Forecasting Models for Academic Course Offering
Towards a Decision Support System for New Era University Department of Computer Science

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Abstract— The Decision Support System for Academic Course Offering of New Era University – Department of Computer Science is a system composed of three interrelated subsystem to assists the academic enrolment. This study explores simple exponential smoothing, moving average and regression models in projecting the number of students enrolled in a subject that help the school administrator in getting the number of section to be offered. The study composed of problem definition, data collection, model formulation, model verification and model integration. Problem definition and data collection includes defining variables to be considered as well as data cleaning. Model formulation uses time series and regression models and graphs in analyzing the patterns in enrolment trends. Model verification is performed by comparing the results of forecasted and actual number of enrollees in a subject. The integration of models in DSS was developed using java programming language and Eclipse IDE. Finding the best forecasting model for each subject was evaluated using symmetric Mean Percentage Error (SMAPE). In this study, 40 subjects, 32 were tested using regression model. Experimental results yield an average of 10% difference between the forecasted actual values. The resulting forecasts in each subject can be used to support in determining the number if sections to be opened before the enrolment commence.

Keywords- DSS (Decision Support System); Data Mining; Forecasting; Academic course scheduling; Enrolment

I. INTRODUCTION

The advents of computer system for solving problems have been built on different principles and with different aims. Decision-making problems in real life are characterized by complex, unstructured nature of problem domains, unpredictable outcome of decisions due to dynamic nature problems and information, and the potential risks associated with making an incorrect/inaccurate decision. Academic resource planning is a complex operation based on board analysis of data related to the educational framework, such as teaching resources, offered courses, course structure, curricula and number of enrollees. As each new term or semester is established, one of the prior tasks of an educational institution.

Educational supply measures the available teaching capacities in terms of the volume of services the faculty’s staff provides to students. Every instructor assigned teaching load which defines the number of academic hours per week to be invested in teaching. Educational demand describes the consumption of the instructor’s academic services by the students who attended courses according to their respective curricula.

Educational institutions abroad project enrolment for the coming semester uses different statistical models to project the number of students to enroll in a certain course or year level. A study on the enrolment forecasting for an upper division general education components uses regression analysis based on historical data to forecast the total number of enrollment as well as the student demand for seats in theme courses.[1] The accuracy of a forecasting model is important as many factors have effect on university enrolment.

The researchers tend to prove the best forecasting model for the enrollment of the New Era University-Computer Science Department to forecast the number of students to be enrolled next semester. Different forecasting models used in enrolment forecasts and different accuracy level will be presented.

Decision Support System (DSS) are software application that have been used over the last few decades to provide support for many structured and unstructured problems such as strategic planning, investment planning, stock portfolio management, enterprise planning, human resources management, supply chain planning, knowledge management, case-based reasoning and help desk automation. A DSS uses models to transform data into information that helps a person to improve on decision making capabilities [2]. The purpose of modeling is to reduce complex institutional problems to simpler proportions, so that the human skills of decision makers can most effectively be brought to bear on the issues to be resolved. Various academic DSS for resource allocation
performance assessment, course scheduling, admission policy, advising, student profile evolution and strategic planning have previously been proposed. DSS targets to support the administrative task of planning the university’s educational capacity in terms of the number of students its courses can accommodate under the specified resource constraints [3]. Forecasting refers to predictions of the future developments that typically are outside the control or influence of a plan design. The resulting forecasts can be used to support in estimating the number of sections to be offer before the enrollment commence. Inaccurate enrollment forecasts can lead to poor utilization of classroom and class schedules.

With the use of some applications that uses decision support and intelligent agent solution in conflicting schedules and managing educational utilization can be solve. These studies attempt to solve room utilization and course schedules using the enrolment projections and statistical models. The concepts and tools stated above can be used any the researcher to develop an application.

A. Goals and Objectives

Specifically, this study seek to accomplish the aim to develop a well-designed and useful application that can help New Era University – College of Computer Studies, Department of Computer Science to have an efficient decision support system for academic course scheduling. With the use of the application the problems stated must be solved. And the purpose of decision support system is to improve the room utilization, lessen the percentage of conflicting schedules, and a consistent approach time period shifts.

B. Statement Of the problem

The main concern of this study is to develop a Decision Support System for Academic Offering. Specifically, the study aimed to answer the following questions:

1. What are the input variables in developing the decision support system for academic course offering?
2. What are the design considerations for the decision support system for academic course offering in terms of the following:
   i. Data mining techniques; and
   ii. Algorithm;
3. What is the level of acceptability of the forecasting model integrated to the decision support system for academic course offering?

C. Significance of the Study

Findings from this study will be helpful to the University to solve the problems in academic course scheduling. This part of the study discusses about the importance of creating the system to following: Academe, the study will help the academe to provide efficient course scheduling system. School administrator and Department heads, the result of

This study might help the school administrators in planning for better facilities. It might also help them to determine the number of section to be open that will lead to good room utilization. Another important contribution of this study is that it would provide the school administration a working decision support system that forecast the enrolment. Students, the study will help the students in using model as their reference and guide in studying other applications in the field of information and technology.

II. METHODOLOGY

A. Conceptual Framework

The proposed software use the DSS for academic course scheduling framework (Figure. 1) to simplify the process of data and solving the problem. This figure shows how data is being process.

![Conceptual Framework of Decision Support System for Academic Course Scheduling](image)

The interactive flow that will apply on Decision Support System for Academic Course Scheduling. The functionalities of subsystems are summarized as:

Database management subsystem: The database management subsystem has the function of manipulating and storing data such as professors, courses, available classrooms, and their size. Model management subsystem: Model base Management system (MBMS) that manages the model base. Different parameters provided by users to assist decision makers in analyzing situation. A model base which contains statistical, optimization and all of the mathematical models used to produce the schedules. This component constitutes the core of the DSS. It stores and manages the modes to support the analysis, design and choice tasks in the decision process. Dialogue subsystem or user interface: The user interface would allow the user to access, edit, modify add, and view the information. The user can interact with the GUI, providing input as prompted and provides report containing a set of solution for the user as the results of the DSS. The primary responsibility of a DGMS is to enhance the ability of the system user to utilize and benefit from the DSS. Display Generator: To support user-system interaction it is important that data results of models are presented in a clear and
appropriate form to the user. The display generator should offer user the possibility to view information in table, charts or graphics form. Report Generator: The Report generator: should not be confused with the display generator shows results of model-based analyses, whereas the report generator reports them. A well-structured and legible report is important for the interpretation and documentation of results and communicating motivation for decisions made, for example, to policy makers, users or other interests groups. A good report describes data; models and results of analysis performed and are written in non-technical (for a lay-person comprehensible) terms.

B. Software Development Procedure

This section describes the approach used for developing the Decision support System for Academic Course Scheduling (Figure 2).

![Diagram of DSS Development Process](image)

**Figure 2 Generalized DSS Development Process by Min Song**

Problem diagnose: The phase concerns with the analysis of formal identification, Identification of objective and resources: A specific objectives must be described and available resources identified, System analysis: This phase concerns with three categories of requirements (functional, interface, coordination). During the analysis phase, information is gathered to define the scope of the project and determine its feasibility, System design: the design phase consists of both logical design and application design. In logical design a blueprint of the database needed to support all applications is produced. System construction: this phase concerns on iterative prototyping approach, with small bit constant refinement employed. System implementation: the implementation phase includes testing, evaluation, and deployment with writing manuals. Incremental adaptation: This final phase is continual refinement of the activities of the earlier six stages. The final phase is to maintain and improved system [4].

C. Data Gathering Techniques

This section discusses the tools and procedures use by the researcher to gather needed data for the completion of the study. The researcher uses documentary analysis and interview as their instrument in gathering from their respondents. These tools are important for the researcher in order to get the best understanding of the research study and it serves as the overview of the study.

- **Data Analysis** -Historical data is analyzed to discover patterns or relations that will be useful in projecting the future values of significant variables. The historical data provided by the university helps the researcher in analysis phase of the study and gave relevant information in order to make the generated schedules accurate.

- **Evaluation** -This often used to determine areas that need improvement and to develop methods and strategies for improvement. The researcher conducted an evaluation among the respondents. All gathered information will be the basis of the performance of the study.

D. Statistical Treatment Data

On this part of the study the researcher will interpret the gathered data from the respondents and show the different statistical tools in order to extract instructors’ preferences and set some rules is knowledge management provided by a data mining technique.

- **Forecast Accuracy** -Is the difference between the actual value and the forecast value for the corresponding period [5].

\[ E_t = Y_t - \hat{Y}_t \]

Where:

- E : Forecast error.
- Y : Actual value.
- F : Forecast value.
- T : Period.

- **Mean Absolute Percentage Error (MAPE)** - Is a measure of accuracy of a method for constructing fitted time series values in statistics, specifically in trend estimation [6].

\[ M = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{d_t - \hat{d}_t}{d_t} \right| \]

Where:

- At: Actual value
- F: Forecast value.

- **Simple Moving Average**- Moving average techniques forecast demand by calculating an average of actual demands from a specified number of prior periods. Each new forecast drops the demand in the oldest period and replaces it with the demand in the most recent period [7].

\[ T_i = \frac{1}{3} (Y_{i-1} + Y_i + Y_{i+1}) \]
Where:

- $Y_t$ is the 1st value from the value to be forecasted.
- $Y_{t-1}$ is the 2nd value from the value to be forecasted.
- $Y_{t-2}$ is the 3rd value from the value to be forecasted.

- **Single Exponential Smoothing:** the exponential smoothing was fitted on enrollment data. Exponential smoothing is highly suitable for environments such as inventory system for forecasting the demands [8].

\[ F_{t+1} = \alpha Y_t + (1 - \alpha) F_t \]

Where:

- $F_{t+1}$ is a forecasted value for the period before current time period $t$.
- $Y_t$ is the actual data at time period $t$.
- $\alpha$ is the weight given to the latest data.

- **Multiple Linear Regression:** Regression analysis is useful for predicting enrollment as soon as the key indicator. Multiple regression models are explored for predicting the future number of enrollees [9].

\[ Y = B_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 \]

Where:

- $Y$: is the dependent variable or item to be forecasted
- $X$: is independent variable or predictor.
- $B$: is coefficient.

### III. RESULTS

The researchers presented, analyzed and interpreted every data to the problem formulated in the study. Data were presented either in tabular or graphical form. Interpretations of findings follow the sequential order of the questions indicated on the statement of the problem. Data used in this study were tabulated and placed into the data file using the Excel and SPSS statistical software packages.

#### A. Input variables in the development of decision support system for academic course offering.

The researchers gathered data that were used in the study. Gathered data covers the BS Computer Science enrollment statistics for academic year 2007-2012 specifically enrollment statistics for major subjects Computer Science curriculum. These factors are past enrolment data, curriculum or program offered, prerequisites and number of students in the program. Based on the enumerated factors, the researchers focuses on curriculum and past data. The projected number of students will be the basis on how many sections to be offered for the next year including the first and second semester.

Figure 3 Show trends for the number of enrollees per subject for academic year 2007-2012. There were ten (10) selected subjects that graphically represented. These subjects are CS131, CS132, CS231, CS232, CS233, CS141, CS142, CS241, CS242 and CS243.

![Figure 3: Number of Enrollees per Subject](image)

In this study, software was developed with statistical tool that assist the academic program administrator in forecasting the number of students expected to enroll in a subject as well as the number of the section to be offered in each subject. Models are based on the data of New Era University – Computer Science Department from school year 2007 to 2012 and were evaluated using actual data of school year 2012-2013.

#### B. Design considerations for the development of the decision support system for academic course offering.

**Data mining techniques**
![Single Exponential Smoothing in CS335](image)

Figure 6: Single exponential smoothing in CS313

Figure 6 shown the trends for actual and forecasted value for subjects CS131. The number of students enrolled on subject CS131 for 2007-2011 are 318, 299, 149, 172 and 285 and has the actual value 296 for the number of students enrolled on 2012. Given the formula of exponential smoothing $F_{t+1} = (0.05)Y_t + (1-0.05)(F_{t-1})$, the forecasted for 2008-2011, $Y_t$ is the actual data at time period of $t$. These effects of the different values of alpha on the different subjects shows that an alpha of 0.05 gives more accurate results on forecasting the actual value. The selection of alpha is based on percentage of error of the actual and forecasted value. Since a subject has this own pattern and there is no definite alpha, subjects may have different alpha. The smoothing constants must be values in the range 0-1.0. Most appropriate smoothing constant depends on the data series being modeled. In general the speed at which the older responses are dampened is a function of the value smoothing constant.

![Single Exponential Smoothing Parameters: Alpha 0.05](image)

Evaluating the given sample on exponential smoothing has the MAPE 38.46% and SMAPE 6.69%.

### Simple Moving Average

![Figure 7 Simple Moving Average Model](image)

A shown in figure 7, $T_i$ is the time period to be forecasted. Y’s are value for consecutive years and 1/3 is the value depends on the given consecutive years.

### Multiple Linear Regressions

![Figure 9: Multiple Linear Regression Model](image)

As shown in figure 10, formula for forecasting the number enrollees in CS335 using regression model. The multiple linear regressions formula interpreted as $Y$ subject to be forecasted or dependent variable X’s are number of passers for pre-requisites subject of the dependent variables or the independent variable. 121.8 is the intercept given for dependent and independent variable, 0.12 is the given coefficient for the first independent variable and -0.17 is the coefficient given for the second independent variable. The value 187.00 and 182.00 are the actual value of independent variables.
Figure 10 shown the trends of the actual and forecasted value for the subject CS335. The number of students enrolled on subject CS335 for 2007-2012 are 115, 91, 113, 116, 115, and 100. CS335 has four pre-requisites: subject CS142 and CS142L. The numbers of students passed on subject CS142 for 2007-2012 are 187, 178, 98, 75, 159, and 104 while on subject CS142 are 182, 186, 115, 84, 175, and 99. Independent variables are the total number of passed on the pre-requisites of a particular subject. The research allow K for independent variables to potentially be related to the dependent variable.

Given the formula for regressions Y is total number of enrollees for 2007-2012, X is the total number of passers for 2007-2012 and B0 is the intercept. The intercept is the value of Y when all the variables take the value zero. Since the data range of all the independent variables do not cover the value zero, do not interpret the intercept. B1 is the coefficients. The coefficient means if it is negative the enrollees will decrease depends on the coefficient and if it is positive the enrollees will increase depends on the coefficient.

In the example given, the intercept for Y as computed is 121.58, the coefficient for subject CS142 is 0.12 and subject CS142L is -0.17. The forecasted value for 2008 as computed 121.58+(0.12)(187.00)+(-0.17)(182.00), for 2009 80.95+(0.12)(178)+0.12(186.00), for 2010 121.58+(0.12)(98.00)+0.12)(155), for 2011 121.58+(0.17)(75)+(0.12)(84) and for 2012 121.58+(0.17)(159.00)+(0.17)(175.01). The forecasted value for 2012 as computed is 110.59 comparing to the actual value for 2012 which is 100.00 and giving 7.86% MAPE and 1.81% SMAPE.

Table 1: Multiple Linear Regression using SPSS

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Std. Residual</th>
<th>CS335</th>
<th>Predicted Value</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.469</td>
<td>115</td>
<td>108.80</td>
<td>6.201</td>
</tr>
<tr>
<td>2</td>
<td>-1.112</td>
<td>91</td>
<td>105.70</td>
<td>-14.703</td>
</tr>
<tr>
<td>3</td>
<td>.047</td>
<td>113</td>
<td>112.38</td>
<td>.615</td>
</tr>
<tr>
<td>4</td>
<td>-1.29</td>
<td>116</td>
<td>117.71</td>
<td>-1.706</td>
</tr>
<tr>
<td>5</td>
<td>.725</td>
<td>115</td>
<td>105.41</td>
<td>9.593</td>
</tr>
</tbody>
</table>

Table 1 shows the evaluation using regression model in IBM SPSS. Case number is the number of year where forecasted value for the year starts in 2008. A residual (or fitting error), on the other hand, is an observable estimate of the unobservable statistical error. Standardization residual (was raw residual that is divided by its standard deviation) for academic enrollment for 2008-2012 are .6201, -14.703, .615, -1.706, and 9.593.

Among 40 subjects, 80% were modeled and tested using regression models. The researcher used the number of passers as predictor on a pre-requisite on a particular subject giving the positive correlation between the dependent and independent variable. The correlation was evaluated using IBM Statistical Product and Service Solutions (SPSS).

Algorithm
The integration of the forecasting model was developed using java programming language and Eclipse IDE. The enrollment forecasting models handles the determination of the subjects as well as the students expected to enroll. All data are stored using WAMP server, it is a windows based programmed that allows to manage easily databases. The developed decision support system will then generate table of the list of the subject and the expected students to enroll.

The table is to be retrieved in the graphical user interface of the decision support system. It can also display the statistics for the past enrollment in each subject graphically. The generated forecasting value helps the system decide on how many section to be opened for the next semester.

public Smoothing(double[][] actualData, double alpha) {
    double forecast = 0;
    int y;
    forecast = actualData[0][0];
    for (y = 0; y < actualData.length; y++) {
        forecast+= alpha * (actualData[y][0] - forecast);
    }
    createSection(forecast);
}

Figure 11 shows single exponential smoothing model integrated using java programming language and used in a subject that has no pre-requisites. The actual data and alpha is set from the model management.

for (int x = 0; x < subjCode.length; x++){
    //Smoothing
    double[] dependent = fdb.getDataDependent(subjCode[x]);
    double alpha = 0.2;

if (subjCode[x].contains("CS 1"))
    alpha = 0.05;
    Smoothing s = new Smoothing(dependent, alpha);
    int enrolled = s.getEnrolled();
    int section = s.getSection();
    if (regCtr , subj.length){
        //Regression
        if (subjCode[x].equals(subj[regCtr][0])){
            double[][] independent = fdb.getDataIndependent(subj[regCtr][1].split(","));
            Regression r = new Regression (dependent, independent);
            regCTR++;
            enrolled = r.getEnrolled();
            section = r.getSection();
        }
    }
    fdb.insertForecast(subjCode[x].enrolled, section);
Figure 12: Forecasting model implementation using java

Figure 12 shows on how model was being implemented to the system. All subjects in selected semester will get from the database. The model set the alpha for single exponential smoothing model. Smoothing results are for no pre-requisites subjects and regression results are for subjects that have pre-requisites. All the forecasted value in every subject will temporarily store in database.

Private void regression
(finat Matrix Y, final Matrix X, final Matrix beta){
    double predicatedY = beta.getValueAt(0,0);
    int i = Y.getNrows() - 1;
    for(int j = 1; j < beta.getNrows(); j++)
    {    
        predicatedY += beta.getValueAt(j,0) * X.getNrowsAt(i, j - 1);
    }
    createSection(predicatedY);
}
Figure 13: Multiple Linear Regression Algorithm

Figure 13 shows on how multiple regression algorithm being implemented using a java programming language. Multiple Linear regression model was used in a subject that have pre-requisites. It computes the beta and matrix to predicted the number of enrollees and create a section.

In the study, the researchers implemented multiple linear regression algorithm on different subjects that has a pre-requisite. Thus, not all subjects are applicable in regression model.

- Level of acceptability of the forecasting model integrated to the decision support system for academic course offering.

Selecting model to be integrated in the decision support system is based on the evaluation of the smallest percentage of error. A SMAPE and MAPE is the main basis since it is not offset by negative numbers in the forecast value. In single exponential smoothing, the model with least error was used to forecast on that particular subject given the alpha for single exponential smoothing. The idea is implemented into a program so that generation of the alpha for single exponential smoothing will not be a tedious and computation extensive work for a forecaster.

Table 2: Model Accuracy

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>SMAPE</th>
<th>MAPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Exponential Smoothing</td>
<td>4.06%</td>
<td>17.14%</td>
</tr>
<tr>
<td>Simple Moving Average</td>
<td>3.67%</td>
<td>14.78%</td>
</tr>
<tr>
<td>Multiple Linear Regression</td>
<td>2.53%</td>
<td>9.79%</td>
</tr>
</tbody>
</table>

Table 2 shows the Accuracy and efficiency of the model. The researchers used two different statistical treatments for evaluating errors; Symmetric Mean Absolute Percentage Error (SMAPE) and Mean Absolute Percentage Error (MAPE). Multiple linear regressions has a lowest percentage error of 2.53% SMAPE and 9.79% MAPE indicate that the model is giving an accurate results. Simple moving average algorithm also showed an acceptable level of accuracy with SMAPE of 3.76% and MAPE of 14.78% while single exponential smoothing has a lowest accuracy with SMAPE of 4.06% and MAPE of 17.14%.

Table 3: Model summary for subjects using SMAPE

<table>
<thead>
<tr>
<th>Subject</th>
<th>Single Exponential Smoothing</th>
<th>Simple Moving Average</th>
<th>Multiple Linear Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS131</td>
<td>7.13%</td>
<td>9.05%</td>
<td></td>
</tr>
<tr>
<td>CS132</td>
<td>7.04%</td>
<td>8.89%</td>
<td></td>
</tr>
<tr>
<td>CS433</td>
<td>2.90%</td>
<td>1.69%</td>
<td></td>
</tr>
<tr>
<td>CS441</td>
<td>3.77%</td>
<td>2.51%</td>
<td></td>
</tr>
<tr>
<td>CS432</td>
<td>1.94%</td>
<td>2.93%</td>
<td>1.54%</td>
</tr>
<tr>
<td>CS335</td>
<td>2.25%</td>
<td>2.49%</td>
<td>1.76%</td>
</tr>
</tbody>
</table>
The findings in this study indicate an increase productivity of decision makers and improve decision making ability in terms of giving the number of section to be opened using the decision support system. The integration of a forecasting module with the developed decision support system assists the enrollment in projecting the number of students expected to enroll in a subject. The effect of single exponential smoothing is a critical factor to be considered in using a time series models. Three statistical models are considered in the study. The single exponential smoothing, moving average and multiple linear regression. MAPE and SMAPE are used to evaluate the fit or accuracy of the data to the models. The researchers used SMAPE to adjust the percent of error due to small amount of enrollment data. About 80% of the subjects were evaluated using multiple linear regression and integrated to the decision support system. The result of the forecasting for academic year 2012-2013 is compared to the naive model used by the university. Initial results less error MAPE with about 9.79% and SMAPE of 2.53% in favor of multiple regression model. The techniques used in this study can be used to other educational institutions with similar settings. The study may also use to enhance analytical thinking in understanding the patterns. Other statistical methods can be integrated to the existing model to further improve the quality and accuracy of the decision support system.

V. RECOMMENDATION

Based from the Discussion/findings and conclusion of the study the following recommendations are offered as possible ways to improve this study.

<table>
<thead>
<tr>
<th>Course</th>
<th>MAPE (%)</th>
<th>SMAPE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS341</td>
<td>3.46%</td>
<td>1.70%</td>
</tr>
<tr>
<td>CS342</td>
<td>3.25%</td>
<td>1.70%</td>
</tr>
<tr>
<td>CS442</td>
<td>1.60%</td>
<td>1.71%</td>
</tr>
<tr>
<td>CS443</td>
<td>7.00%</td>
<td>3.21%</td>
</tr>
</tbody>
</table>

Table 3 shows the accuracy of the three forecasting model in different subjects. The projected data from multiple linear regression yields less error using SMAPE with 2.535 difference in favor of the multiple linear regression model. Thus, all the techniques in this study have an acceptable level for forecasting the enrollment. The integration of the model was based on the data in each subject. All subjects that had no pre-requisites were not preformed using multiple linear regressions. Among 40 subjects, 32 were evaluated using multiple linear regression.

IV. DISCUSSION

In terms of forecasting, future researchers are encouraged to enhance their mathematical skills specifically in probability and statistics that will help future researchers in analyzing behaviors for enrollment trends.

4. The study used SMAPE to evaluate the accuracy of the model due to small numbers of gathered data since the study covers only enrollment statistics of Computer Science Department. Future researchers are advised not to limit their study in one department it may have small amount of data which may affect the accuracy of the models.

5. The researcher used IBM SPSS software and MS Excel to test and evaluate the three models. Future researchers are advised to have the basic skills in running different statistical software

REFERENCES