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CONTENTS

From Editor

In this issue of "International Journal of Electronics, Mechanical and Mechatronics Engineering (IJEMME)", we have especially selected the scientific areas which will cover future prospective Engineering titles such as Robotics, Mechanics, Electronics, Telecommunications, Control systems, System Engineering, Biomedical, and renewable Energy Sources.

We have selected only a few of the manuscripts to be published after a peer review process of many submitted studies. Accepted papers are as follows:

Prof. Dr. Osman N. UCAN
Editor in Chief

Preparation of a Carbon Fiber Reinforced Epoxy Composite and Increasing The Flight Performance for Radio Controlled Model Helicopters

Doi: 10.17932/ IAU.IJEMME.m.21460604.2015.5/3.949-953

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Abstract

Composite-material technologies have matured over the past 40 years to the point where high performance composites are being used to enhance the performance of nearly every new flight vehicle [1]. Carbon fibers have been used to replace metals used in composite materials because its performance-price is changing favorably [2]. They are also lighter and stronger than metals. This is the main reason why carbon fibers are used in composite materials. They also reduce fuel consumption and provide energy efficiency [2]. Furthermore, they have been used in many products, such as cars, airplanes, sporting goods, space vehicles and custom-designed products [2]. In this study, carbon fiber reinforced epoxy composite (CREC) was prepared and the flight performance of a radio controlled model helicopter with CREC chassis was evaluated. According to test flights it was observed that carbon fiber reinforced epoxy composites increase the flight performance of model helicopters.

Keywords:*Composites, carbon fiber, flight performance, radio controlled model helicopter*

1.Introduction

The materials needed to construct theoretrical models conceived by aircraft designers did not exist for many years [1]. Composite materials have allowed engineers to overcome difficulties and now they are frequently used in the aircraft industry. They are five times lighter and seven times stronger than aluminium. Therefore, they are important to the aviation industry. The most important benefit of composite materials is their weight, which plays a fundamental role in their selection. They provide additional advantages such as high strength, design flexibility, dimensional stability, high dielectric strength, corrosion resistance, light weight, simplicity of molding, surface treatment compatibility, high temperature resistance, transparency, high chemical resistance, vibration damping, acoustic conductivity and sound absorption. These factors have roles in reducing the operating costs of aircrafts in the long term, increasing fuel efficiency and performance [3,4,5].

A composite material is formed by combining two or more constituent materials with

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substantially different physical or chemical properties, resulting in better properties than either constituent can provide independently. But, unlike a metal alloy, the constituents do not dissolve into or blend with each other, they remain separate and distinct within the finished structure [6,7]. One constituent serves as a bonding matrix while the other serves as reinforcement, in the form of fibers within the matrix[1]. In principle, a base matrix is prepared in a mould under high temperature and pressure. Subsequently, an epoxy or resin is poured over the base material, and when the composite is cooled, a strong material is attained [3].

1.1.The manufacturing process

A common feature of all composite processes is the combination of a resin, a curing agent, and a reinforcing fiber. In general, heat and pressure are used to shape and cure the mixture into a finished part. The resin holds the fibers together and transfers the load to the fibers in the manufactured composite part. The curing agent (or hardener) acts as a catalyst in curing the resin into a hard plastic. The reinforcing fiber gives strength and other properties which are necessary for the composite.

The most common manufacturing process is prepregging. In this method, the resin and curing agent are impregnated into the reinforcing fiber. The prepreg must be reserved in a freezer until used in the manufacturing process. Cold storage is maintained to prevent premature chemical reaction. These prepreg materials are frequently preferred in the composite industry, especially in the aircraft and aerospace industries (Figure 1).

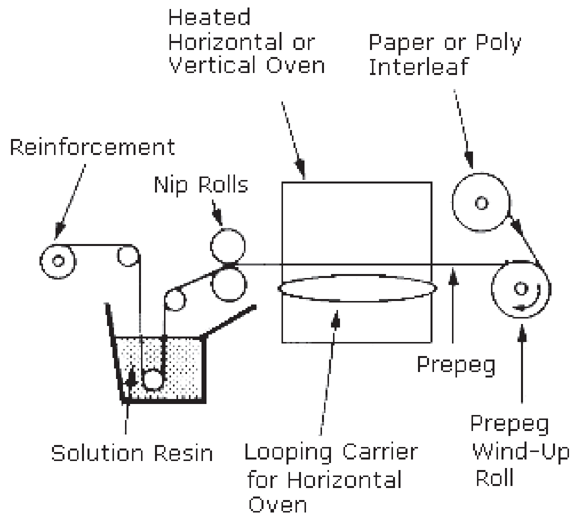

Figure 1. *In the prepregging process, a resin is applied to a reinfocement fiber. To saturate the fiber, it is dipped through the liquid resin or it is impregnated through heat and pressure.*

1.2.Polymer matrix composite resin systems

Thermoset resins are generally used in manufacturing composites. They require addition of a curing agent or hardener and impregnation on to a reinforcing material, followed by a curing step during the manufacturing process of the finished part.

The most common and important class of epoxy resins widely utilized in the industry is formed from reacting epichlorohydrin with bisphenol A. The curing agents or hardeners are fundamental ingredients of a composite sytem because they control the reaction rate and determine the performance features of the finished part. These compounds must include active sites on their molecules because they serve as catalysts.

1.3.Fiber Reinforcements

Fibers are added to the resin to give strength to the finished part. They are an integral part of the composite system; however they don't react with the resin. The most frequenly-used reinforcement materials are carbon fibers[8].

Carbon fiber is a very durable material which has a fibrous structure. The raw material of carbon fiber is acrylic. Carbon fiber is produced by the combination of nylon and tar [9]. This fiber is manufactured at furnace temperatures of 1000-2000°C. At these temperatures, the carbon atoms in the fibers are rearranged to provide the properties necessary for the finished fiber[8]. The carbon fiber manufacturing process comprises four chemical stages:

1)The Oxidation step, achieved by heating the fibers at lower temperatures in air (approximately 200-300°C), which allows the spun fibers to pick up oxygen molecules and separate from hydrogen.

2)In carbonization step carbon atoms are bonded in a crystalline structure, which is accomplished by heating the fibers to approximately 1000-3000°C.

3) Electric surface treatment helps prepare the fibers for bonding to resins by adding small amounts of oxygen and roughening the surface or electrically coating the fibers [10].

4) Coating, where a neutral finish protects the fibers from proximate treatments such as prepreg, is performed on fibers that are typically molded with epoxy resin to act as an interface between the fiber and resin [4].

Carbon fibers are manufactured by the controlled thermal treatment of organic precursors (polyacrylonitrile, pitch or rayon) in fibrous form [5]. Today, the polyacrylonitrile (PAN)-based carbon fiber is the most utilized precursor in the composite industry [8]. This white fiber is produced by extruding and processing an acrylonitrile-based polymer, which when integrated with plastic resins produces a carbon fiber composite prepreg for fabricating composite structures [11]. Polyacrylonitrile, a hard, rigid thermoplastic material that is resistive to numerous chemicals and solvents, is of low permeability to gases and slow-burning and is the key ingredient in high-performance parts used in aerospace applications [12]. Its features are key to obtaining the high tensile stiffness and tensile strength properties essential in defense and commercial aircraft applications [11].

2. Material and Method

In this study, CREC material was prepared. Test flights were carried out by using an aluminium alloy chassis and a CREC chassis and compared.

2.1. Materials

- Radio controlled model helicopter: x2; Align Corp.Ltd
- Motor: DJI.920 KV Brushless Motor
- Flight Control Board: DJI Naza. M V2 Main Controller
- Battery: 14.8 Volt 10.000 mah li-po
- CREC material: Shandong Evergreen Industries Ltd.
- 2024-t3 aluminium (Al) alloy: Zhongfu Industrial Henan Jiayuan Al Industry Co. Ltd.

2.2. Determination of weight and flight performance

The 2024-t3 aluminium alloy, which is used in construction of passenger aircraft (Figure 2), was cut and mounted onto the radio controlled model helicopter (Figure 3). The process was repeated for CREC material (Figure 4) on another radio controlled model helicopter.

Figure 2. *2024-t3 Aluminium alloy chassis.*

Figure 3. *Radio controlled model helicopter.*

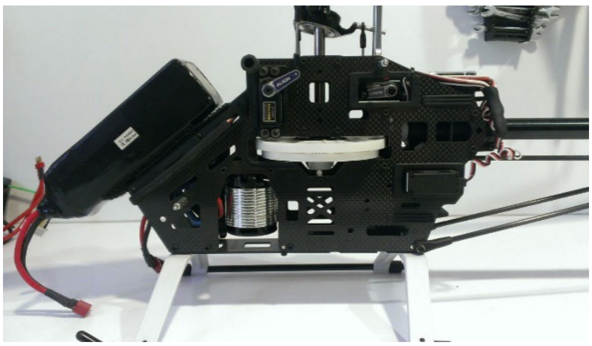

Figure 4. *Carbon fiber reinforced epoxy composite chassis*.

The weights of vehicles made with aluminium alloy chassis and carbon fiber reinforced epoxy composite chassis were measured and test flights for both vehicles were carried out. Test flights for both vehicles were repeated three times and their flight times were determined.

3.Results and Discussion

The weights and flight performances of radio controlled model helicopters were compared (Table 1)

Table 1. *The Comparison of CREC and Al Chassis*

	Aluminium alloy chassis	Carbon fiber reinforced epoxy composite chassis	Difference in percentage
Weight (kg)	2.33	1.9	18.45% ↓
Mean flight time (min)	13	17.3	33%↑

It was observed that the radio controlled model helicopter with CREC chassis was lighter and its flight performance was better than the model helicopter made of aluminium alloy.

4.Conclusion

In this study, it was determined that the flight performance of the radio controlled model helicopter was increased by using lightweight CREC material.

Carbon fiber composites have a great future ahead of them and it is a growing market. Composites are used for areas such as aerospace and aviation industry, weapons, rockets and other ammunition industries, urbanism, household appliances, automobiles, civil engineering, agriculture and construction equipments[4].

Carbon fiber composite materials are important to the aircraft industry because they provide a lighter weight and greater structural strength when compared to metal alloys. Usage of such materials will reduce fuel consumption, improve efficiency and reduce direct operating costs of aircrafts[3].

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Fast and Lossless Image Compression in Chaos-Based Encryption

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Abstract

The wide use of digital images leads to the necessity of securing them when they enter into an insecure channel. Image cryptography plays a vital role in the modern communication. For telecommunication systems through the internet, various compression and encryption techniques are proposed to satisfy a fast and secure transmission. However these two techniques have been studied separately. In this paper we propose new approach of fast image encryption algorithm with chaos-based encryption system using by cipher structure and in compression process by using a context matching method driven by the correlation between adjacent neighbor mask pixels. With this approach the size of transmission can be reduce and transmission can be secure.

Keywords: *Image Compression, Cyrptography, Chaos Based Encryption*

Introduction

In today's heterogeneous network environment, this requires more and more new techniques to meet the increasing needs of a modern society. In recent years, with the rapid development of computer science and network technology, people are obtaining, using and processing digital images more frequently. This situation brings us convenience, as well as potential threats. How to protect the information within the digital images from the attacks of intruders is becoming a more and more serious problem. Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or downloaded from Web pages[1-5].

However, for any communication system, it is necessary to take into account two major requirements: a fast transmission to send the information from a transmitter to a receiver (that can be done using an efficient compression technique) and a secure transmission of information which can be achieved using a powerful encoding algorithm. To satisfy these constraints, new compression and encryption methods allowing a fast and secure information transmission are proposed in the literature.

In case, these methods (compression and encoding) are often developed in an independent manner although they are strongly connected and one influences the other. Accordingly, we propose to combine compression with encryption and propose a new method of compression and encryption at same time[6-7].

It is supposed that we transmit important images to a receiver, preventing non-authorized people from intercepting the images. In order to encrypt the images we

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cover the images with an insignificant image. In addition we would like to compress the transmitting data, to achieve a high speed Communications[8]. For this purpose we utilized a compression scheme which also uses multiple predictors. However the predictors are generated using local statistics and are used based on a switching algorithm which relies on the correlation between pixels. And in next step, chaos-based image encryption algorithm, in cipher architecture, is proposed. The flowchart of the algorithm is shown in following flowchart. An image is producing a binary data stream with masking data of image with a random key stream by a chaos-based random key stream generator then corresponding encrypted image is formed. The specific details of each component are to be discussed in the following sections[9].

Fast and lossless Image compression

Recently, Compression schemes have been greatly developed by various researchers [1]–[4].

This was introduced in order to solve the problems which consist of the separation of independent sources using observed mixed texture without a strong knowledge about sources and, in particular lossless compression schemes rely on statistical structure in the data. Lossless compression relay o statistical structure in the data and work on non-random data contain duplicated information that determine the probability of occurring and assigning the smallest part of the most common data.

This kind of algorithm is used in computing, for saving space and sending data through the web and viewing image online; The algorithm work in tow way; prediction and correction-based conditional average.

Prediction

Firstly, we perform prediction using a predictor selected from a fixed set of 9 simple linear predictors. Prediction errors are reordered to obtain probability distribution expected by the data model.

To predict the intensity of a specific pixel *X*, we use fast linear predictors up to 3 neighboring pixels: first left-hand neighbor, second upper neighbor , and third upper-left neighbor .

Lossless compression has eight linear predictive schemes named JPEG lossless algorithm.

Main algorithm of predictors:

1) First step make no scheme

2) 1-D predictors

$$x^{\eta}(i,j) = x(i-1,j)$$

$$x^{\eta}(i,j) = x(i,j-1)$$

$$x^{\eta}(i,j) = x(i-1,j-1)$$

3) 2-D predictors

$$x^{\eta}(i,j) = x(i-1,j) - x(i-1,j-1) + x(i,j-1)$$

$$x^{\eta}(i,j) = \{\frac{x(i-1,j) - x(i-1,j-1)}{2}\} + x(i,j-1)$$

$$x^{\eta}(i,j) = \{\frac{x(i,j-1) - x(i-1,j-1)}{2}\} + x(i-1,j)$$

$$x^{\eta}(i,j) = \{\frac{x(i,j-1) - x(i-1,j)}{2}\}$$

In this process $x(i,j)$ is the pixel of (i,j) and $x^{\eta}(i,j)$ the value of predictors.

If there is a subtraction operation in a calculation of the predictor, then its value may Be out of the nominal range of pixel intensities $[0;2^{n(i.j)}-1]$, where *N* denotes image bit.

Depth. In such a case, we take the closest value from the above range. We compress the Residuum symbol that is a difference between the actual $x(i,j)$and the predicted $x^{\eta}(i,j)$
We reorder residual values to get the probability distribution close descriptive by simply picking symbols: first, last, second, last but one and so on:

$$x^{\eta}(i,j) = \begin{cases} 2n(i,j) & for\ n(i,j) < 2^n - 1 \\ 2(2^n - n(i,j)) & for\ n(i,j) > 2^n - 1 \end{cases}$$

Correction base

The conditional exception of x set of observation in y_i condition is:

y_1	y_2	y_3
y_4		

$$E[X|Y_I] = \sum_X P[X = x|Y_I = Y_1, Y_{2,} Y_3, \dots, Y_N]$$

The optimal value:

$$E\left[x_{i,j}\middle|(x_{i-l}, y_{j-m})_{l,m}^{i,j}\right] = 1$$

Prediction by particle matching is method is method to predict. The symbol depending on pervious. This method is called MARKOV model in [10-13].

Pixel $x_{i,j}$ we can define a set of pixels which are neighborhood of $x_{i,j}$ as it context. That are depending on the scanning and hence operational method. The pixels $x_1^{i,j}, x_2^{i,j}, x_3^{i,j}, \dots, x_k^{i,j}$ with set of value $\alpha = (\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_k)$ define:$\varsigma_k(\bar{\alpha}) = \{x_{l,m}: x_1^{l,m} = \alpha_1, x_2^{l,m} = \alpha_2, x_3^{l,m} = \alpha_3, \dots, x_k^{l,m} = \alpha_k\}$
ς_k Consist of all the pixels on the value of $(\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_k)$ for sample mean:

$$\mu_{x|\alpha} = \frac{1}{\|\varsigma_k(\bar{\alpha})\|} \sum_{x \epsilon \alpha} x$$

Process algorithm

1) N set of x observation
2) For each x_i is in sequence of x on replace i: $y = [x_{i-n}, \dots, x_i]$
3) Let y target amount
4) Update all y amounts

x_1	x_2	x_3
x_4		

x_n y_m
(Content bass matching windows)
Pseudo-code:

While (not last value of α_n) do
    Read neighbors
    Shorten to 4 neighbors of content
While (context amount $(\varsigma_k(\bar{\alpha})) < 0$ do
    Escape sequence of $(\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_k)$
    Calculate average sample mean $(\mu_{x|\alpha})$

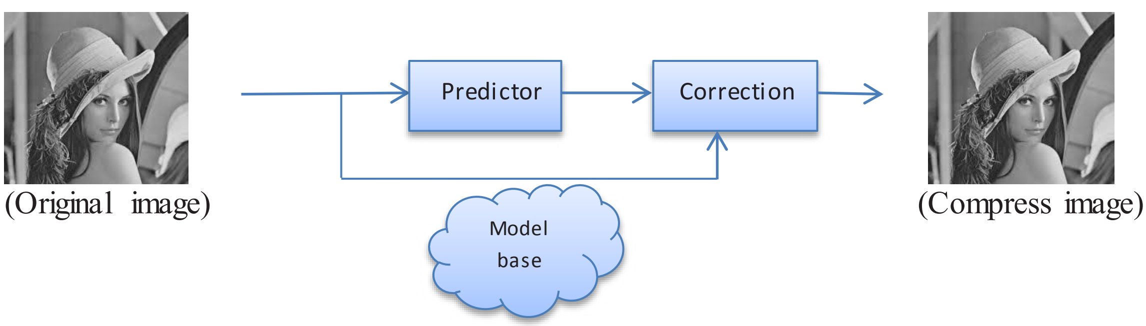

Figure 1. *compression process*

Fast Encryption chaos-base

Chaos-base image encryption scheme: the main idea of chaos-based image encryption system is proposed in the diagram (2) that consist of two major parts, serving of initial key and mixing base upon two different chaotic maps.

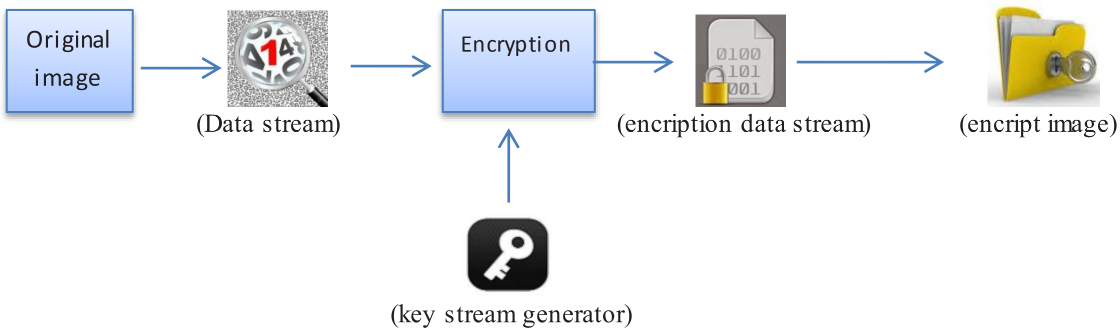

Figure 2. *encription procces*

To generating the random key stream , the first should be created. For first key the following mathematice formolas describe:

$$x_{n=1} = f(x_n) = \begin{cases} g\left(\dfrac{x_n}{p}\right) & if 0 < \dfrac{x_n}{2^l+1} < p \\ g\left(\dfrac{2^l+1-x_n}{1-p}\right) & otherwise \end{cases}$$

In this formolus $p \epsilon [0,1]$, $x_n \epsilon \{1,2,\ldots, 2^l\}$ and x_0 the first value of g(0) function.
Which can be flooring. This this randome algorithm is so weak and not good enough due to its randome process therefore, we are using

high dimentional map to mixing up the sequence generator. This theory in[4]
Is serving the porpose
Cat map is formed by:
h_c: y=Ax mod 2^l
Where x=$[x_1, x_2, x_3, x_{4,} \ldots, x_m]^t$ and y=$[y_1, y_2, y_3, y_{4,} \ldots, y_n]^t$
x_i *and* $y_j \epsilon [0, 2^{l-1}]$

A=
$A_{1\,1}A_{1\,2}A_{13}A_{14}A_{15} \ldots A_{1\,M}A_{2\,3}A_{2\,4} \ldots A_{(M-1)\,,M}$

Is an matrixM*M with each $A_{i\,j}$ mixing I th and j th dimention in details:

A=

$$\begin{bmatrix} 1 & a_{12} & \cdots & 0 \\ b_{12} & 1+a_{12}b_{12} & 0 & 0 \\ 0 & 0 \ldots & \ddots & \vdots \\ \vdots & \vdots & 1 & 0 \\ 0 & 0 \ldots & & 1 \end{bmatrix} \cdots \begin{bmatrix} 1 & 0 & \cdots & a_N \\ 0 & 0 & 0 & 0 \\ 0 & 1 \ldots & \ddots & \vdots \\ \vdots & \vdots & 1 & 0 \\ b_M & 0 \ldots & & 1+a_N b_M \end{bmatrix}$$

$$\times \begin{bmatrix} 1 & 0 & \cdots & 0 \\ O & 1 & a_{23} & 0 \\ 0 & b_{32} \ldots & \ddots & \vdots \\ \vdots & \vdots & 1 & 0 \\ 0 & 0 \ldots & & 1 \end{bmatrix} \cdots \begin{bmatrix} 1 & 0 & \cdots & a_N \\ 0 & 0 & 1 & 0 \\ 0 & 1 \ldots & \ddots & \vdots \\ \vdots & \vdots & 1 & 0 \\ 0 & 0 \ldots & & 1+a_{N-1}b_{M-1} \end{bmatrix}$$

Where a_N, b_M are integer in $[0, 2^{l-1}]$ .This high-dimensional Cat map, h_c, is used as our post-processing unit for mixing up the initial key stream.

key stream generator

the useful way for sending secret data without data integrity is bite sequence as key. Therefore, adds this to plain text to form of the cryptogram like bellow chart.

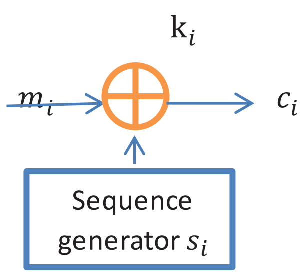

Figure 3. *key generator key generator*

The key can be parameter in f and first state is $s_0.s_i = f(k, s_{i-1})$, $\mathrm{k}_i = g(s_i)$, $c_i = m_i \oplus \mathrm{k}_i$ Byte-based stream cipher with initial $s[k]$=k for I in 0,…, 255 and 0,…,255 equal to $s[k] + k[i] \leftrightarrow s[j] + k[i]$

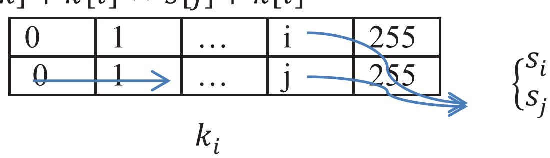

Figure 4. *first key stream*

Pseudo algorithm

(1) With a user key, construct the parameters needed for the key generator. The computational procedures are to be discussed in above.

(2) The image is firstly transformed into a standard data stream (Fig. 1). Taking an image in true color with

(N*M) pixels as an example, if each pixel consists of RGB format, a stream of total c_i data can be formed by partitioning the bits obtained from pixels.

3) For each data m_i, it will be masked by the key stream with the following function: $c_i = (d_i + k_i + c_{i-1}) mod 2^l$

4) The encrypted data stream is converted back into RGB format for storage or transmission. Decryption is similar to encryption, except that the following decryptions function: $\widehat{D_\iota} = (c_i - k_i - d_{i-1}) mod 2^l$ $\widehat{D_\iota}$ Is decrypting sequence[13-15].

Experimental results

In order to validate our approach several simulations are conducted. "Lena" compressed image are encrypted and decrypted by the proposed method. 512×512 color JPEG format files are used as the original images. An example of the simulations is shown in Fig. 8. The first row of Fig.4 shows the original source images (a), the images in the second row were obtained by applying optimize chaotic to the compressed image in (b), and the last row corresponds the reconstructed images which the receiver can obtain (c). After execution of cat map and applying chaotic algorithm to the compressed components with the random key generator, we can get the source images.

The quality of the reconstructed images, however, is not as same as the original ones, because compression cut off higher frequency components. Moreover, the order of the outputs is not always same as that of the original images.

Figure 4a. *Orginalimage*

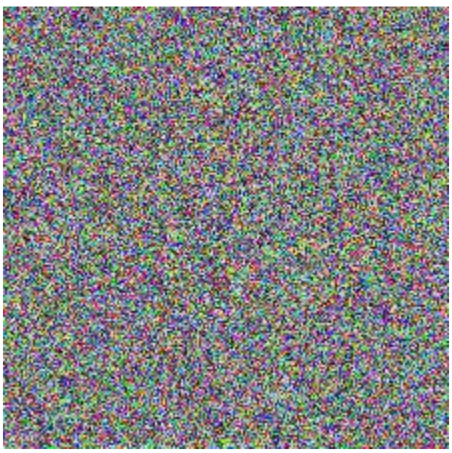

Figure 4b. *encripted and copressed*

Figure 4c. *recovered image*

In this test the below table shows ability of this algorithm:

Items	value
PSNR	78.04
MCSE	0.002
ENTROPY	7.62

The picture of histogram shows no different between original image and recovered image.

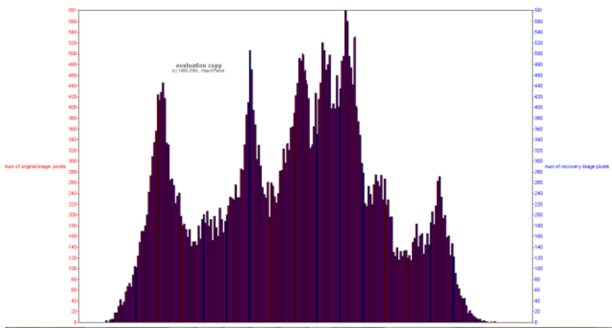

Figure 5. histogram diagram

Conclusion:

In this paper, we presented a novel image encryption technique for compressed domain. Our proposed technique can work efficiently and independently regardless of the image size, quality and dimension. The experimental results shown in this paper proved that the encryption of the proposed method is extremely high if the relative compression ratio is compromised. Double layer of security for the embedding text ensures the protection of data against any intruder attack. In addition, the user has been given the freedom of choosing the key and using it by anyway s/he likes. Further research over the proposed method has also been discussed so that studies on this Stream can be continued smoothly.

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Design Equations from Geometric Programming

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Abstract

Geometric programming is an optimization tool that permits the development of design relationships. Most researchers do not develop the design relationships, but only solve the specific optimization problem for a set of specific input parameters and a new solution must be developed for any changes.

For some problems with few degrees of difficulty, design relations can be developed which given an insight into the importance of the input constants. An example from a previous paper using the Cobb-Douglas production function is used to illustrate the development of design relationships.

Keywords: *Geometric Programming, Design Equation Development, Cobb-Douglas production function*

1. Introduction

Clarence Zener is credited as being the father of geometric programming with the publishing of the paper "A mathematical aid in optimizing engineering designs" in the Proceedings of the National Academy of Science[1] in 1961. He is better known for the invention of the Zener diode. He later co-authored with Richard Duffin and Elmor Peterson the book "Geometric Programming"[2] in 1967 published by John Wiley. Several books have been written about geometric programming, but few consider or emphasize the development of design equations.

The mathematics of geometric programming are rather complex and presented in more detail in the references presented[3-5]. Geometric programming is similar to linear programming in that it has both a primal and a dual formulation. The primal problem formulation is somewhat similar to the primal formulation in linear programming, and is often solved by traditional search methods. The dual formulation is harder to formulate, but is much easier to solve. The

design equations can be found by utilizing the primal-dual relationships. The example presented will be with zero degrees of difficulty to illustrate the solution procedure for finding the design equations. It is easier to determine the design equations for cost models than it is for profit models.

The example presented is that of Ibrahim Guney and Ersoy Oz in the paper " An Application of Geometric Programming"[6] in Vol. 2 of the Internal Journal of Electronics, Mechanical and Mathematics

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Engineering. This example concerns the minimization of production costs for a fixed production level using the Cobb-Douglas production function.

The basic formulations of the primal and dual will be shown and then the example will be presented following the steps of the formulations. One of the requirements for geometric programming is that the terms used are posynomials, that is, they are positive polynomials. That prohibits functions such as the sin(x) and fractional powers that cannot be expanded, such as $(2 + 4x)^{3.3}$.

2. Primal and Dual Formulations

The primal problem is formulated as:

$$Y_m(x) = \sum_{t=1}^{T_m} \sigma_{mt} C_{mt} \prod_{n=1}^{N} x^{mtn} \quad \text{for } m=0,1,2..M \qquad (1)$$

where

$\sigma_{mt} = \pm 1$ (signum function to indicate sign of term)

$C_{mt} > 0$ positive constant coefficients

$Y_m(x) \leq 1$ for the constraints, $m=1,2,...$ M

$Y_0(x)$ = objective function

The dual formulation initially appears more complex, but it results in several linear equations which are easier to solve. The dual objective function is not linear and is solved after the dual variables have been determined from the dual formulation model. The dual objective function is :

$$d(\omega) = \sigma \left[\prod_{m=0}^{M} \prod_{t=1}^{T_m} (C_{mt}\omega_{m0}/\omega_{mt})^{\sigma_{mt}\omega_{mt}} \right]^{\sigma} \qquad (2)$$

for $m = 0,1,2,...M$ and $t = 1,2,....T_m$

where

σ = signum function for objective function (1 for minimization and -1 for maximization)

σ_{mt} = signum function for dual constraints ($\pm$ 1)

$C_{mt} > 0$ positive constant coefficients

ω_{m0} = dual variables from the linear inequality constraints

ω_{mt} = dual variables of dual constraints

σ_{mt} = signum function for dual constraints

$\omega_{00} = 1$

The dual is formulated from four conditions

First, a normality condition is expressed by:

$$\sum_{t=1}^{T_m} \sigma_{0t}\ \omega_{0t} = \sigma \quad \text{where} \quad \sigma = \pm 1 \qquad (3)$$

and

σ_{0t} = signum of dual objective function terms

ω_{0t} = dual variables for dual objective function terms

The second conditions are the N orthogonal conditions

M T_m

$$\sum_{m=0} \sum_{t=1} \sigma_{mt} a_{mtn} \omega_{mt} = 0 \quad (4)$$

where

σ_{mt} = signum of constraint term

a_{mtn} = exponent of design variable term in primal

ω_{mt} = dual variable of dual constraint

The third condition is the T non-negativity conditions that require that the dual variables must not be negative, that is:

$$\omega_{mt} \geq 0 \text{ for } m= 0,1,2,.M \text{ and } t=1,2,3,..T_m \quad (5)$$

The fourth condition is the M linear inequality constraints expressed by:

$$\omega_{m0} = \sigma_m \sum_{t=1}^{T_m} \sigma_{mt} \omega_{mt} \geq 0 \quad (6)$$

The complexity of a problem is indicated by the number of degrees of difficulty(D). The higher the degree of difficulty, the more difficult the problem is to solve. The formula for determining the degrees of difficulty is:

$$D = T - (N + 1) \quad (7)$$

where

T = number of terms in the primal formulation

N=number of orthogonal conditions (which is equivalent to the number of primal variables)

Once the dual variables are determined, the primal variables can be determined from the relationships between the primal and dual variables. As in linear programming, the primal and dual objective functions must be equal and thus $Y_0(x)$ and $d(\omega)$ are equal. The two equations relating the primal and dual for determining the primal variables are:

$$C_{0t} \prod_{n=1}^{N} x_n^{mtn} = \omega_{0t} \sigma d(\omega) \quad (8)$$

and

$$C_{mt} \prod_{n=1}^{N} x_n^{mtn} = \omega_{mt} / \omega_{m0} \quad (9)$$

for $t=1,2,...T_m$ and $m = 1,2,...M$

3. Cobb-Douglas Cost Minimization Model

The initial formulation is to minimize labor and capital costs to obtain a specific output level. The model by Guney and Oz() is slightly modified and can be stated in its primal form as:

$$Y(x) = r_1 x_1 + r_2 x_2 \quad (10)$$

subject to the Cobb-Douglas production constraint

$$q = A\, x_1^{\alpha}\, x_2^{\beta} \quad (11)$$

where

x_1 = labor amount

r_1 = labor rate

x_2 = capital amount
r_2 = capital rate
q = desired output level
A = total productivity factor
α = labor elasticity
β = capital elasticity

The constraints must be written in the form of inequalities with the right hand side being unity and thus the constraint becomes:

$$(q/A)\ x_1^{-\alpha}\ x_2^{-\beta} \leq 1 \qquad (12)$$

Thus the primal objective function is given in Eqn. 10 and Eqn 12.is the constraint. The number of degrees of difficulty using Eqn 7 is:

$$D = 3 - (2 + 1) = 0$$

The degrees of freedom must be greater than or equal to zero.

Since all the terms in Eqns. 10 and 12 are positive, the signum values are all positive, that is

σ_{00} = 1 (objective function is minimization)
σ_{01} = 1
σ_{02} = 1
σ_{11} = 1
σ_{10} = 1 (RHS of constraint is positive)

The dual can be formulated using Eqns.3, 4 and 6 as:

Eqn 3 $\quad \omega_{01} + \omega_{02} = 1 \qquad (13)$

Eqn 4 (x_1) $\quad \omega_{01} \quad -\alpha\,\omega_{11} = 0 \qquad (14)$

Eqn 4 (x_2) $\quad \omega_{01} \quad -\beta\,\omega_{11} = 0 \qquad (15)$

Solving Eqns 13-15 for the dual variables one obtains:

$$\omega_{01} = (\alpha / (\alpha + \beta)) \qquad (16)$$

$$\omega_{02} = (\beta / (\alpha + \beta)) \qquad (17)$$

$$\omega_{11} = (1 / (\alpha + \beta)) \qquad (18)$$

Now ω_{10} can be determined using Eqn 6 and is

$$\omega_{10} = \sigma_{10} \sum \sigma_{mt}\ \omega_{mt} = 1*(1 * (1/(\alpha + \beta))) = 1/(\alpha + \beta) \qquad (19)$$

The dual objective function of Eqn 2 can now be determined and is:

$$d(\omega) = 1* [\{r_1*1/(\alpha/(\alpha+\beta))\}^{(1*(\alpha/(\alpha+\beta))} * \{r_2*1/(\beta/(\alpha+\beta))\}^{(1*(\beta/(\alpha+\beta))} * \{q/A\}^{(1*/(\alpha+\beta))}]^{1} \qquad (20)$$

Note that both ω_{11} and ω_{10} are equal. Now using the primal-dual relationship of Eqn. 8 for the two terms of the objective function, one obtains:

$$r_1 x_1 = (\alpha(\alpha + \beta)) * 1 * \ d(\omega) \qquad (21)$$

$$r_2 x_2 = (\beta(\alpha + \beta)) * 1 * \ d(\omega) \qquad (22)$$

Solving Eqns. 21 and 22 for x_1 one obtains:

$$x_1 = (\alpha/\beta)\ (r_2 / r_1)\ x_2 \qquad (23)$$

Now using Eqn 22 in Eqn 11and solving for x_2:

$$x_2 = (q/A)^{(1/(\alpha + \beta))} \ (\alpha r_2/\beta r_1)^{(-\alpha/(\alpha + \beta))} \quad (24)$$

Using Eqn 24 in Eqn 21 x_1 is found to be

$$x_1 = (q/A)^{(1/(\alpha + \beta))} \ (\alpha r_2/\beta r_1)^{(\beta(\alpha + \beta))} \quad (25)$$

The primal objective function can now be determined from the primal variables and Eqn 10 becomes

$$Y(x) = r_1 * (q/A)^{(1/(\alpha + \beta))} \ (\alpha r_2/\beta r_1)^{(\beta(\alpha + \beta))} + r_2 * \ (q/A)^{(1/(\alpha + \beta))} \ (\alpha r_2/\beta r_1)^{(-\alpha/(\alpha + \beta))} \quad (26)$$

Equations 20 and 26 have quite different appearances, but the numerical values will be the same.

4. Model Results and Validation

The equations developed were used to compare with the data reported by Guney and Oz[6] on the construction sector in Turkey. The input values are given in Table 1 and the output values are in Table 2. The input values of A, α, and β were fixed at 1.0, 0.53, and 0.47 for all four reported cases.

Table 1. *Yearly Input Data for Estimate Calculations*

Year	Production Index q	Labor Index r_1	Capital Index r_2
2006	118.4	121.88	114.32
2007	124.9	137.80	122.32
2008	115.6	153.85	140.06
2009	96.4	158.53	131.48

The results for x_1 and x_2, the labor and capital estimates, were in complete agreement with those of Guney and Oz[6] so only one set are included in results given inTable 2. The primal and dual values of the objective function from Equations 20 and 26 are identical as expected and although the objective function was not given in the reference[6], it would most likely have been the same. In the model equations presented, the values for A, α, and β from the Cobb-Douglas production equation could be varied and a sensitivity analysis of these parameters could be evaluated and would not require resolving the adjusted problem.

Table 2. Out put Values of Model for Estimates.

Year	Labor Estimate x_1	Capital Estimate x_2	Primal Total Cost (Y)	Dual Total Cost d(ω)
2006	121.56	114.93	27955.11	27955.11
2007	124.96	124.84	32488.98	32488.98
2008	117.03	114.000	33973.08	33973.08
2008	93..41	99.88	27941.39	27941.39

5. Conclusions

The development of design equations for a geometric programming model of from data of the construction sector in Turkey. These design equations (Eqns. 20,24,25,and 26) give the solutions for the model outputs and the model does not need to be resolved. The design equations for the variables x_1 and x_2 can then be used to determine the total cost to meet the desired production level.

The design equations also permit easy analysis of the impact of the Cobb-Douglas elasticity exponents and total productivity factor upon the total cost. The development of design equations takes considerable effort, but the equations permit a more rapid analysis of the impact of the input variables upon the output.

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Optimizing Bus Lines in Urban Public Transportation by Cost and Trip Calculation Methods: A Software Model Design Doi: 10.17932/ IAU.IJEMME.m.21460604.2015.5/3.969-977

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Abstract

Planning of a public transport system in an ordered way is the key which offers potential users a mode of transport. To attract travelers from other modes of transport, sufficiently attractive overall journey times must be provided, so reducing traffic congestion and obtaining delivered benefits like road safety and lower atmospheric and noise pollution. The congestion that close with increasing demand is becoming a part of our lives and it is complicating our lives. Some work is done to reduce the traffic congestion. If we want to provide an efficient and balanced layout in public transport system, we must place the right stop at the right places. Hence, we consider some components like cost, security, noise pollution, etc. In this study, it is aimed to solve a set covering problem for locating the smallest number possible of bus stops.

Keywords: *Bus Stop Spacing, Bi-Level Optimization Model, Trip Demand, O-D Matrix.*

1. Introduction

Purpose of this work is to make an optimal bus stop location and spacing model which minimizes the operator cost of all the transport system, examine the equilibrium travel costs by installing the route under travel costs among the studied O-D (Origin–Destination Matrix) pairs, stated by the travel distribution [1, 2]. Firstly, we calculate operator cost, later we will compare these costs. We will determine analysis of the operator cost between two routes and identify routes that cause the most cost [1, 2, 3]. Our focus will be on optimizing these routes. If we need to change stops, we will change stop places. We need to put the best stops on the most appropriate places and to solve this problem we use the estimation method [2, 3]. Once a decision is made to modify the

location of bus stops in an area then changes will be made to the initial conditions [1] on which travelers in all the system base their modal choice decision.

Operators can use these data. It is aimed to ensure traveling comfortably [4, 5] and safe movement for passengers from a place to another.

2. Methodology

Trip generation determines the frequency of origins or destinations of trips in each zone by trip purpose, as a function of land uses and

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household demographics, and other socio-economic factors [1, 4, 5]. Transportation planning [1] is reached by O-D matrix. Trip distrubtion step of transportation planning is done modelling by these using matrix.
An illustration of the O-D matrix is given in Figure 1.

Origin \ Destination	1	2	3	Z
1	T_{11}	T_{12}	T_{13}	T_{1Z}
2	T_{21}			
3	T_{31}			
Z	T_{Z1}			T_{ZZ}

***Figure 1:** An Illustration of the O-D Matrix (Üçer, 2009)*

Here, T_{ij} = Trips from origin i to destination j. For example; if the passanger comes from origin 1 to destination i, trip will be a T_{11}. In this project O-D matrix values are used. Generally, O-D matrix values are reached with survey [4,5]. But for this project data is received from IETT (General Directorate of Istanbul Electricity, Tramway and Tunnel) Information Technologies Section. Values are used within the equations. The following example is given for a better undertanding of O-D Matrix.

O-D	1	2	3	4	5	6
1	0	35	35	45	54	55
2	25	0	25	5	52	45
3	35	32	0	22	43	68
4	54	23	23	0	12	35
5	55	55	32	68	0	23
6	55	54	40	35	13	0
Distance	224	199	155	175	174	226
Time	448	398	310	350	348	452

***Figure 2**: Example of an O-D Matrix*

The vertical portion of the matrix show the origin and the destination of the matrix show down time in Figure 2. Examination starts with the first line. Firstly, if you go from origin 1 to destination 1, distance is equal to 0. Secondly, if you go from origin 1 to destination 2, distance is 35. We process the opposite this condition. So if you go from destination 2 to origin 1, distance is equal to 35 or if you go from destination 2 to origin 3, distance is equal to 32. It continues like this for other numbers (1-6). When we add automatically line in Excel, distance values are reached. Typically, the distance is twice that of time. Time is calculated with this information.

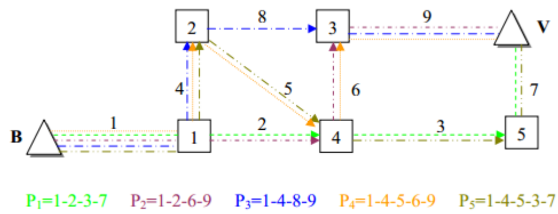

***Figure 3:** Examples of Network (Üçer, 2009)*

Figure 3 shows the cost between routes. For instance, the green route is preferred then the cost is 13. P1, P2, P3, P4, P5 are calculated. This figure allows to find the shortest distance.

2.1. Calculating the Operator Cost

The total cost of the kilometers covered (CK) will be calculated [1, 2, 5, 7] as:

$$CK = \sum_l \sum_k L_l \, f_l CK_k \delta_{k,l}$$
(2)

Where,
L_l = length of route l (km per bus)
f_l =frequency of route l (bus per hour)

CK_k= unit cost per kilometer covered by bus type k (₺ per km)
$\delta_{k,l}$= mute variable worth 1 if bus type k is assigned to route l and 0 if not.
The cost of buses being stationary with the engine running (CR) will be depend on the time they spend at the bus stop dealing with passenger. This value is calculated [1] as:

$$CR = ({t_{sb}}/{60}) \sum_l \sum_k CR_k \delta_{k,l} Y_l \quad (3)$$

Where,
t_{sb} = average time for passengers getting on and off the bus (min per passenger)
CR_k=unit cost per hour of bus type k standing stil with engine running (₺ per hour)
Y_l= journey demand on line l (passengers per hour)
$\delta_{k,l}$= mute variable worth 1 if bus type k is assigned to route l and 0 if not

The personnel cost [1, 7] (CP) is :

$$CP = Cp \sum_l \sum_k ({tc_l}/{h_l}) \quad (4)$$

Where,
Cp= is the unit cost per hour of the staff (₺ per hour)
tc_l=is the time of a round trip (min)
h_l=is the headway on route l (min) $= {1}/{f_l}$

The total financial fixed cost [1, 2, 4, 7] (CF) is:

$$CF = \sum_l \sum_k (\left({tc_l}/{h_l}\right).CF_k.\delta_{k,l} \quad (5)$$

Where,
CF_k =Unit fixed cost per hour of bus type k (₺ per hour)
tc_l=is the time of a round trip (min)
h_l=is the headway on route l (min) $= {1}/{f_l}$
$\delta_{k,l}$= mute variable worth 1 if bus type k is assigned to route l and 0 if not.

$$\delta_{k,l} \in (0,1)$$
$$OC \leq OC_0$$
$$\sum_l ({tc_l}/{h_l}) \leq fls_0$$
$$F_{min} \leq f_l \leq F_{max}, \forall l$$

Where, the first constraint defines the characteristics of the binary variables $\delta_{k,l}$ and the rest of the constraints represent the group of operational constraints which need to be implemented in the model, such as maximum operator cost (OC), fleet restriction, and maximum and minimum allowed frequencies [1, 7, 8].
Once and for all, we will calculate OC by the equation below;

$$OC = CK + CR + CF + CP \quad (6)$$

In detail, be showed as follows.

$$OC = \sum_l \sum_k L_l\, f_l CK_k \delta_{k,l} + \left({t_{sb}}/{60}\right) \sum_l \sum_k CR_k \delta_{k,l} Y_l + \sum_l \sum_k (\left({tc_l}/{h_l}\right).CF_k.\delta_{k,l} + Cp \sum_l \sum_k ({tc_l}/{h_l})$$

3. Overview Of The Study

The general aim of this article is to provide detailed trip reports that can be used by the operators, and provide the means need to find the stops that need to be optimized.

3.1 Model Perspective

Our model is independent and totally self-contained, and not a part of any other program [9]. MySQL database with PHP language is used. This work is exploited by gmapV3 API support. We also used HTML 5 and jscript for interfaces development. The parameters and variables used in the calculations [1, 2, 4, 7, 8, 9, 10] and their definitions are shown in Table 1.

3.2 Model Functions and Variables Used

Below there is a map (Figure 4) showing the route from the origin to the destination along with the routes stops [10, 11, 12]. Details concerning the stops and the route [1, 13, 14] will be shown on the right of the map.

***Table 1 :** Variables Used in the Model*

Name of Variable	**Description**
Dname	driver's name
totaltmvehic	is equal to total time in vehicle in the database
vehictm	Value of time in vehicle
waittm	is equal to value of waiting time in the database
avgwaittm	is equal to average waiting time
Stop line	Stop line
stop name	stop name
stop code	stop code
access time	in the database is equal to total access time value
total access time	total access time
Frequency	Frequency
Line name	Line name
Line name	Line name
Line code	Line code
district	district
Manager	Every district must have a manager.
personalsost	The cost paid to person.
x coordinate	x coordinate
y coordinate	y coordinate
Linelength	length of the line.
ocost	The data will be used in the operator cost calculation. Operator cost includes CK equation. CK equation include CK_k. CK_k= unit cost per kilometer covered by bus k (₺ per hour). İt is thought as fuel.
avgpassenger	The average passenger number
busname	Bus name
busid	Bus ID
ctraveltime	Value of car travel time
totaltravelt	Total car travel time
orderino	Order no
tcost	The data will be used the operator cost calculation. Operator cost include CF equation. CF equation include CF_k. CF_k = unit fixed cost per hour of bus type k (₺ per hour)
lname	driver's surname
time	Time
driver	Every bus must have one driver. This makes easy to find bus by identifying the driver.
DID	Driver's identification number.
tottript	The total time it takes the bus to do a complete trip.
direction	Direction (from origination to destination)

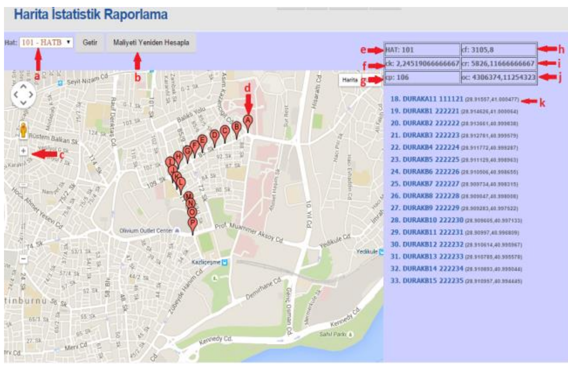

***Figure 4:** Map Page*

Figure 4 is the map page of our software model. Here, the user first **(a)** select the line you want to know the cost of the part. Then users will want to select the button (**b**). Calculate the operator cost of the program. When users pressed the button (**b**), stops are ordered, such as in figure (**d**). The user will be able to see the shape and then the line stops (**e**). The name of the line that selected shown in the section (**e**). In part (**f**) has a CK value. CK is determined as the total cost of the bus as we know it. (**g**) Include the value of the CP section. This is the cost paid to the driver. In part (**h**) takes place in the CF which is a fixed cost. The fixed cost portion of the vehicle fuel is at the forefront. If the CR motor runs but does not move occurring is the cost of the car (**i**). In part (**j**) seems to be the OC (Operator cost) value by which the operator is able to find the optimal line. The operator will reach it by making the change on the stops. In the section (**k**) the name of the stop code and coordinate information are shown. By using section (**c**) it is possible to zoom out the map like you want the user part will be able to clearly see the area which is choice of users.

4. Model Results

CF values of all line according to bus as follows. In Figure 5 shows that total fixed cost for each bus. We see that HAT A has the maximum cost, as shown in the graph. The user who wants to look at events in terms of fixed costs in HAT A, the user should change on the HAT A.

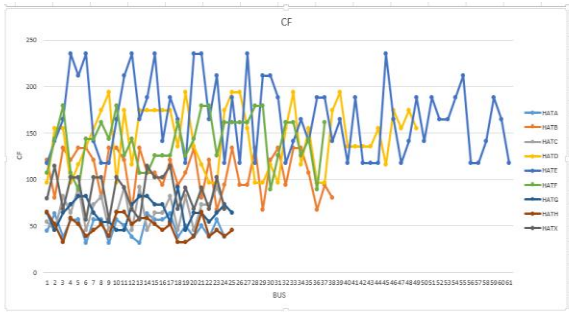

Figure 5: The Total Financial Fixed Cost Graph

CK altering graph of all line according to bus as follows in Figure 6. This graph show total cost of the kilometers covered.

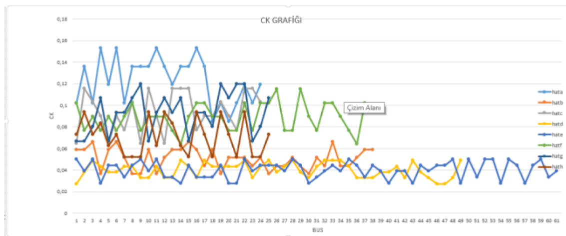

Figure 6: *Total Cost of the Kilometers Covered Graph*

CR altering graph of all line according to bus as follows. CR is unit cost per hour of bus type k standing still with engine running (₺ per hour), Figure 7 show us CR graph. Here, we take into account part that is time for passengers getting on and off the bus (minutes per passenger). Numbers express the bus name. Horizontal line express the CR values according to each line.

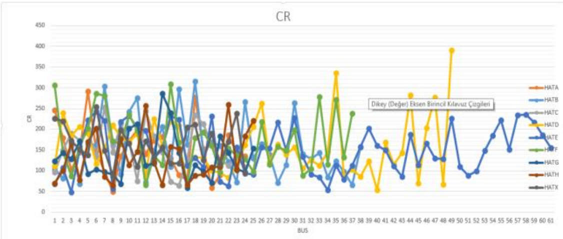

***Figure 7:** The Cost of Bus Standing Still with Engine Running Graph*

CP altering graph of all line according to bus as follows. In Figure 8, it is defined the paid to the driver that the total cost calculation is performed and the chart has been drawn.

***Figure 8:** The Personel Cost Graph*

4.2 Comparison of the Results

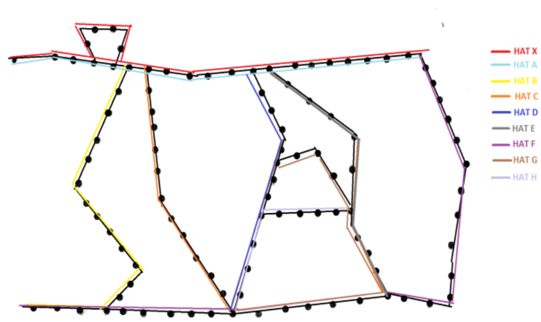

***Figure 9:** Diferent Line Variations*

The above lines were investigated in Figure 9. With different colors from each other, each line has its own unique costs were calculated.

As a result of this calculation, the following charts reached.

Here we will consider Figure 9. We will examine by comparing HAT X (Line X) and HAT A (Line A). Normally the HAT X is our route (Figure 9). We removed some stops on the HAT X. When we removed stops from HAT X, HAT A is our new line. Then cost account made for the HAT A. HAT A and HAT X the only difference from occurring also are the stops. We just pulled the stops from HAT X. Other variables remained the same. Stops were used as a variable. The charts below includes the reached results of our investigations.

Software model compares CF value that is between HAT A and HAT X, as follows; (Figure 10)

Fixed costs that is also occurring on the HAT X are more likely to HAT A. The numbers in the horizontal column is buses. Fixed costs are as shown in vertical space. According to the fixed cost, a user must choose HAT A. The goal of our model is to find the line which has the lowest cost. Here, at HAT A we saw lower cost.

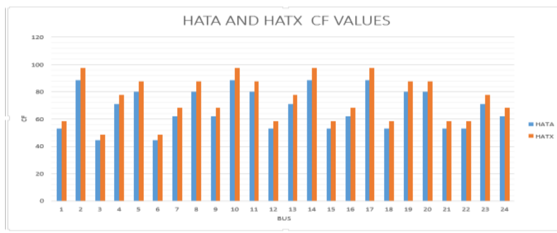

***Figure 10:** Comparison the Total Financial Fixed Cost Graph*

CK value graph that is in the between HAT A and HAT X, as follows in Figure 11. This graph show us total bus costs. The numbers from 1 to 24 refers to the buses on here.

According to graph, HAT X has the most cost.

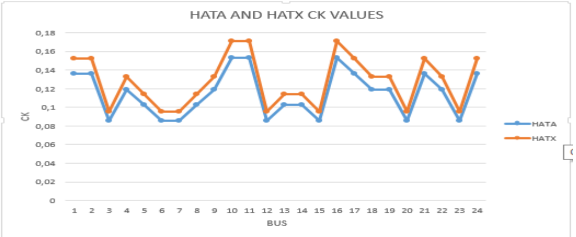

Figure 11: *Comparison Total Cost of the Kilometers Covered Graph*

CR value graph that is in the between HAT A and HAT X (Figure 12).

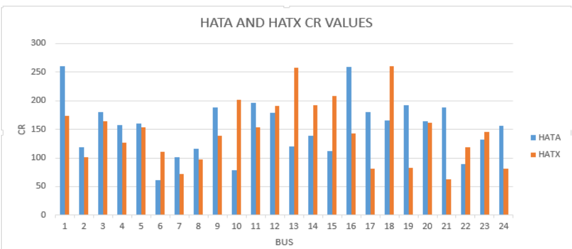

Figure 12: *Comparison the Cost of Bus Standing Still with Engine Running Graph*

Figure 13 shows the variation of the cost paid to the driver. The difference between the two lines as seen below.

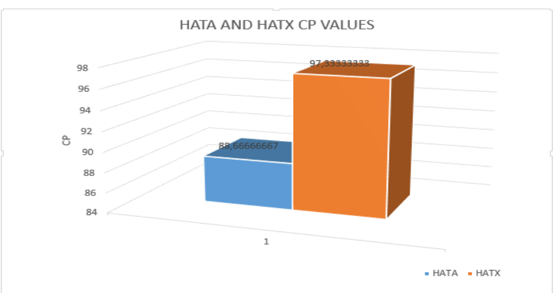

Figure 13: *Comparison the Personel Cost Graph*

We come through as follows with information mentioned above. CP-CK-CR-CF graph; also refers to the lines from 1 to 9 in Figure 14.

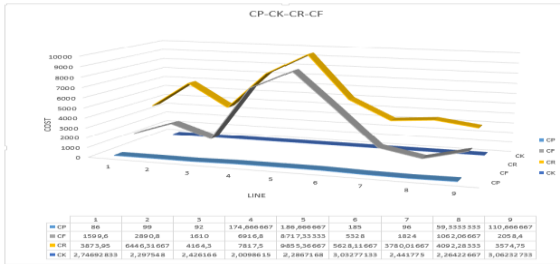

Figure 14: *Comparison all Cost Graph*

Each number corresponds to one line. Here, the values are examined individually in a cumulative manner.

Result of an operator cost graph as follow in Figure 15.

Figure 15: *Operator Cost Graph*

As a result, we can see all values above graph. The graph examine changing cost values. Operator will compare all values about graph in Figure 15, later will decide line where user want to optimize [12, 14, 15]. HAT A and HAT X is compared by above graph. User can see all data. For example we compare HAT A and HAT X lines, we see that operator cost of HAT A is 1595992,41 and HAT X is 20340115,43. Operator decides [14, 15] routes and stops by looking at these results.

5. Conclusion

O-D traffic demand matrix is an important source of data for the equilibrium assignment. So, O-D traffic demands is important for a reliable estimate of the calculations we make. In this study, the traffic calculation according to the assignments made, and as a result is provided to detect the most optimal stop. Over the years, socio-economic factors that will be due to the change and improvement in the data obtained, the developed model can be made with the update of the data is provided renewed at any moment.

Our study include 283 drivers, 8 lines, 110 stops and 283 buses. The values that occurr at the stops were examined individually. Graphs were obtained with from occurring values. Making comparisons are provided between two lines.

Separate cost accounts for the cost of the operator are reviewed. By the way, cost functions are affected by the volume of traffic.

As a result of the equations that are used on the value of the cost of an operator has been reached. These values were compared with all lines comparison results are shown in the graphs. Even the cost of any changes affecting the whole of the line was calculated. We want to optimize costs that occur even after the changes we made a comparison was made of the cost of old.

In traffic assignment, which is done by raising the calculated travel time from the proposed method works well with each other, they left a very big difference, therefore it has been determined that.

The calculation of user cost values that occurred at each stop is a subject of another study. In this context, it is planned to perform this calculation and show these values for each bus stop. Being able to observe stops on their cost values is an important concern for passengers. In this context, it is planned to perform calculation of both user and operator costs in a software model in a future work.

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