

OPTIMIZATION PROGRAM DESIGN OF LAYING DOWN PATTERNS IN THE PLANE

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Abstract.

There are lots of events compelling everyone to lay down several patterns in a bounded area like garment factory, wood handicraft company, or metal industry. Various conditions push people to show patterns such that the used area becomes minimal. These days many individuals still use the patterns by guessing but the case will be difficult when patterns don't have regular configurations. By using Tabu search for optimal positions and using computer as a tool, it is hoped that constraints be overcome.

The objectives of this research were to design and build a system of optimal searching of laying down the patterns in bounded area using Tabu search method. In this undertaking, a location optimally searching program was made starting from entering an input in the shape of the pattern pictures, changing to pattern objects used, processing them to produce an output in the shape of combined picture of the patterns.

Testing using an input of a pattern consisted of three sections, though there are cases to be handled, i.e. picture usage with bitmap windows format can eliminate the accuracy of the picture as a result of executing refinement effect against the graphics made.

Keywords: optimization, plane, pattern, Tabu search, program design

1 Introduction

In everyday life, there exist situations where we have to put down a maximal number of patterns on some bounded area. For instance, these situations happen in a garment company, a wood handicraft company, or a metal industry. More specifically in an industrial world, many people use raw materials in the form of sheets like metal sheets, plywood, cloth, etc., then they are cut according to required patterns to produce a certain configuration having a high selling price. In mosaic industry, a plate of glass is cut according to the necessity to make a mosaic glass. In metal industry, a sheet of stainless or aluminium steel is cut to make a neon box, traffic sign or others. In a garment company, a dress is formed from several pieces of cloth with the same motives or colors. In the process of the making, these patterns are put on a wide sheet of cloth to be cut in accordance with the patterns.

This paper focuses on ready-to-wear garment industry for instance, but, the possibility is still open to be applied to other industries having the same characteristics or raw materials. In ready-to-wear garment industry, the process to produce a dress is as follows:

First, determine the required sample patterns that are formed in a sheet of newspaper. The sample patterns are put on a sheet of cloth as a required model from the cloth. Then, the cloth is cut according to the determined pattern. After the patterns from the cloth are found, they are cut to be sewed to make a ready-to-wear garment.



Figure 1.: Example of a dress pattern

To improve the competitiveness in the country, or even abroad for instance the import of used garments from China, we can make cost efficiency by using raw material of cloth maximally, i.e., the remaining or unused raw material by the cutting becomes minimal. This means that the cost of production becomes lower.

However, the present reality shows that many involved people still use raw material inefficiently because of putting down the patterns by guessing. They think their guessed patterns are the best but their guesses can be inaccurate.

There are a lot of remainings or unused raw materials that can often be seen e.g. plates of iron, sheets of cloth, where their quantities are still large, but the conditions have been the remainings because maybe they cannot be entered to the machines or the patterns produced by the remaining are enough. So, "the remaining" are in fact used properly, if in the designing the putting down patterns can be optimal, i.e., the usage of raw material can be minimal.

1.1 Design Formulation

How to describe an object in the real world to become one in the computer graphics then it is used to find an optimal position of putting down several objects in a plane using Tabu search method such that the remaining or unused raw material produced becomes minimal can be satisfied.

1.2 Design Specification

Program design of pattern optimization uses:

- a. Operating system Windows XP Service Pack 2
- b. Programming language Microsoft C#Net 2003

1.3 Problem Cover

The cover in the making of this paper are:

- a. Input constitutes a pattern picture with colors 24-true color with format Windows Bitmap (BMP).
- b. Neglecting the length of processing time needed for searching the best result.
- c. The maximal number of input patterns is three.
- d. Rotation executed of each pattern is 90° .
- e. There exists a detail subtraction when the picture is mapped into the grid. No. 3-5 are done because of reversedly proportional to the length of the processing time

1.4 Objectives and Benefits

Objectives

- a. To search an optimal solution appropriate with the required need.
- b. To apply an optimization method to solve industrial problems
- c. To make a computer application program to ease calculations with the method used, so it can be implemented in the field.

Benefits

To industrial executives

- a. To be able to improve profit as the result of the material saving.
- b. To help to overcome the problem if there is a lack of raw material because of the existing raw material already optimized.

1.5 Research Methodology

Research methodology used by the authors in this paper are:

a.Literature study method

The authors found Tabu Search method, a technique in the computer graphics that supports the making of the paper and programs from libraries, internet and other sources. The authors then studied and understood material related with the research topics.

b.Laboratorium research method

The authors tested the method of finding optimal pattern position in the laboratorium with designed application program using language C#Net 2003.

2 Tabu Search

Tabu search is a meta-heuristic approximation that gives a basis to a procedure of local heuristic seeking used to search a possibility of finding another solution beyond local optimality level or to search an optimal solution or to search solutions close to it. Tabu search dramatically has changed our capability to solve problems in applied sciences, business, or engineering. Method to find a solution by Tabu search has been a dominant focus for the last three decades and is still being a dominant focus at present.

Meta-heuristic itself means a master strategy that gives a basis and modifies other heuristics to produce a solution or conclusion, other than the usual one applied to research to find an optimality level. (Glover and Laguna, 1997, p17).

Tabu search is based on conclusion, that problem solution, to satisfy a quality as an intelligent method has to combine adaptive memory and responsive exploration. Adaptive memory capability on Tabu search gives possibility to implement a procedure capable to find a solution encounter efficiently and economically. The importance of the usage of responsive exploration on Tabu search, implemented by determinant or probability, is found from the assumption that the choice of bad strategy can produce more information than a good choice found randomly. In the system using memory, a bad choice that is taken based on strategy can give useful conclusion about how a strategy can be changed to a better one.

Responsive exploration combines basic principle of intelligent searching like always attempt to look for the best solution as long as still looks for all existing possibilities. Tabu search always attempts to look for new and more efficient method in taking profit from combination of adaptive memory and responsive exploration mechanism.

2.1 Components of Tabu search

- Initial Solution: Object pattern P is put at the corner of the plane, near the origin O(0,0).
- Move: Move the pattern through tracks determined by definite criteria. For every move can be executed several processes needed like updating the boundary of the plane, checking when a collision happens and others when needed.
- Basic Neighborhood $N(\pi)$: Neighborhood of π consists of solutions found through a move from present solution π .
- Tabu List: Tabu List is defined as set $T = \{T_1, T_2, \dots, T_s\}$ T_j is a j-th element of T containing related objective value. If s varies with manner acyclic, then looping can be avoided.
- Tabu tenure: Tabu tenure is st dynamically.
- Stopping rules: rule/condition to terminates a calculation, can be chosen by infinite, i.e. process tries to do all possible, or by criteria if solution found does not experiences improvement after experiencing repeated iterations t_j times or others.

2.2 Computer graphics

According to Xiang (2001, p1), computer gaphics studies foundations of drawing science application in a computer. Image processing is a branch of computer graphics that manipulates a drawing or configuration produced by computer graphics to produce a drawing required by the user, drawing produced can be ralistic, abstract, even virtual (Xiang, 2001, p4).

2.3 RGB Color Management

Color management of RGB is made with large classification of true color intensity symbolized with value 0-255 or 8 bits for each basic color, thus for true color there exist 24 color bits able to be utilized.

In its basic development, it is only required about 200 color levels to be able to produce just color gradation. To be able to be differed by human eyes, it is made 256 color levels because of two cases (Fraser et al., 2003, p61):

Head room, this is used to overcome a missing/changed color as an effect of various processes experienced by a color (after printed, scanned, and others).

Bits, representation with bit is very inadequate if when applied for just 200 levels, where 7 or 27 bits produces 128 levels and 8 or 28 bits produces 256 level intensity. Thus, with representation $256 \times 256 \times 256$ colors RGB system can produce 16.8 million types of color. Of course, there are plenty combinations compared to color representations delegated less than 24 bits or true colors.

With the development of hardware technology, at present card graphic cards have been able to give color effect 32 bits where the remaining 8 bits are intended for quantity of bright intensity of color, symbolized by α . With the magnitude of color intensity 8 bits or 256, then color model RGB can also be represented in hexa-desimal 2 digit, from the smallest level 00 up to the highest FF (255).

Thus for example black color, because there is no combination of light, then delegated with hexa 000000, on the contrary, white is combination of three maximum light, delegated with hexa FFFFFFFF.

2.4 Bitmap Document(.bmp)

This bitmap document bmp is one of picture/image formats. In a document bmp one can save picture starting from 1 bit color (black/white) until 24 bit color (true color).

According to Bourke (1998), structure of this document as seen at Figure 2.6 consists of four sections: header, info header, optional palette and image data. The bitmap header contains 14 byte data containing information stating identification as a bitmap document, data magnitude or size in this document, as well as initial information of bitmap document reading

2.5 Two Dimensional Transformation

Foundation of all computer graphics systems is ability to simulate results of object manipulation in space (Xiang, 2001, p68). Function of this transformation is necessary, if there are several objects, where each has co-ordinate system, needs to be put down together in a master of system co-ordinates. There are two important points in describing an object transformation. Firstly, the object is relatively transformed with respect to fixed system co-ordinates. Mathematical terminology in this case is called geometric transformation applied to every point of the object. Secondly, the object is fixed but its system co-ordinates are relatively transformed with respect to the object. This case can be found by co-ordinates transformation. An example to differ both of them is by watching the movement of a car with respect to its neighborhood.

We can simulate that event by moving a car while its neighborhood remains fixed (geometric transformation), or the mobil is kept fixed by moving its neighborhood (co-ordinates transformation).

A point can be represented in a two dimensional plane through its co-ordinates. The values of the co-ordinates can be more specific as a one row and two columns matrix $[x, y]$ or a two rows and one column matrix $\begin{bmatrix} x \\ y \end{bmatrix}$. A

network of points in a computer is described as matrices where their elements are numbers. This position can be controlled by matrices manipulation of the points. (Rogers, 1979, p24).

2.6 Cartesian Two Dimensional Coordinate System

A Picture in general constitutes a form of two dimensional system, therefore a mathematical concept can be applied to process it. (Anil K. Jain, p11).

In a two dimensional plane, we can choose a point and call it as an origin. Through the origin point, we can make two perpendicular lines called axes. These axes are usually called x-axis and y-axis. The direction of the plane can be determined by positions of x-axis and y-axis. If a rotation of 90° can be measured counterclockwise from positive x-axis to positive y-axis, then we call the coordinate system is right-handed. In the contrary, if the direction of the rotation is clockwise the coordinate system is called left-handed.

Straight lines perpendicular with respect to x-axis and perpendicular with respect to y-axis form square grids in a two dimensional plane.

Every point P in the plane lies at the intersection of exactly one straight line perpendicular with respect to x-axis and exactly one straight line perpendicular with respect to y-axis.

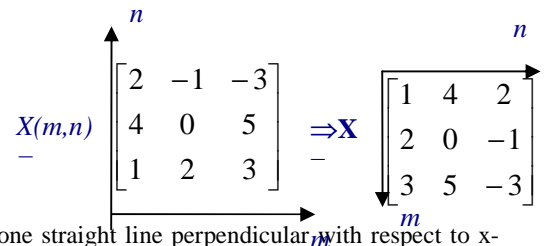
the Through dot of origin that is we earn to make two diametrical plump line which named by tinder. This tinder is usually called by axis of the abscissa and . Instruct from the area can be determined from positive position of axis of the abscissa and tinder y. If rotation of 900 contrary degree of clockwise of positive area of x and is positive of y, hence the system co-ordinate named by right-handed on the contrary if rotation clockwise hence the system co-ordinate named by left-handed.

Vertical lines perpendicular with respect to x-axis and vertical lines perpendicular with respect to y-axis constitute a rectangular grid in the two dimensional plane. Every point P in the plane lies at the intersection of exactly one line perpendicular to x-axis and also exactly one line perpendicular to y-axis. An ordered pair (x, y) associated with point P is called a Cartesian co-ordinate of P. Using this method, every point in the plane can be represented by a pair of co-ordinates.

Matrix

A matrix is a rectangular table that consists of rows and columns. Notation a_{ij} is used to represent a matrix element residing at the i th row and j th column.

A two dimensional matrix is often used to represent a picture. A picture matrix representation is obtained by 90° clockwise rotation of a two dimensional matrix is co-ordinate matrix.



Every point P in the plane lies at the intersection of exactly one straight line perpendicular with respect to x-axis and exactly one straight line perpendicular with respect to y-axis.

Size measure or dimension of notation matrix in $m \times n$ where m represent the amount of line of and matrix of n represent the amount of column of matrix. Matrix can be used for the presented f geometry transformation in computer graph.

$$a(m,n) = \begin{bmatrix} a(1,1) & a(1,2) & \dots & a(1,n) \\ a(2,1) & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ a(m,1) & a(m,2) & \dots & a(m,n) \end{bmatrix}$$

Algebra of matrices:

a. Scalar multiplication

If A is a matrix and k is a constant, then matrix kA is obtained from matrix A by multiplying all elements of A with k.

b. Matrix addition

Two matrices $A = [a_{ij}]$ and $B = [b_{ij}]$ of size $m \times n$ can be added to form a matrix $C = A + B = [c_{ij}]$ where $c_{ij} = a_{ij} + b_{ij}$.

c. Matrix multiplication

Matrix A of order $m \times p$ can be multiplied with matrix B of order $p \times n$ to form matrix C of order $m \times n$ by doing dot product on line i of matrix A with column j of matrix B. Multiplication of matrices is not commutative, i.e. $AB \neq BA$.

Boundary

A boundary is an edge that forms characteristics of an object. Boundary represents a series of pixels that forms the edge of an object, but it is not part of the contour of the object itself. Boundary is very useful in measuring configurations in geometry like measuring an area. Conceptually, boundary can be formed by following interconnected edges.

A representation of an accurate boundary is very important in analyzing and forming a pattern. Shape analysis is usually required for detection and recognition of an object on an assignment. Formation of an object is very useful in computer-aided design (CAD), picture simulation like video games, cartoon movies, environmental modeling of planes and its training.

Geometric Transformation

Suppose there is a plane with a co-ordinate system. An object Obj as a set of points is mapped to the plane. Every point of the object has co-ordinates (x, y) . Suppose an object Obj is moved to a new position. Let Obj' be the new object where its points with co-ordinates P' resulted from the original points P using transformation calculation (Xiang, 2001, p69).

a. Translation

In translation, an object will be moved with respect to a certain

distance and direction from its original position. If the movement is given in v vector $v = txI + tyJ$, a new object at the point $P'(x', y')$ can be calculated using transformation formula T_v at point $P(x, y)$
 $P' = T_v(P)$
where $x' = x + tx$ dan $y' = y + ty$

b. Rotation with respect to center point

In rotation, an object is rotated with respect to center point with angle θ . If θ is positive, the direction of the rotation is counter clockwise, If θ is negative, the direction of the rotation is clockwise.

Formula of rotation R_θ is

$$P' = R_\theta(P)$$

$$x' = x \cos \theta - y \sin \theta$$

where $y' = x \sin \theta + y \cos \theta$.

A key to understand how a geometric object can be described and manipulated in a graph system of a computer is to understand how to play in geometry and numbers (Xiang, 2001, p271). We have owned elementary bases of geometry like how to describe a line, an angle, shapes and properties of the objects like rotation, translation, distortion, etc. We also recognized computers that can process numbers fast. The problem is how to describe our geometric ideas into numbers so the computer can understand and do our duty.

Bubble Sort

Bubble Sort or exchange sort is a simple sequential algorithm. Its sequential process is by comparing every object in its list with the next object and exchange them if needed. This process is conducted repeatedly until all objects are in the situation where they are well ordered. This matter looks like a situation where a larger value "bubble"

downwards in the list while smaller value climbs up in the list.

Pseudocode of bubble algorithm is:

```
function bubblesort (A : list[1..n]) {
  var int i, j;
  for i from n down to 1 {
    for j from 1 to i-1 {
      if (A[j] > A[j+1])
        swap(A[j], A[j+1])
    }
  }
}
```

Beneficial matter of bubble sort is that this algorithm is simple and easy to be implemented while its loss is that its algorithm is inefficient. This situation causes that this algorithm is suited for short list with the number of objects is not large (for example less than one hundred), because it has an efficient level that is almost the same as one of more complicated and sophisticated algorithms. But for objects having many elements, this algorithm is not suitable to be implemented, because it will cause tardily sorting process.

3. IMPLEMENTATION AND RESEARCH RESULT

Specification of Hardware and Software

This design can work well at configuration of hardware minimum using processor AMD Athlon XP processor 1700+ with memory 512 Megabytes DDR-SDRAM (Dual Data Rate - Synchronous Data of Random Access Memory). The needed memory capacity equals to 1 Megabytes, just for installing this program. The used monitor equals 17 inches with resolution 1024 x 768 presenting the overall form of the program.

Configuration of hardware more than one mentioned above will yield better performance, especially in part of processor and memory, because this program needs computational resources especially speed.

The used software in this design is Microsoft WindowsXP Professional Service Pack 2 32-Bit as operating system, while for its programming language uses technology of Microsoft C# Net 2003. This design also uses software Corel Draw 12 as picture processor needed to help or make the used patterns.

3.1 Preparation of Data

For the process of Tabu search, the needed data are pictures with format windows bitmap bmp) owning pattern pictures to be used in Tabu search process. To prepare pattern pictures, it is used software Corel Photo-Paint software 12 to make patterns in format of BMP.

For testing in this chapter, the used pattern is a rectangular pattern divided into three parts. The conducted division is one part of in form of 'L' and the other two parts become irregular forms. The reason of using this pattern is to know whether the program is able to combine three parts mentioned above becoming the original rectangular pattern. This matters, because we easily know that the original form is an rectangular. Another situation, when the used pattern having an original shape when we combine the fractional parts of the original pattern we are not sure if the result is optimal although the program states it is optimal.

. Thus the objective using the pattern like this is to be able to easily compare the ability of human beings and computer calculation. Then, the conducted testing

rotates the second pattern with angle 180° . This testing is done in order to know whether the existing pattern can be rotated by the program, because other wise optimal condition is not achieved.



Pattern 1 Pattern 2 Pattern 3

All three patterns already mentioned are then be saved to become three files in format of windows bitmap (bmp) needed by the program as an input. For more detail about specification of each picture, please look at the following table:

No	Name	File Name	Color	Scala
1.	<i>Pattern1</i>	<i>Pattern1.bmp</i>	Red	1:25
2.	<i>Pattern2</i>	<i>Pattern2.bmp</i>	Cyan	1:25
3.	<i>Pattern3</i>	<i>Pattern3.bmp</i>	Chartreuse	1:25

3.2 Research Result

After implementation by using input of three patterns, then we get a result in the form of the alliance picture of three position patterns. Searching process requiring this 12 seconds indicates that existing patterns experience rotation. First red pattern experiences rotation of 180° . The second blue pattern also experiences rotation of whereas third green pattern does not experience any rotation. There is possibility of distinction in the positions of three patterns resulted with initial pattern condition before broken, where initial pattern before broken has orientation landscape horizontal whereas the result obtained has portrait orientation vertical vertical. The distinction can happen since he program can rotate all existing patterns, but the result does not affect the initial objective, i.e., finding optimal position.

The result can be said that it has shown optimal pattern positions. This can be seen from the result constituting a rectangle, where the existing cavity among patterns is minimal, so the area needed for the patterns is also minimal.

From result of this research can be said that the program can function according to initial objective and estimation by placing the three existing patterns optimally like initial patterns before broken, although there is orientation distinction of the result, but it does not matters.

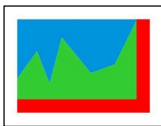


Figure 2 : Result of best position

3.3 Conclusion

Based on the result of testing to the program and previous discussion on the relevant chapters, we draw the conclusion as follows:

- Techniques used in computer graph can be used to represent objects in real world becoming data objects and these data are processed using calculations in geometric transformation.
- Program resulted from the help of Tabu search as technique, for its searching it can show optimal position from patterns laid down in the plane.
- Tabu search method used in the program is flexible enough for a searching method, so it is possible to develop it according to existing searching need.
- Searching process for optimal pattern position still has a weakness, i.e., still needs a lot of processing time mainly for patterns more than three as well as for detail of high pattern.
- The use of picture format windows bitmap (.bmp) in the program has strength and weakness. Its strength includes the number of its supporting software for manipulate pictures in the format and it constitutes a picture format very widely used. And also format windows bitmap uses coordinates system so it is easy to synchronize with the patterns used in the program. Nevertheless the picture format has a weakness i.e. the picture processor software used always makes pattern line refinement effect made, so the accuracy of the picture is decreased.

3.4 Recommendation

Based on the result of testing and theoretical discussion to this application program, then several recommendations can be advanced for the development of this application program for other researchers are as follows:

- Using Tabu search in the application that needs searching technique, because this method has proved to be applied in various fields.
- For application making using data coming from real world, it is necessary to learn techniques in computer graphs and its calculation technique like geometric transformation, coordinate transformation, and others.

- c. Picture format used constitutes only windows bitmap format. It is hoped that the format can be developed to use picture format more widely used like JPEG, TIFF and others.
- d. The length of processing time needed for patterns more than three and small scale. It is hoped that we can develop methods to increase the speed of this program. Several methods that can be tried include (1) using the better soft ware that really shortens the processing time. (2) using other programming language with property Object Oriented Programming.(3) using other method and (4) developing new technique in Tabu search. This is probable since the nature of Tabu search that is very flexible.

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4 References

Anil, K and Jain. 1989. *Fundamentals of Digital Image Processing*, Prentice-Hall, Inc., New Jersey

Anonymous. The RGB Color Space. *The Color Of Televisions and Computer Monitors*. [Online] TECHCOLOR Graphics, Inc.[Cited: December 20, 2008.] <http://www.techcolor.com/help/rgb.html>.

Associates, O'Reilly &. 1996. Pros And Cons Of Bitmap File Formats. [Online] http://netghost.narod.ru/gff/graphics/book/ch03_08.htm.

Pros And Cons Of Bitmap File Formats. [Online] 1996. http://netghost.narod.ru/gff/graphics/book/ch03_08.htm.

Boumphrey and Frank. 2003. Basic Color Theory 1. *Hypermedic Color Pages*. [Online] [Cited: December 20, 20 December 2008.] <http://www.hypermedic.com/color/theory1.php>.

Bourke and Paul. 1998. BMP Image Format. [Online] [Cited: December 20, 20 December 2008.] <http://astronomy.swin.edu.au/~pbourke/dataformats/bmp>.

Fraser, et al. 2003. *Real World Color Management*. Peachpit Press, Berkeley

Glover, et al. 1997. *Tabu Search*. s.l. : Kluwer Academic Publisher

Lamont, Boston and Lamont. 2004. Bubble Sort. [Online] <http://linux.wku.edu/~lamonml/algor/sort/bubble.html>.

Liberty and Jesse. 2002. *Programming C# Jilid 2*. O'Reilly, California

Rogers and David, F. 1985. *Procedural Elements For Computer Graphics*. McGraw Hill, Singapore

Rogers, David, F and Alan, J. 1979. *Mathematical Elements For Computer Graphics*. McGraw Hill, Annapolis

Xiang, et al. 2001. *Computer Graphics Jilid 2*. McGraw Hill, Singapore

Enclosure:
Result of Optimization

