is not yet stable. In the second scenario, the highest accuracy results are at K = 3 (86.89%), but the level of accuracy is also not stable. The accuracy value in the first scenario and the second scenario were not stable.

In the third scenario, the highest accuracy value is at K = 7 (93.69%). The level of accuracy is quite stable but there is still a decline. Meanwhile, in the fourth scenario, the highest accuracy value is at K = 5, K = 7, and K = 9 (90.24%). Furthermore, in the fourth scenario, the value of accuracy is the most stable compared to other scenarios because at the time K = 5, K = 7, and K = 9 the model produces the same input rate. Thus, testing of the prediction model with a combined approach of case-based reasoning and k-nearest neighbor in this study resulted in an accuracy value of 90.24%. The highest and stable accuracy value obtained in the testing scenario uses 90% of training data and 10% of testing data.

4. Conclusion

This research has proposed a prediction model by combining two approaches namely case based reasoning and k-nearest neighbor. Prediction models are applied to attributes in the form of numerical data. Testing of the proposed model shows that the model produces an accuracy value of 90.24% with a test scenario of 90% of training data and 10% of testing data, as well as with the nearest neighbors at K = 5, K = 7 and K = 9. The test results prove that the resulting prediction model is able to predict student graduation. Further research is needed to

test the consistent prediction model by adding other attributes so that the number of attributes becomes more. Attributes of distance from home to campus, income of parents, how many children, and the number of siblings can be considered for further development of prediction models.

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