Royal Marty
Final Project

Use of the Simplex Algorithm and Linear Systems for Theatrical Purposes

MATH 3220: Data Mining Methods

Executive Summary

The problem introduced throughout this paper is to create a system in which the theater industry can use to price out and budget flats (also called walls). This process of budgeting and pricing out flats is often performed by the Technical Directors. The Technical Directors have many other duties as well. Thus is why it would be an invaluable asset to have a system in which the user can quickly price out and budget the current production. The system can be represented in many different manners, including programs, tables, and graphs. Through the graphs and tables the results will be an estimate only, but will provide the user with guidance to speed up their process. With the introduction of a computer program, the system will be as accurate as the algorithm will allow. For example by inputting the x and y dimensions, the program would provide the user with the figure of how much the unit would cost.

I will use the simplex algorithm to create a system to price out and budget flats. The simplex algorithm is often called the simplex method. It is a method for solving linear programming and linear equations. When the Simplex Algorithm is performed it tests the adjacent vertices of a set, when the set is tested it forms a new vertex. Thus the algorithm is always converging to the closest and most accurate answer or staying the same. Because the simplex algorithm will never diverge, it is important to this process. Because the algorithm is always converging the answer will become more and more concrete and more accurate. Throughout this process it is vital for the solution to be as accurate as possible, as people are relying on the system to save them money in the labor and in the construction phase.

When organizing the Simplex Algorithm I will divide the algorithm into five different parts containing, two different styles of construction. The styles will be standard and Hollywood with three different construction materials. The first will be ¼" lauan, ¼" CDX Plywood, and the third flat covered with a fabric called Muslin (the price of this is an estimate, taking the price per yard). The algorithm is organized in this fashion for several reasons, the first being that the most popular and standard construction techniques are resembled in the algorithm. The second reason the algorithm has the specific organization, is because it will give the user a great deal of freedom and the user will be able to quickly recognize which construction style best suits their budget.

The solution to the Simplex Algorithm in this case came after a fair amount of using the algorithm and figuring it out. The answers that the system outputted were expected, as I had a sense of what the algorithm should output from my previous experiences budgeting and costing out a flat. After performing the techniques and steps detailed through the Simplex Algorithm and creating a series of linear equations and programs it was quickly

evident that if this were a system in which the user solved by hand it would not save the user any time. In fact it would be more time consuming than physically counting the amount of materials needed. But, seeing the model of this system and the research, it seems as though the Simplex Algorithm and Linear Programs can be programmed so a machine can do the calculations. If a machine could perform this system reflected, the system would be a great asset, as it would help solve the system at a quick and accurate rate.

Problem Description

Throughout the theatrical industry and among many other industries much time is taken to price out and budget materials for projects. In the theatrical industry, the majority of the times taken to budget out items are the same, often referred to as flats. Flats are used in many different ways but usually as walls. The construction techniques vary from location to location, but are often very similar. The human hours spent on budgeting and costing out the flats depends from person to person but is, always time consuming and mundane. Thus is why the introduction of a system in which the user can input the dimensions of the flat or the square footage, would be invaluable.

The system created must contain the ability to input different material costs. The ability to input a different material cost is vital, as the prices fluctuate from geographical locations and depend on the market. With the ability to input different material costs the user can also depict what the unit will be constructed with. The user will not be locked into only using the same lumber the system was created with. For example, the user can depict whether the unit would be constructed with wood, steel, aluminum, plywood, lauan, etc.

One of the problems for the system is the fact that it needs to be easy to use, as the users will have different mathematical skills along with time. Because of the amount of mathematics that will be required for the system, there will be many different ways to represent the problem and solution. There are many different options, the user will be able to put the information into a table or graph and use it for reference purposes. But the drawback for the table or graph is that the information would not be as exact as performing the mathematics for the problem. Another way for the user to use the system would be to input the data into a program, the program would need to be written but it would allow the user to quickly input the information and receive the most accurate answer.

Analysis Technique

To create a model to solve the solution of budgeting flats and standard scenic units the user will begin with the Simplex Algorithm. The Simplex Algorithm is a method for solving a linear programming problem. The algorithm consists of a collection of linear inequalities with a number of real variables and a given linear functions which can be maximized or minimized. The method is devised into adjacent vertices of a similar set in a sequence, so that at each vertex the function is always improving or staying the same.

The Simplex Method is considered to be a very simple and efficient method, generally taking only two to three equation constraints (which is a very minimal amount of altering an equation).

Mathematically the Simplex Method can be solved through a series of matrices or tableaus. The user considers the variables to be; maximize, $\mathbf{c}^T\mathbf{x}$ subject to $\mathbf{A}\mathbf{x} \leq \mathbf{b}$, $\mathbf{x} \geq 0$. It is through these variables that the Simplex Method is organized. It is organized as a linear program in augmented form, which is resembled in this form as a matrix:

$$\begin{bmatrix} 1 & -\mathbf{c}^T & 0 \\ 0 & \mathbf{A} & \mathbf{I} \end{bmatrix} \begin{bmatrix} Z \\ \mathbf{x} \\ \mathbf{x}_s \end{bmatrix} = \begin{bmatrix} 0 \\ \mathbf{b} \end{bmatrix}$$

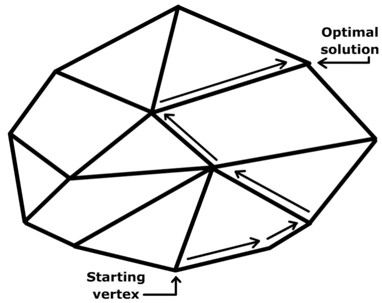
The simplex algorithm can also be displayed in a tableau, a table that depicts an illustration. Below is an example of how the Simplex Algorithm could be depicted in tableau form.

P	x	y	s	t	k	Eqn
1	-2	-1	0	0	0	1
0	1	2	1	0	6	2
0	1	1	0	1	5	3

In the matrix above the x are the variables, x_s are the introduced slack variables through the augmentation process, c contains the optimization coefficients, A and b describe the systems of constraint equations, and Z is the variable to be maximized. The system described is often undetermined; meaning the number of variables is greater than the number of equations and constants. By having an undetermined equation it gives the user freedom as they can adjust the formula to the needs necessary. It also affects the degree of precision as the variables get adjusted.

When the Simplex Algorithm is solved through the use of a tableau the equations are represented in a table form. In order to input the formulas into the tableau the formulas must be written without inequalities, therefore the user places slack variables into the formula. The slack variables stand for an arbitrary difference that will later make up the difference between the two sides of the formula. The slack variables are generally notated with *s* and *t.* The table is organized with one row per equation and one column per variable. The top row is always the equation for the objective function, while the rows below are the rows for the coefficient equations.

The algorithm is often organized in a latter fashion, meaning the higher and broader values towards the top. As the algorithm progresses the more detailed and precise answer the algorithm will produce. The fashion in which the algorithm is organized can be varied. One of the more popular ways to organize the system is through a polytope:



Through a polytope the user follows the "paths", starting at the beginning point and working their way toward the end to achieve the most precise answer. Another way of organizing that data is through the use of a table. In a table layout all of the data is organized into two sections as the user follows the data on the x and y axis to achieve their ideal data.

C_j	-4,00	-15,00	-12,00	-2,00	0,00	0,00	RHS	
CB \ V	x1	x2	x3	x4	s1	s2		
0	0,00	-2,00	-3,00	-1,00	1,00	0,00	-1,00	1
0	-1,00	-3,00	-1,00	1,00	0,00	1,00	0,00	2
Z_j	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3
C_j-Z_j	-4,00	-15,00	-12,00	-2,00	0,00	0,00		4
-12	0,00	0,67	1,00	0,33	-0,33	0,00	0,33	5
0	-1,00	-2,33	0,00	1,33	-0,33	1,00	0,33	6
Z_j	0,00	-8,00	-12,00	-4,00	4,00	0,00	-4,00	7
C_j-Z_j	-4,00	-7,00	0,00	2,00	-4,00	0,00		8
-12	0,25	1,25	1,00	0,00	-0,25	-0,25	0,25	9
-2	-0,75	-1,75	0,00	1,00	-0,25	0,75	0,25	10
Z_j	-1,50	-11,51	-12,00	-1,99	3,50	1,50	-3,50	11
C_j-Z_j	-2,50	-3,49	0,00	-0,01	-3,50	-1,50		12

In the case of using the Simplex Algorithm to find the value of theatrical flats and standard scenery, the use of a table will be extremely helpful and efficient. The data can be organized so the user can create the table occasionally, merely as the prices fluctuate. The table can then be used by not only the creator but by the average person, because the table will be easy to use and read.

Assumptions

The assumptions that I made throughout the solving and modeling process are:

- The price of hardware is not included (i.e. staples, screws, glue, etc.)
- The Simplex Algorithm is a technique accurate enough to solve this system
- The model created is large enough and provides realistic data

Results

Through this process of the Simplex Algorithm, a tableau was constructed with five different construction techniques. The construction techniques involve different materials, which were displayed with the columns in the tableau.

	1 x 4	**¼” Lauan**	**¼” Plywood**	**Muslin**	**Other Materials Needed**	**Amount Budgeted**
Standard- ¼” Lauan	16.8	13.6			3.43	200
Hollywood- ¼” Lauan	16.8	13.6				200
Standard- Muslin Covered	16.8			12.2	6.43	200
Standard- ¼” Plywood	16.8		27.5		3.43	200
Hollywood- ¼” Plywood	16.8		27.5			200

Displayed in this tableau is the value of which the flats could be constructed, a price list in which the prices could be obtained can be found in the appendices. All values displayed in the table are in dollar form. After constructing this tableau, the tableau is then adapted to create the formulas and variables for the equations.

v	w	x	y	z	-1	
16.8	13.6			3.43	200	$= -p$
16.8	13.6				200	$= -q$
16.8			12.2	6.43	200	$= -r$
16.8		27.5		3.43	200	$= -s$
16.8		27.5			200	$=f$

Once this table is formed the equations then become very simple to construct. The user uses the rows and the assigned variables to make the equation equal the variable in the last column. For example the formula would first be constructed as:

$$16.8v + 13.6w + 3.43z - 200 = -p$$

With simplification the formulas reflect the formula below.

$$16.8v + 13.6w + 3.43z + p = 200$$

Once these tableaus and equations are constructed the user can then manipulate the formula to solve for what they want the information to depict. This is when it becomes visually evident that the Simplex Algorithm is an ideal system for solving many linear problems and equations at one time. With a computers help the equations could be solved in a matter of seconds as opposed to a human physically performing the arithmetic.

Issues

The largest and most evident issue with the system created would be the use of the algorithm. It is evident that if one were to perform this algorithm and arithmetic by hand it would not save time. If the algorithm relied on a human to solve the functions it also puts the accuracy in the hands of the solver. All of these issues are issues that are very important to the system because they do not help the user, and in many cases they inhibit the user from using the system. The solution would be to have a computer solve the computations. If a computer were to solve the computations then the issues become irrelevant.

Appendices

On the following page is a price list assembled prior to computing the values given in the tables above. Figuring how much one would need to construct the flat, and multiplying that by the cost of the material computed the values. For example:

It takes 2.5 1 x 4 x 16’-0” to construct a 4’-0” x 8’-0” Hollywood flat. Therefore 2.5 x 6.72= 18.8.

Material Price List

Location: Webster University- Conservatory

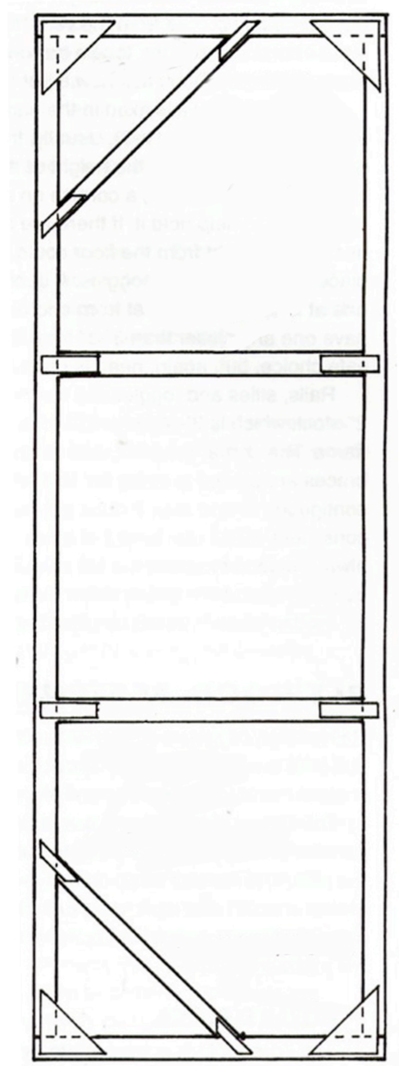
Prepared By: Royal Marty

Updated: September 18, 2008

Material	Price Per Unit	Date of Estimate	Vendor	Notes
1"x4"x16'	$6.72	September 18, 2008	Beyers Lumber	Paint Grade Spruce
1"x6"x16'	$10.88			Paint Grade Spruce
1"x8"x16'	$14.40			Paint Grade Spruce
1"x10"x16'	$21.60			Paint Grade Spruce
1"x12"x16'	$25.28			Paint Grade Spruce
2"x4"x16'	$5.76			Spruce
2"x4"x20'	TBA			
2"x6"x16'	$8.16			Spruce
2"x6"x16'	$12.48			#1 Yellow Pine
2"x8"x16'	$14.08			#1 Yellow Pine
2"x10"x16'	$16.80			#1 Yellow Pine
2"x12"x16'	$24.96			#1 Yellow Pine
4"x4"x8'	$11.36			#1 Treated Pine
4"x4"x10'	$16.20			
4"x4"x12'	$19.44			
4"x4"x14'	$14.00			
4"x4"x16'	$25.92			
1/4" Ply- 4'x8'	$27.50			Available in AC Only
5/8" CDX Ply- 4'x8'	$22.80			Yellow Pine
5/8" CDX Ply- 4'x8'	$25.60			Fir
3/4" AC Ply- 4'x8'	$42.80			AC Fir
7/16" OSB- 4'x8'	$9.75			
5/8" OSB- 4'x8'				Available in Units Only
1/4" Luaun	$13.60			
1/8" STD Hardboard	$7.70			Also Called Masonite
1/4" STD Hardboard	$13.20			Also Called Masonite
1/2" Black Insulation	$7.95			
1/2" Pink Foam- 4'x8'	Market			Order Necessary, Price Fluctuates
3/4" Pink Foam- 4'x8'	Market			Order Necessary, Price Fluctuates
1" Pink Foam- 4'x8'	Market			Order Necessary, Price Fluctuates
1-1/2" Pink Foam- 4'x8'	Market			Blue Foam
2" Pink Foam- 4'x8'	$28.95			Blue Foam
3/4" White Bead Foam- 4'x8'	Market			Order Necessary, Price Fluctuates
1" White Bead Foam- 4'x8'	Market			Order Necessary, Price Fluctuates

In the tables above, the column for "Other Materials Used" resembles pieces built called conerblocks and keystones, which are pieces that are vital for construction as well as disposable hardware.

Below is an illustration that depicts a standard flats and Hollywood flats.



<u>Work Cited</u>

Simplex Algorithm-
http://en.wikipedia.org/wiki/Simplex_algorithm
Simplex Method-
http://mathworld.wolfram.com/SimplexMethod.html
Mazoo's Learning Blog: Example of Using Simple Algorithm-
http://learning.mazoo.net/archives/000878.html
<u>Linear Programs and Related Problems</u>
By Evar D. Nering and Albert W. Tucker
Revision: The Simplex Algorithm- The Student Room
http://www.thestudentroom.co.uk/wiki/Revision:The_Simplex_Algorithm
The Simplex Method
http://www-fp.mcs.anl.gov/OTC/Guide/CaseStudies/simplex/
Tutorial For The Simplex Method
http://people.hofstra.edu/Stefan_waner/RealWorld/tutorialsf4/frames4_3.html