B.YILDIZ IZMIR KATIP CELEBI UNIVERSITY 2019

IZMIR KATIP CELEBI UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DETECTION OF UNDERGROUND POWER CABLE ROUTE USING SHORTEST PATH ALGORITHMS

M.Sc. THESIS

Baran YILDIZ

Department of Geomatics Engineering

JANUARY 2019

IZMIR KATIP CELEBI UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DETECTION OF UNDERGROUND POWER CABLE ROUTE USING SHORTEST PATH ALGORITHMS

M.Sc. THESIS

Baran YILDIZ
(Y150108007)

Department of Geomatics Engineering

Thesis Advisor: Assist. Prof. Dr. Osman Sami Kırtıloğlu

JANUARY 2019

İZMİR KATİP ÇELEBİ ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ

EN KISA YOL ALGORİTMALARI KULLANARAK YERALTI GÜÇ KABLOSU GÜZERGÂHININ BELİRLENMESİ

YÜKSEK LİSANS TEZİ

Baran YILDIZ
(Y150108007)

Harita Mühendisliği Ana Bilim Dalı

Tez Danışmanı: Dr. Öğr. Üyesi Osman Sami Kırtıloğlu

OCAK 2019

Baran YILDIZ, an M.Sc. student of IKCU Graduate School Of Natural And Applied Sciences, successfully defended the thesis entitled "DETECTION OF UNDERGROUND POWER CABLE ROUTE USING SHORTEST PATH ALGORITHMS", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor :

Asst. Prof. Dr. Osman Sami KIRTILOĞLU ....
Izmir Katip Çelebi University

Jury Members :

Assoc. Prof. Dr. Mevlüt YETKİN ....
Izmir Katip Çelebi University

Assoc. Prof. Dr. Çiğdem TARHAN ....
Dokuz Eylül University

Date of Submission : 31.12.2018
Date of Defense : 14.01.2019

To my family,

FOREWORD

In this study, which was prepared as a Master Thesis in Izmir Katip Celebi University, Institute of Science and Technology, Geomatics Engineering Department, the determination of underground power cable route, its optimization and its comparison with the manually determined route, were examined.

I have come to the end of the period that I have considered as the most productive years of my life. I've always been happy and sometimes sad but always hopeful with events. This long-term study and development period, and then the accumulation of this period, the best way to present the enthusiasm and excitement, the factors that make life meaningful for me.

I would like to thank to Asst.Prof. Dr. Osman Sami KIRTILOĞLU, my esteemed teacher and advisor, who gave me his support and devotion with his patience and dedication during the writing of the thesis. I would like to thank my family for my choices and decisions, and for always making me feel lucky with my never-ending patience and support.

January 2019 Baran YILDIZ

TABLE OF CONTENTS

Page

ABBREVIATIONS

UPC	**:** Underground Power Cable
GIS	**:** Geographic Information System
ETL	**:** Energy Transmission Line
GA	**:** Genetic Algorithm
ABC	**:** Artificial Bee Colony
AHP	**:** Analytic Hierarchy Process
APR	**:** Automated Primary Router
TETCO	**:** Turkish Electricity Transmission Corparation

LIST OF TABLES

LIST OF FIGURES

Page

DETECTION OF UNDERGROUND POWER CABLE ROUTE USING SHORTEST PATH ALGORITHMS

ABSTRACT

Urbanization and population growth are increasing by the need for electricity day by day. In parallel with this need, electricity transmission is gaining importance. The increase in urbanization necessitated using high cost crosslinked polyethylene insulated underground cables.

In this thesis, it is tried to determine the underground power cable route which has a significant role in energy transmission. First of all, a traditional route determination method has been introduced. The Dijkstra’s algorithm is widely used in the shortest path solution with a single criterion. In this direction, the route between two transformer centers was detected by using Dijkstra’s algorithm which is the shortest path solution.Routes were determined manually using traditional methods by three route engineers and compared with the output of algorithm.

As a result of the study, the length of Dijkstra’s algorithm route the route has calculated 6% shorter than the length of averages of the manually determined routes. The selection of the route with the Dijkstra’s algorithm has been shown to reduce the cost by shortening the length of the cable.

EN KISA YOL ALGORİTMALARI KULLANARAK YERALTI GÜÇ KABLOSU GÜZERGAHININ BELİRLENMESİ

ÖZET

Kentleşme ve nüfus artışı, elektrik ihtiyacını gün geçtikçe attırmaktadır. Bu ihtiyaca paralel olarak elektrik iletimi de önem kazanmaktadır. Şehirleşmedeki artış, yüksek maliyetli çapraz bağlanmış polietilen ile yalıtılmış yeraltı kablolarının kullanımını zorunlu kılmıştır.

Bu tezde, enerji iletiminde öneli rolü olan yeraltı güç kablosu güzergâhı otomatik olarak belirlenmeye çalışılmıştır. Öncelikle geleneksel güzergâh belirleme yöntemi ortaya konmuştur. Dijkstra algoritması tek kriterli en kısa mesafe çözümünde oldukça yaygın olarak kullanılmaktadır. Bu doğrultuda, en kısa mesafe çözümü olan Dijkstra algoritması kullanarak, iki trafo merkezi arasında güzergâh belirlenmiştir. Üç güzergâh mühendisi tarafından geleneksel yöntemlerle manüel olarak güzergâhlar belirlenmiş ve algoritmanın çıktısı olan güzergahla karşılaştırılmıştır.

Sonuç olarak, Dikstra algortiması tarafından belirlenen güzergâh uzunluğunun manüel belilenen güzergâh uzunlukları ortalamasından %6 daha kısa olduğu görülmüştür. Dijkstra algoritması ile yapılan güzergâh seçiminin, kablo uzunluğunu kısaltarak, maliyeti azalttığı görülmüştür.

1. INTRODUCTION

1.1 Background and Motivation

In the developing countries, the demand for energy is increasing due to reasons such as increase in population, industrialization and quality of life, migration, increase in urbanization and so on. Underground and overground energy transmission lines are of great importance in terms of energy distribution in the interconnection system and transmission of electricity. Overground energy transmission lines are preferring rural areas. Because of the high costs of expropriation and easement in urban area, the underground power cable is establishing public roads [1].

Underground power cable (UPC) route planning is traditionally based on experiential knowledge and problem-solving experiences and intuitive strategies. The traditional route selection procedure for underground power cables is a costly, time-consuming process for detailed examination of the user who selected the route. The problem of the traditional route selection can be defined as the shortest path between the start and destination. The selecting of UPC route is a cost calculation process. The success of the manually route selection is related to data process, interpretation and the experience of the engineer. Therefore, the route selection problem should be considered as the shortest path finding problem and should be solved in this way.

1.2 Objectives and Scope of The Study

The selection of the route for the UPC is a spatial decision problem that needs to be addressed in detail and multidimensionally. The preferred alternative route should have certain qualifications; short, cost-effective, safe, easy to use. The route definition can not succeed without the use of multiple layers and the evaluation of route alternatives.

The aim of this study is to provide a solution for UPC route selection. An improved model to assist engineers in selecting an appropriate route to minimize construction costs and the cost of cable to be used. The problem was solved by the shortest path analysis of the decision based on GIS to obtain the optimal route. In the study, the network analysis shortest paht tool of arcmap was used.

The preferred method in this study carries, the route with accessible features and minimized cost, risk and impact factors for UPC route identification. In basic and single criteria route selection problems generally solved by Dijkstra’s altgoritm. In this study, underground power cable routing problem tried to soved by Dijkstra’s algorithm asist of GIS.

1.3 Literature Review

When the route determination studies are examined, its clear that, GIS is preferred to process, analyze and manage multiple layers at the same time. First of all, it would be logical to give brief information about GIS. GIS is a system for managing location-based data: data capture, data handling, data processing and analysis, including data capture and preparation, storage and maintenance, and data presentation [2]. The use of geographic information systems is becoming widespread in many areas with the appreciation of location-based data. GIS is being used in many of spatial decision-making processed. Recent GIS developments have led improvements in land-use decision-making with shortest path and network analysis to significant being one of the most important processes [3]. Using GIS, routers can better configure maps and data, relevant attributes, and other spatial information. Because of its spatial capability, GIS helps routers identify spatial relationships between different data sets. In consideration, while GIS allows you to use only spatial properties and attributes, it can also be used as an analysis tool [4]. In Decision making and routing shortest path studies generally, dijkrans algorithm, artificial bee colony algorithm and ant colony algorithm used by GIS.

The problem, which Euler published in 1736 and known as Königsberg's Seven Bridge, is considered the beginning of the graphic theory and modern route finding solutions. Network analysis, route finding and planning algorithms on graph theory and vector based GIS can produce solutions on predefined networks and grids. Therefore, these methods should be adapted if different alternatives should be found on a continuous surface in real life. When the computer and GIS began to be used in spatial analysis in the 1970s, continuous space was simulated as a lattice or grid. Goodchild is one of the first to review the error and the approximate result of this approach. It has proven that only orthogonal progression on a surface will not be sufficient, and that it is necessary to proceed in the diagonal directions so that the elongation and deviation on the route can be reduced and the real-world situation can be better represented [5].

An emergency routing method produced by [6], combining the Dijkstra's algorithm and analytic hierarchy process (AHP) for firing forces. Weighting was made based on time criteria and a new improved routing technique was achieved using the Dijkstra's algorithm. The results of the original Dijkstra's algorithm and the results of the improved model were compared. Research proves the model can great help to the emergency planning for the fire forces.

Raster-based shortest path techniques are commonly applied in route planning, corridor alignment, for robotics and video games to avoid road obstacle, For example [7] compare the vector and raster approaches to identify the shortest paths minimizing obstacles. The vector side uses spatial information and GIS functionality, which offers significant advantages in finding the optimal solution to the routing problem.

The problem of creating efficient, spatially different alternatives to the corridor location problem for energy transmission, highways, pipelines etc. created for a real landscape and compared with the results with previous studies by [8]. The multi-passage short-path problem created in the study can create a wide range of alignments that demonstrate efficient planning.

The most cost-effective algorithm created by [9], to find the best way, with topography, linear start and end points channel or path and slope criteria. The algorithm is based on dynamic programming techniques that are adapted to solve the raster structure of the Dijkstra's algorithm used in GIS, which is usually used to solve the short distance solution. Although no real cost criteria were used, the results were consistent and showed the effect of the algorithm.

A continuous space-based technique to derive the shortest-guaranteed path between the two locations among obstacles developed by [10]. The problem is formulated in GIS by the euclidean distance and convex hull algorithms. The results are presented to demonstrate the general integration potential in the context of a series of spatial analyzes.

The Dijsktra's algorithm used by [11] for transmission line Energy Transmission Line (ETL) routing by GIS. According to the route detection criteria, the digital maps of the sample work area arranged, weighted, converted to a raster-based format and collected using ArcGIS Desktop 10 software. By selecting different start and end points in the sample work area, the accuracy and performance of the best routes are evaluated according to the least close path Dijkstra's algorithm.

Genetic algorithm (GA) and artificial bee colony algorithm (ABC) examined by [12] to detect the best routes with less curve overground power transmission lines. As a result of this study, the performance of ABC algorithm is better than GA. The accuracy of the algorithms has been proven by comparing the results with the results of the cost distance, cost path ESRI ArcGIS Desktop 10 software tools. Experimental results showed that manual developed algorithms performed better than software sample Dijkstra's algorithm in terms of reducing curves of power transmission lines.

The artificial bee colony ABC algorithm used by [13] for rotating the pedestrian navigation. The modified algorithm can be used to create an optimum route for pedestrians at night, taking into account the pedestrian distance, walking environment lighting and pedestrian paths. The results can be compared with the well known Dijkstra's shortest path algorithm.

GIS software ArcGIS shortest path Dijkstra's algorithm used by [14] to determine the quickest routes for fresh vegetable delivery. The model is applied to determine the parameters that affect route selection with respect to the fastest delivery of fresh vegetable.

American Structured public involvement were developed by [15]. It was adapted as a GIS-based tool for route detection of electrical transmission lines. The aim of this system is to increase the efficiency of route detection process of lines and to create alternative routes and lead to public satisfaction.

Prototype system has been developed by [16], for planning fiber to the home automatically by the Floyd-Warshall algorithm with geographic data. This system is designed as a GIS based fiber vehicle. Firstly, geographic urban data of the region is collected and topological bases are formed. Then, the Network design process involves introducing the interlocking parts of the path into the program as a node. The needs of each region are determined. Network scanning is performed with maximum efficiency considering the cable lengths and distances required for transportation to every home. The pipeline route was determined in the United States, using the Dijkstra’s algorithm, based on the GIS infrastructure. The route determining criteria were commited. The model developed by using Visual Basic for Application and ArcObjects and used for ESRI's ArcGIS Desktop 9.3.

An optimization model has been formed by [18], for the highway route plan by using geological engineering conditions, entry and exit intersection points along the route, and route length factors. The weight of each factor affecting the route determination was determined by an AHP. This model is based on the ABC algorithm and GIS.

In the work of [4], GIS uses the shortest path algorithm to determine the most suitable paths for the underground cable route by arranging the weights of the criteria affecting the route determination with the analytic hierarchy process.

An automated tool created by [19], optimizing route detection of main power cables in underground residental distribution systems.

The Automated Primary Router (APR), which is applied by [20], in a GIS-based tool, has used the search algorithm. Based on the results of the study, APR demonstrates significant stability and efficiency in finding the optimal route solution for primary cable.

As a result of literature review, in basic and uncomplicated route detection studies generally solved by Dijkstra’s altgoritm. In this study, underground power cable routing problem tried to soved by Dijkstra’s algorithm asist of GIS.

1.4 Structure of The Thesis

This section, illustrates the route selection process. Section 2 discusses the algorithms used in route selection and its integration with GIS. It describes the Dijkstra’s algorithm, which is very common in basic and uncomplicated route detection studies. In the third section, the collection and processing of the data used in the study is explained. Section 4 describes the adaptation of the data sets and the algorithms used in the route selection to the study. Finally, section 5 contains the results of the study, discussions and recommendations for future studies

2. ROUTE SELECTION ALGORITHMS

This issue has been examined many times with the studies on the determination of the shortest path between two points and the algorithms presented. In this section, GIS and routing algorithms were studied.

2.1 Shortest Path Algorithms

The shortest path defined as one of the most fundamental problem of computer science. As it is an important planning process for business and operators, the shortest path finding problem solution approaches will be discussed in this section.

Mathematical objects used for the algorithmic solution of shortest path problems are point and edge. Graf is a geometric drawing defined by a set of nodes and a set of lines connecting them to each other. Road network applications in GIS technology take a large part and are solved based on the network topology (address search, shortest path, optimal route finding), which is considered to be a GIS application. The network topology approach forms the basis for spatial analysis on objects that occur from points and lines (node). The network (node line) topology is generally evaluated with polylines such as road, infrastructure elements. As a result of these evaluations, it is possible to calculate the road lengths and route optimization process. Simple queries can be made about the infrastructure network such as electricity, water and sewerage [21].

As can be seen clearly from the literature review, the most used algorithms in route detection are Dijkstra’s, bee colony, ant colony, Floyd Warshall’s algorithm, Bellmann Ford algorithm, a star search algorithms. This section refers to the most commonly used algorithms for route detection.

2.1.1 Dijkstra’s algorithm

One of the classical and most widely used algorithms in route detection is the Shortest Path [22] algorithm. The classic shortest path finding algorithm was discovered by Dijkstra in 1959 [23]. This algorithm finds the distances between all nodes in all directions from the starting point to the end point. Two or more nodes must be available for the implementation of the Dijkstra’s algorithm. Each node is connected to each other. These connected edges weight can be cost, time, distance. The shortest path algorithm depends on minimum distance between the nodes [24].

It is designed for basic route detection and shortest path problem. This algorithm is a graphical algorithm that aims to solve the shortest path problem based on the shortest path network and with the cost of the edge path. The distance from a node to the other node in the graph or network.

Steps of solve [6]:

1) Assign to every node a distance value. Set it to zero for our initial node and to infinity for all other nodes.

2) Mark all nodes as unvisited. Set initial node as current.

3) For current node, consider all its unvisited neighbors and calculate their distance (from the initial node).

4) When we are done considering all neighbors of the current node, mark it as visited. A visited node will not be checked ever again; its distance recorded now is final and minimal.

5) Set the unvisited node with the smallest distance (from the initial node) as the next ”current node” and continue from step 3.

If this distance is less than the previously recorded distance, the Dijkstra’s algorithm has traditionally been applied to solve network problems. As indicated (Figure 2.1), a vector data structure is networked between two nodes. Using the cells in the raster data structure, each cell forms a node bound to eight neighbors and is depicted as the network of neighboring connections formed on the raster surface [9].

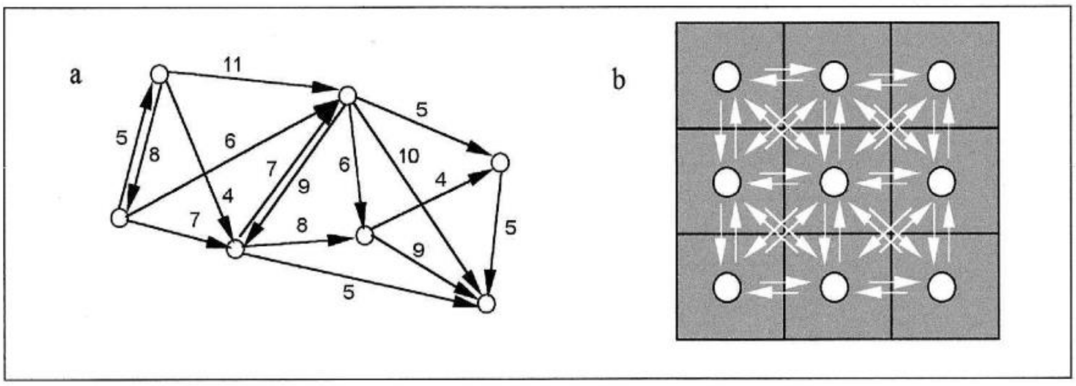

Figure 2.1 : Vector data network nodes and links; network representation of raster data structure [9].

mathematical equations of the algorithm as follows The basic steps and formulation of the Dijkstra's algorithm are as follows:

T = Group of nodes in the network

S = source node

n = Target node

N = The new source formed by combining the source with the next node at each step in the network

W = A set of nodes, which is the resultant of the paths between the nodes passed through the row and the *S* point before reaching the target point "*n*".

C (i, j) = Link value between node i and button *j*. If a node is not directly connected to the source node, the connection value in the first stage is accepted as ∞.

$D_s(n) = C(S, n)$ The shortest path value between the source node "*S*" and the destination node "*n*". n$\epsilon\{T\}$

First stage: Group *N* = *{S}*. Each node *n* ϵ {*T*}

$GrupD_s\ (n) = C\ (S, n)$

Second stage: $W\epsilon\{T - N\}. D_s(W)$ is the total value of the calculated shortcuts when processing the algorithm. Then, *W*, the last node to which this value is determined, is assigned as the new resource.

From this stage, the new short path value is as follows.

$D_s(n) = Min\{D_s(n), D_s(W) + C(W,n)\}$

If

$D_s(W) + C(W,n) < D_s(n)$

Then

$D_s(n) = D_s(W) + C(W,n)$

Else

$D_s(n) = D_s(n)$

The short path value between the target point and the source is the first value. The short path value between the source and the new node is assigned as the new source-destination short path value, calculated from the new path, if the sum of the value between this new point and the target is less than the initial value. If the opposite is the case and the 1st case is less than 2, the old value is retained. So the way is not changed. n ϵ $\{T\}$.

The third stage: the second stage is continued until $N = T$ [25].

As mentioned, the Dijkstra's algorithm only gives the shortest path between selected points on a network. In order to find the shortest path with this algorithm, the algorithm is applied step by step by giving labels to each node and by updating the values of the labels and passing to permanent labels from the new temporary labels.

2.1.2 Artificial bee colony algorithm

The ABC algorithm was developed [26] by observing the behavior of the bee colony in the nutrient search process. The number of bees involved in this algorithm is equal to the number of food sources. The number of worker bees and observer bees is equal to each other. When the amount of nectar in the source is over, worker bee will be observer bee. Finding food source in step, the worker bees start searching for food at random. The worker bee responsible for taking the bee food to the hive. The worker, who was originally commissioned as an explorer, dances to the hive after discovery and gives information about the source. Once food supply exhausted worker bee will be observer. Observers choose one of the sources according to the distance of the source and the quality of the food. This nutrient discovery process of bees includes in the literature as an optimization problem.

In this problem and problem-based algorithm, the location of food sources is considered a problem. The amount of food in the food source represents the quality of the solution. The aim of the study is to find the optimumal source and the optimal solution of the problem [27].

Artificial bee colony algorithm steps [26]:

1) Detection of nutrient sources

2) Worker bees are sent to food source and calculation of nectar amount

3) Calculation of probability values of observers

4) Selection of food source sites by observer bees according to the calculated probability values

5) Source separation criteria: production of limit and exploration bees

2.1.3 Ant colony algorithm

Ant algorithm first revealed by [28]. In the experiment, on a group of ants in equilibrium, two paths at different distances to the food source were used (Figure 2.2).

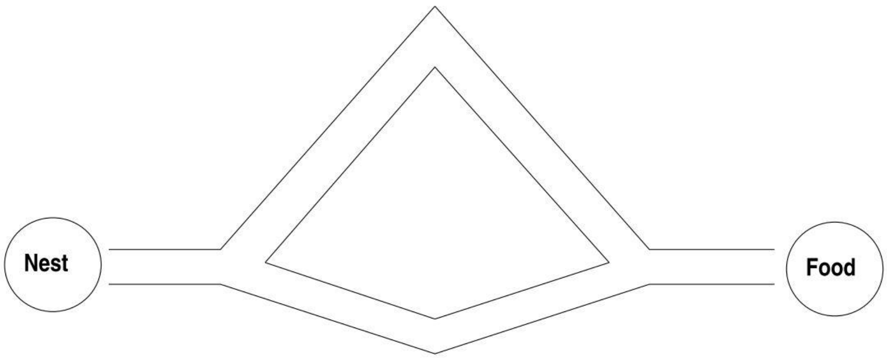

Figure 2.2 : Different ways from nest to food source [29].

Both of these roads were branched as preferable to both departure and return. At the end of the observation, ants used short paths after trials. The possibility of choosing a short pathway of ant colony appears to decrease as the difference between the roads increases. Short path selection behavior is provided by positive feedback and stigmergy based on the communication between ants. Ants decide on the way of pheromones in the road separations by spreading a chemical called pheromone while going to and from the nest [30].

At the beginning of the experiment, the ants would prefer one of two equal possibilities because they cannot predict the shorter of the two paths. In this case, the ants passing through the road will reach the food source more quickly. Ant groups goes back to the nest and goes to the decision phase. In this case the shorter path will take less time, the shorter the pheromones in the shorter the more will be fresh. It should be kept in mind that the pheromone hormone accumulated on the roads has changed depending on the conditions such as humidity and temperature. This behavior has an auto catalytic effect. Short paths are preferred and the other long way is not used in time [30].

Mathematical equations of the algorithm as follows [31]:

The ants in the ant colony release food for the ants to mark the path along the way. This behavior model creates a system based on the preference for ants with more ferromas. The algorithm was developed based on adjusting the amount and density of the pheromone at each edge. The probability of the selection of the edge is based on the selection algorithm.

$$p_{ij} = \frac{[\tau_{ij}]^{a} \ [n_{ij}]^{\beta}}{\sum_{h\epsilon s}[\tau_{ij}]^{a} \ [n_{ij}]^{\beta}} \tag{1}$$

The amount of τ pheromone n is the inverse of the distance between the two nodes. α and β are parameters weighting the relative importance of the pheromone and of the heuristic information.

Each ant uses two different methods:

Local route update method: when ants move between weddings, they update the pheromone as in the following equation

$$\tau_{ij}(t) = (1-\rho).\tau_{ij}(t-1) + \rho.\tau_0 \quad (2)$$

Here, ρ is the evaporation rate. τ_0 is the initial value of pheromone pathways and can be calculated as follows: τ_0 = *(n / Ln) -1* where n is the number of nodes.

Global route update method: all ants update all paths using the following link after passing all sides.

$$\tau_{ij}(t) = (1-\rho).\tau_{ij}(t-1) + \frac{\rho}{L^+} \quad (3)$$

Here, L^+ is the length of the best path [32].

2.1.4 Floyd-Warshall's algorithm

This algorithm has been developed by [33, 34]. Instead of calculating the path to all other nodes from a specific node in the network that contains the nodes, the calculation on the other node is performed in a single loop. As a result, the matrix *Dist [i; j]* shows the distance from node i to node j. In addition, a matrix *Next, [i; j]* represents the successor of the node at the shortest path from node i to node j.

for all nodes i of N do

for all nodes j of N do

if there is an edge from i to j then Dist[i; j] := d(i; j) else Dist[i; j] := ∞

for all nodes i of N do

for all nodes j of N do

for all nodes k of N do

if Dist[j;i] +Dist[i;k] < Dist[j;k] then Dist[j;k]:= Dist[j;i]+Dist[i;k]; Next[j;k]:=i;

The algorithm of Floyd - Warshall has the time complexity equivalent to performing Dijkstra's algorithm n times. Similar to the techniques for improving the complexity of time in Dijkstra's algorithm, Johnson's algorithm can be considered a superior approach to finding the shortest paths between all node pairs in a sparsely oriented graph. The edge ensures that some of the weights are negative, but the network must not have negative weight loops [35].

According to the Dijkstra's algorithm, a different approach calculates the shortest path between any two nodes in the network. At the core of the algorithm is the approach of creating a N-line and N-columned square matrix for the solution of an N-node network. The square matrix creation approach is considered both as distance matrix (D) for both distances between nodes and as - node order matrix (S). If there is a direct connection between i and j, it receives the connection values. Gets the value ini if there is no connection. It is known that the same approach applies to the Dijkstra's algorithm [21].

The lines between the nodes give a weight value to the lines as the distance value. The Floyd Warshall algorithm uses these weights as a calculation criterion for determining the shortest route [36].

It works by using the Bellmann-Ford algorithm to calculate a transformation of the input graph, which removes all negative weights, allowing Dijkstra's algorithm to be used in the converted chart. The Bellman-Ford algorithm allows us to test the existence of negative cycles by continuing only one additional iteration, the Floyd-Warshall algorithm does not provide such a mechanism [35].

2.1.5 Bellmann-Ford algorithm

The Bellman - Ford algorithm is an algorithm that calculates the shortest path from a single corner to all other corner points. It can solve the graphics where a part of the edge weights is negative (Figure 2.3). The basic principle of this algorithm is to calculate all points, as a source, by calculating the connections through them. Cost between each point and neighbors is determined and written as a matrix. Then the shortest paths are calculated as a result of the comparison between these matrices [25].

Algorithm [37]:

Stage *1: Startup D [i]. D [i] represents the distance from the starting point V to the object point Vi.*

Stage *2: w (m, n) is the weight of the edge e (m, n) and is the shortest path between e (m, n). E (m, n) for each edge.*

If D [m] + w (m, n) is <D [n], D [n] = D [m] + w (u, v)

Stage 3: *The loop performs i - 1 and i is the number of points. If the above process does not update D[i], the shortest path is searched or some points cannot be reached. Otherwise, it will be executed until the next cycle.*

Stage 4: *Test the diagram to find out if it has a negative loop (the total weight is less than 0). If D[u] + w (u, v) <Remote [v], there is a negative loop, which means that the shortest path in the chart cannot be established. Otherwise D[i] saves the shortest path. For example, if there is a negative loop, the values of each point will be reduced after a point.*

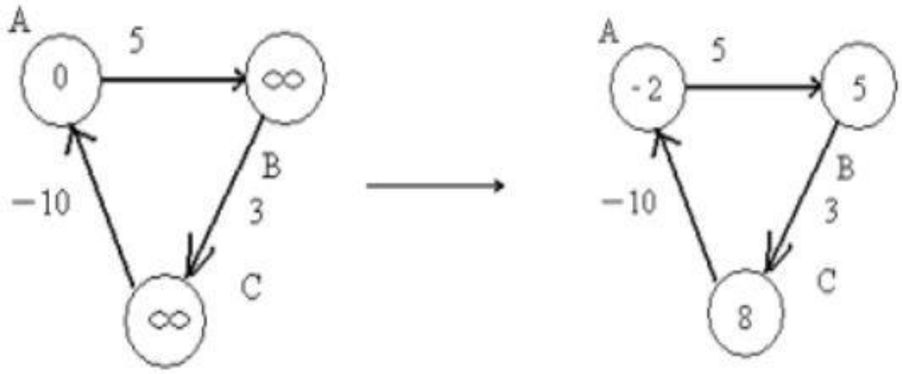

Figure 2.3 : A negative loop in Bellmann Ford graf [37].

2.1.6 A star search algorithm

A * algorithm for optimization problems can be used in many different disciplines because it is flexible. A * is like Dijkstra's Algorithm because it is suitable for finding the shortest path. The secret of his success is that he combines the pieces of information used by the Dijkstra Algorithm (supporting positions close to the starting point) and the information used by Greedy Best-First-Search (supporting positions close to the target). The A * algorithm is called intuitive search because it is based on intuitive information. The A * algorithm calculates the cost for each node on the current network, choosing the most logical result. This added new route will be used to find a shorter route. The A * search algorithm finds the shortest distance by examining the nodes. Creates a set of nodes, from the starting point to the endpoint, scans all nodes and selects the most appropriate one [38].

As it can be seen from the literature, the Dijkstra’s algorithm is used for the shortest path solution in the single-criteria weighted network model. If the values of the edges are smaller than zero, Bellman – Ford algorihm can be used for more general algorithms. The Floyd algorithm offers the shortest path from each node on the network without relying on a specific start and end point. The result of the Floyd algorithm can also be obtained by running the Dijkstra algorithm up to the number of nodes in the globe.

As a result of that the single criterion to be used to determine the cable route is the distance, it is understood from the literature that, the most appropriate solution for the single-criteria route approach is the Dijkstra’s algorithm.

3. DATA ACQUISITION

3.1 Study Area

The study area is located in Izmir Province (Figure 3.1) located at western (Aegean) region of Turkey.

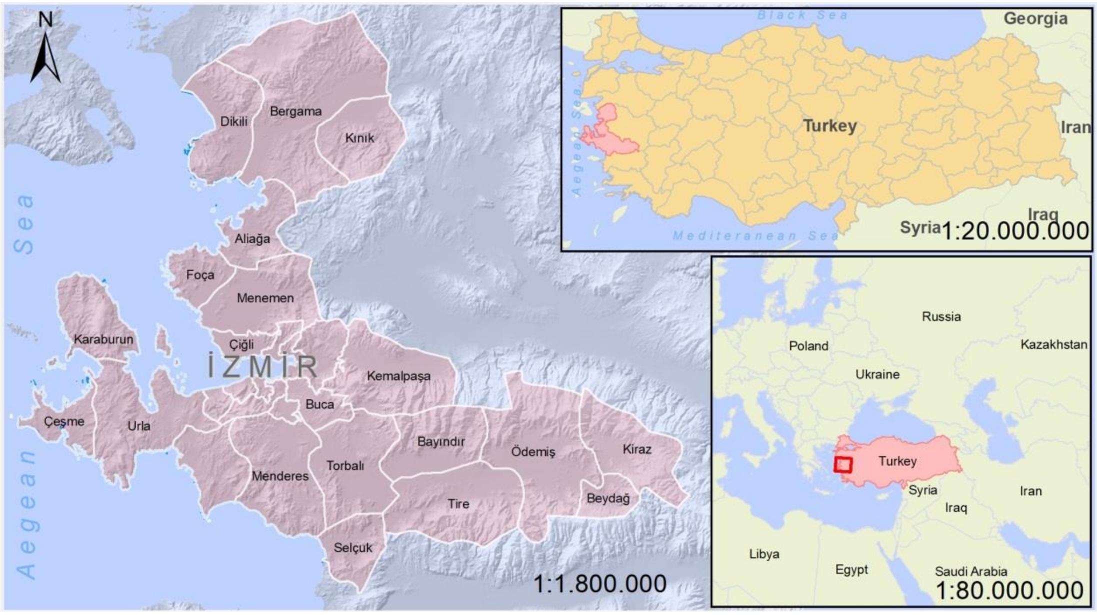

Figure 3.1 : Study area.

In the study area including Karabağar and Buca districts (Figure 3.2). It is planned to make a route detection between the substations. Turkish electricity transmission corporation (TETCO) will connect sustations by the underground power cable.

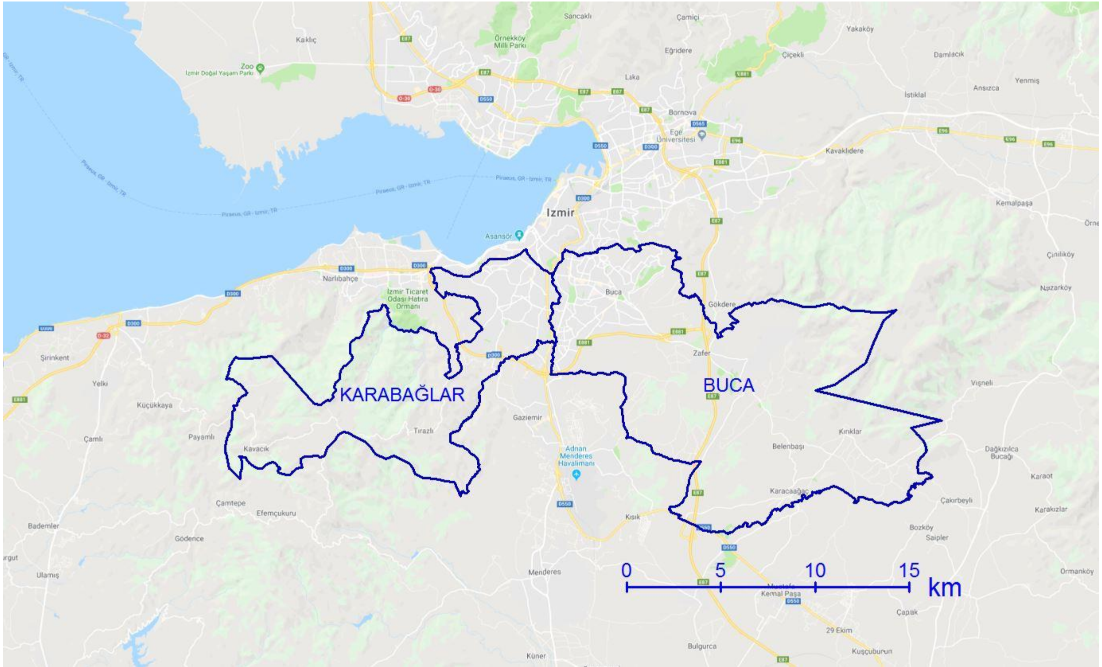

Figure 3.2 : Karabağlar and Buca districts.

The distance between the two substations (Figure 3.3), the availability of aternative roads in the route area, and the minimum cost demand of the project were determinant in the selection of the study area.

Figure 3.3 : Karabağlar and Buca substations (transformer centers).

The fact that, having alternative streets in the study area increases the importance of automation in the process of routing. The existing roads in the study area were used as networks in the Dijkstra's algorithm.

3.2 Data Set

There are several factors which have influenced the selection of UPC routes. Existing infrastructure layers location, land use, width of streets and length of cable are basic factors. Length of cable is the most important factor which affets cost.

In this study, tried to optimize the UPC route length. It is celarly that, basic route detection ptoblems has been solved by the method of Dijkstra's algorithm. In the sub-headings, the factors affecting the route selection and their importance are explained. In addition, the way GIS are used to determine the route and the reasons for using it have been mentioned.

3.2.1 Road network

In the process of cable routing, the state of urbanization is very important. The narrow roads make cable laying difficult. The cable route passes through roads as it must not coincide with private property parcels. Otherwise, the cable may need to be displaced later. All of these situations cause the route to pass through the main transportation roads.

In the study, transportation road data, which are located within the boundaries of karabağlar and buca districts, were used. Road network data was obtained from the open street map.

3.3 General Information About Energy Transmission and Underground Power Cables

Electrical energy has been a resource that makes life easier since the first discovery of electricity by humanity. Throughout the many processes that human beings left behind, their dependence on electricity increased exponentially. Increased population, urbanization, the use of electronic equipment has increased the need for electricity. This increased need led to new problems. While the production of electricity and the availability of resources were the problems encountered in the first place, the transmission of electricity in later times became an important problem.

Similar methods are used in each country for the transmission of electricity in the world. In turkey responsibility for construction and operation of power transmission lines are owned by turkish transmission system operator . Towards the end of the 1960s, in the early days of high voltage electrification, the Turkish network consisted of 154 kV lines that fed only the big cities. Modernization of the Turkish interconnected system was carried out under the guidance of Professor Francesco. Turkey today's interconnected system has, on an international scale, many substations, underground cables and has energy transmission line [39].

The power transmission lines transmit electricity from the place of production to the place where the electricity is produced or to the low voltage, and also provides power distribution within the national interconnected system. The energy transmission lines are installed as an overhead line in the rural area and as an underground cable in the urban.

The use of UPC in electricity, distribution and transmission systems has increased significantly over the years with the demand of electrical energy and population density in different areas. Therefore, it is very important that UPC replace overhead lines. [40]. Due to the fact that physical safety problems are less than the overhead lines and due to the space shortage resulting from the rapidly increasing population, the transmission of the energy with the underground cables will be unavoidable in the near future [41].

The UPC has many advantages. Weather conditions such as lightning and wind are less affected. The electromagnetic emission is less exposed to the environment. Occupies space as a corridor less than overhead lines. they are not dangerous for aircraft and helicopters flying close to the ground. It is more environmentalist, since there is no chance of being exposed to the danger of being caught in the flow.

Cable laying process is made easier than overhead lines. Routes and channel dimensions are determined before the excavation. Cable laying process (Figure 3.4) along the route is done gradually.

Figure 3.4 : Underground power cable laying process.

There are some disadvantages of UPC. The cost of the plant is more expensive and it is difficult to access point of failure in terms of operation than the overhead lines. The way of cable placement and the quality of production of the cable affect the cable life and efficiency in the plant (Figure 3.5). As a result of a cable failure, the repair is long, it interferes with the security of the interconnected system and the interruption time is longer.

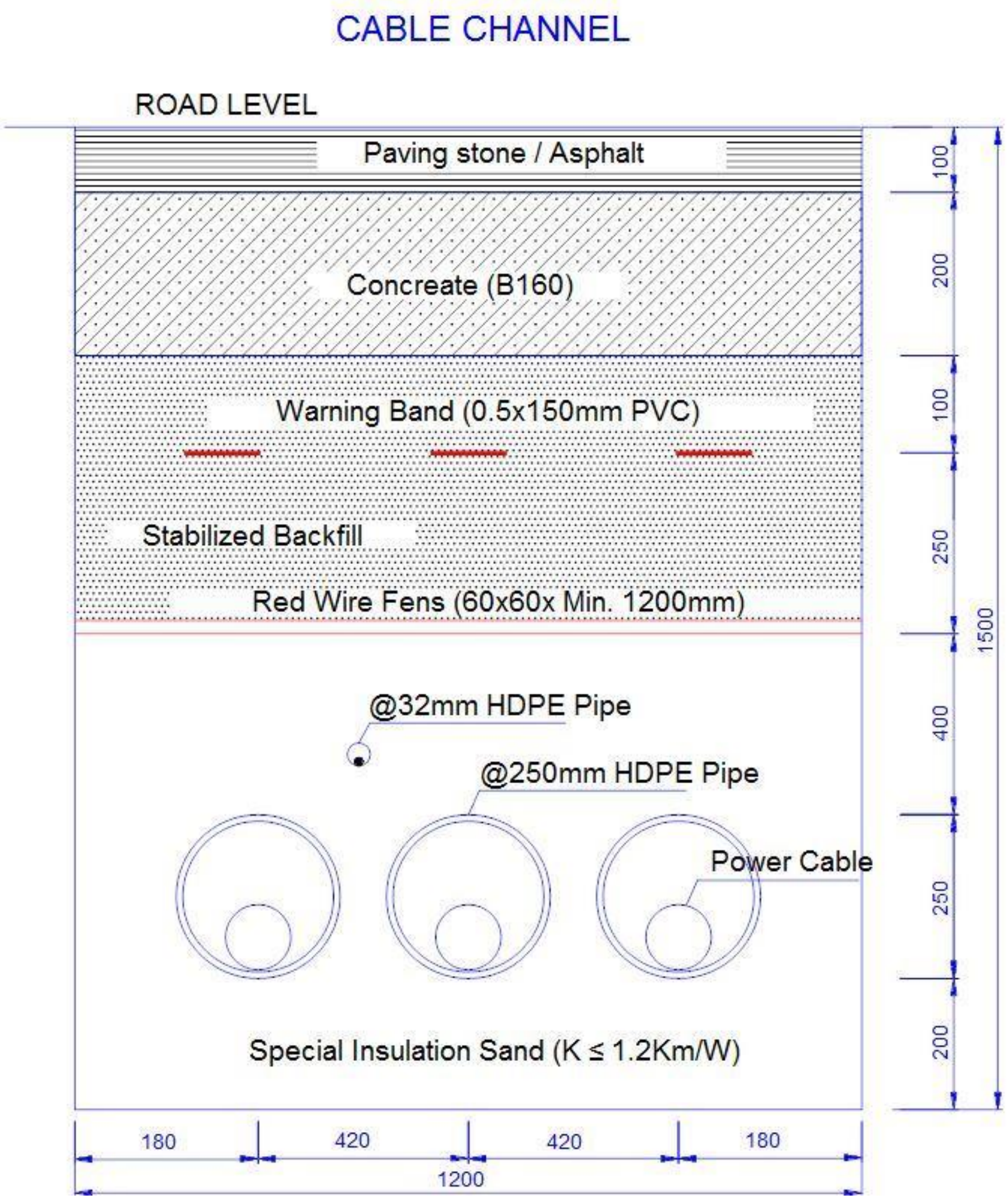

Figure 3.5 : Cable trench channel cross section.

In the form of ground cables, current carrying factors are seen where the cables are only passed through the cable or pipe, and in case the cables are completely closed, the current carrying capacity is tried to be increased, especially if the pipes are covered with polyethylene pipes.

The cables should be able to be used at maximum efficiency when it is thought to be high cost. İn order to operate with maximum current carrying capacity, the plant conditions must be as appropriate as possible [42].

3.4 Traditional Cable Route Detection Process

Traditionally, the problem of route selection is encountered in the engineering project of highway, railway, pipeline, power transmission and many more. In these problems, the criteria for route selection varies from project to project. For each project, a different experience and professionality is required. The quality and the applicability of the selected route vary depending on the experience of the router.

TETCO, which is responsible for energy transmission and distribution in Turkey also increased the need for underground cables with increased urbanization. accordingly, route selection has become an important problem at this point.

As the procedure, firstly UPC Project is taken into the investment program of TETCO. The starting and ending points of the cable are defined in the investment program. These points can be different substations or another cables. The primary rough route is determining by the engineer using satellite image and street map as a basemap. In the primary route detection operation, a straight line is drawn between the start and end points of the route. This straight line is the guide of the primary route. The route engineer draws lines on the street map and satellite image with the help of the guide line, following the streets while selecting the cable route (Figure 3.6). As a result of this process, the quality of the primary route depends entirely on the experience and capacity of the route engineer.

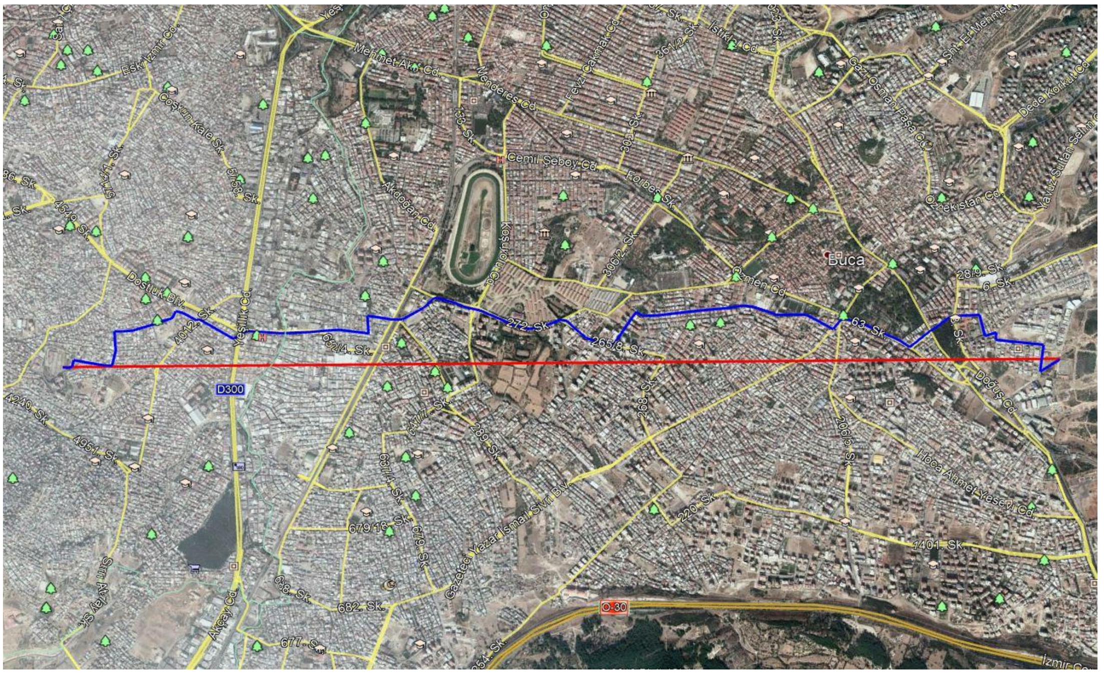

Figure 3.6 : Primary route detecting by satellite ımage and street network layer. The red line is guide line and blue line is UPC primer route.

Environmental impact assessment corridor of primary route detecting (Figure 3.7). This imprecise preliminary route and corridor send to the infrastructure institutions and municipalities for their opinion. It is stated that excavation work can be done in this corridor area. The comments are valid for the area in this corridor.

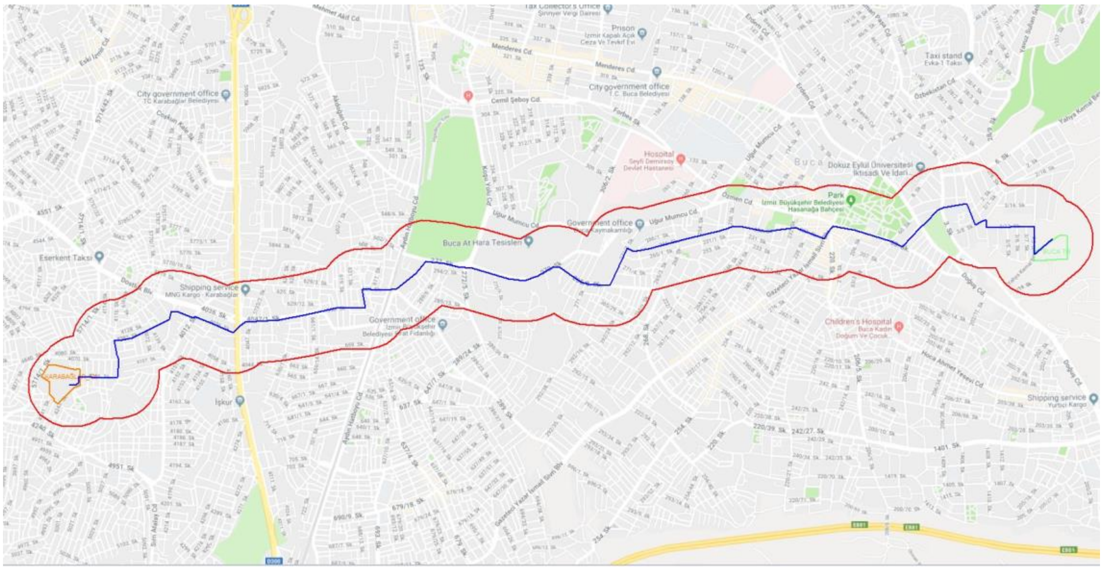

Figure 3.7 : Environmental impact assessment corridor of the route.

Cadastral property map, land use map and existing infrastructures lead to detection of precise route and generates database by different layer (Figure 3.8). At this stage the router edits the route using different layers to form final precise route. Then the cost of projects detects depending length of the route. Finally, cable establishment and laying process begins.

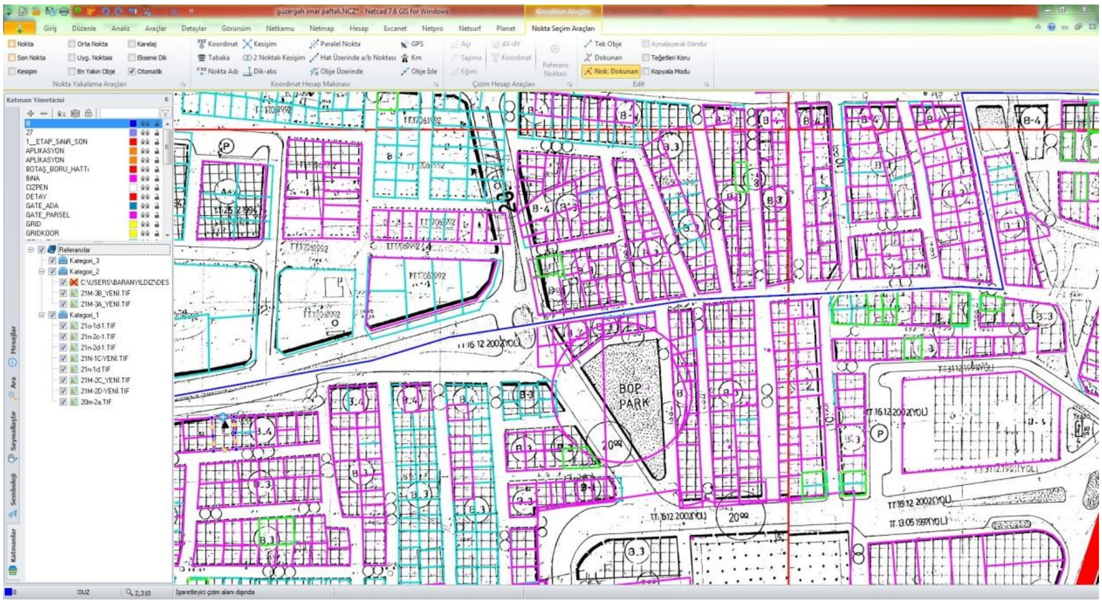

Figure 3.8 : Editing primar route by using cadastral property map and land use map to detect precise final route.

As can be seen from this process, the cable route length is the most important factor affecting the project cost. At the end of the process steps (Figure 3.9), The route is related to the primary route which determined in the first process. The quality of the primary route depends on the experience of the engineer who determines the route.

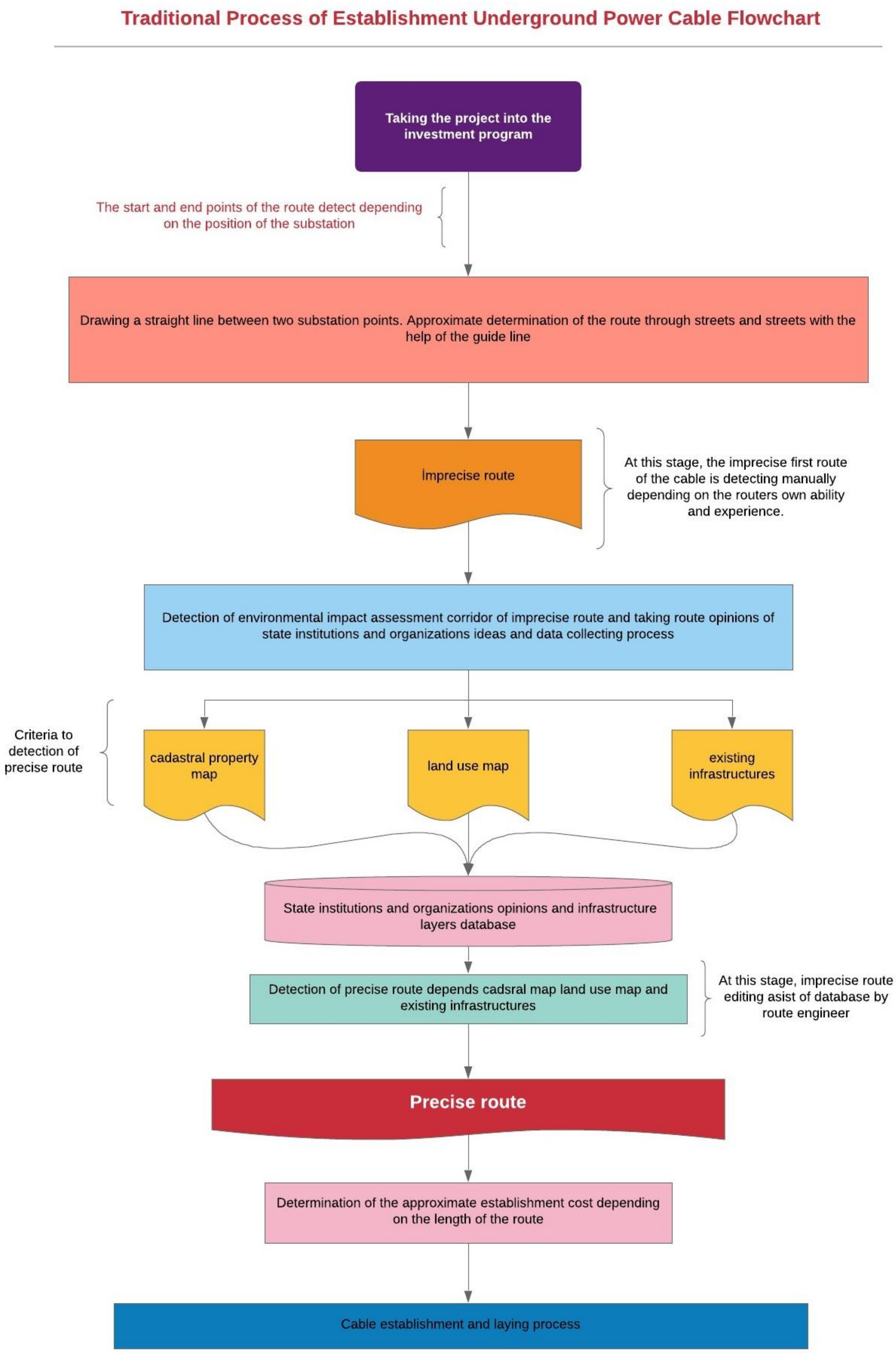

Figure 3.9 : Traditional Cable Establishment Process.

3.5 GIS and Its Role In Routing Process

GIS is a new computer technology that is not very old and helps users in the decision-making process. The origin of GIS is based on different sciences. These sciences; computer, geography, mathematics, decision making, statistics, remote sensing, engineering, data processing, planning, environmental science, research, landscape architecture, modeling, map and cadastral science [43].

The regular processing of databases, data and information is used for storing and understanding the user. With the technology in the developing world, the database can store and use very high data. The function of database systems is to shorten and facilitate the decision-making process. In addition to these databases, geographic information systems also contain location information of the data.

The location-based data contained in the database are stored as attribute tables in the GIS software and these data are graphically contained in the data layer. maps are called chart data and attribute data are the tables of maps [21].

Spatial data elements are recorded as point - line - area and referenced in standard coordinate system. These spatial data elements, on a scale, generate maps. The graphical data are stored and analyzed as the form of maps. At this point, the importance of CAD software and satellite image analysis systems emerges at this point. All this process has contributed to the formation of a GIS [44].

GIS is designed to conduct, combine, and analyze large data sources at the same time (Figure 3.10). Asist of the GIS process method, large-scale projects are carried out quickly and on time, with lower costs. It helps the decision-making process without wasting documents. The decision-making mechanism, by examining the different data sets, taking into account the effects of the results, without the need for a standard procedure performs the operation. The importance of GIS is reflected in such projects.

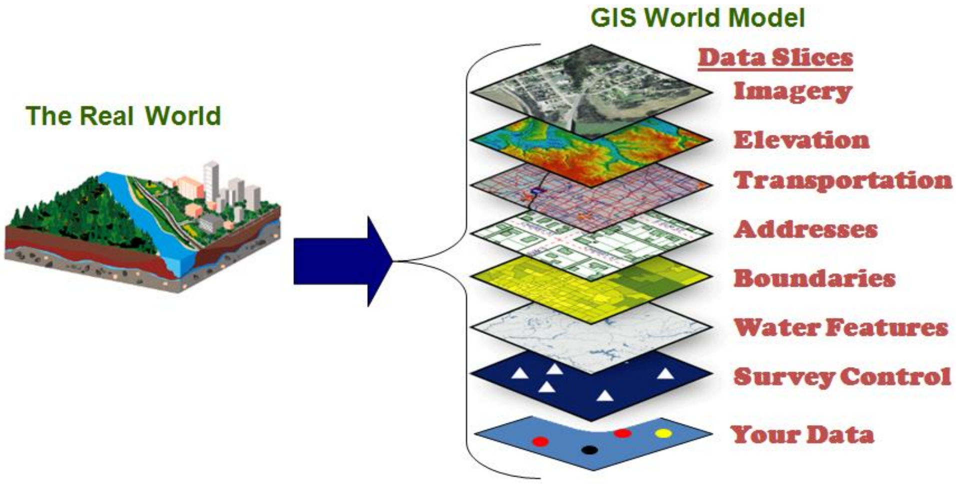

Figure 3.10 : Different data sets [44].

The use of GIS in optimization problems has increased recently. Multi criteria decision analyze approach, finding the most suitable site selection and detecting route problems, GIS software, are used very often. With the help of GIS, the route problem can be solved. Improved cost distance and cost path solutions, optimal route finding solutions, are very useful for this. The route selection problem with the Dijkstra's algorithm finds a solution to the problem which based on simple criteria or time or distance based route finding. The route solution with Dijkstra's algorithm is a common solution in the literature.

4. METHODOLOGY AND ANALYSES

4.1 Introduction

In this section, the methods, calculations and analyzes used in this study are discussed. The importance of GIS in determining routes mentioned. In the previous section, the route detection process of the UPC and the importance of the power cable in the TETCO transmission system are mentioned. In addition to the algorithm used, the same route was determined by three different engineers by manually and compared with the route detected automatically.

4.2 Definition of The Problem

At the present time, the determination of the route of UPC is a manual, time-consuming and laborious task. These routes are determined by the routers in the field depending on personal experience. The route is feasible and cost-effective, depending on the person setting the route. The aim of this study is to automate this process with the shortest path solution.

4.3 Dijkstra’s Algorithm About Route Detection Methodology

The Dijkstra’s algorithm is an effective algorithm that is frequently encountered in the literature in solving the shortest path problem. Dijkstra’s algorithm is named by E.W.Dijkstra. It aims to find the shortest path in a weight-defined network. The weights defined to every edge of the network. Weights can be distance, time and cost. İt called the single source shortest paths.

This problem is associate with branching tree (Figure 4.1). The graph showing the distance from one point to all points network. G = (V, E) function can be written for graph. Where in the waypoint V group, E is boundaries (edge) indicates the group.

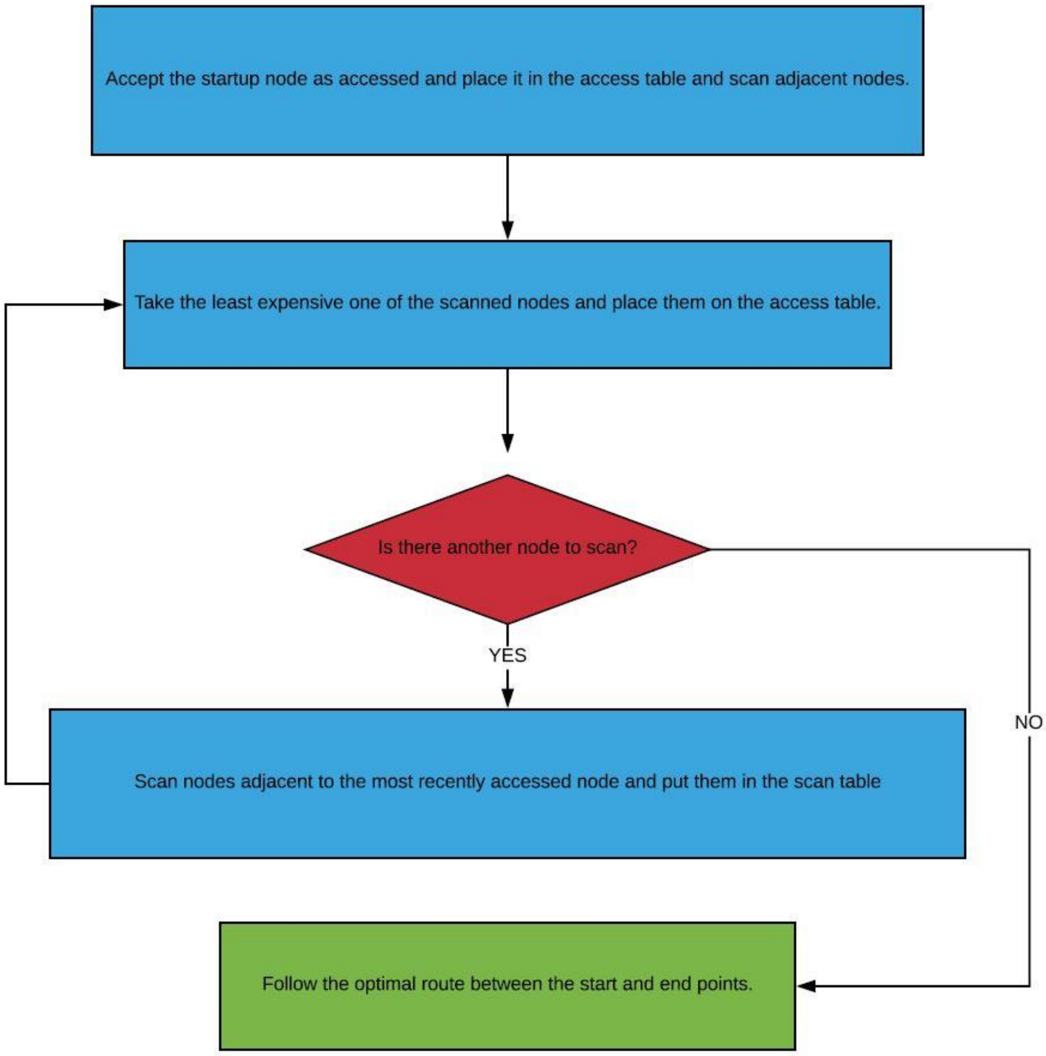

Figure 4.1 : Flowchart of Dijksta's algorithm shortest path network solution.

G = (V, E), in the function V = {1, ..., n} and E for all (i, j) 's midpoints, j, including algorithm from 1 to n midpoints points and li determine the shortest distances to all waypoints (1, 2, ..., n) from the 1st midpoints point in a diagram given with the boundaries i (i, j) with the edge lengths j> 0. Input data are the number of midpoints (n), limits (i, j) and lij. The output data is the length of the shortest paths is j which can be defines as (j = 2, ..., n) in formula.

4.4 Software Process and Results

The main purpose of this study is to automate with GIS software by demonstrating a different approach to the determination of UPC route. For this purpose, the 154 kV Karabağlar-Buca Cable Project, which is located in the boundaries of the Karabağar and Buca district where the population of Izmir is dense, and which has been planned by TETCO, selected.

In this study, ArcGIS software used to run the algorithm. With the network analysis module, the route is determined by the shortest path solution. Network analysis is a type of analysis performed with vector-based data. Network analysis, draws results from line-based geographic data connection and generates decision-making results.

Selecting one of the shortest links between the two nodes with more than one tie is called the optimum route selection. The solution may be distance based or time-based. For this purpose, firstly a geodatabes was created by adding the location of the TETCO transformer substations where the software has the starting and ending points of the route and the road basemap data obtain from the open street map (Figure 4.2).

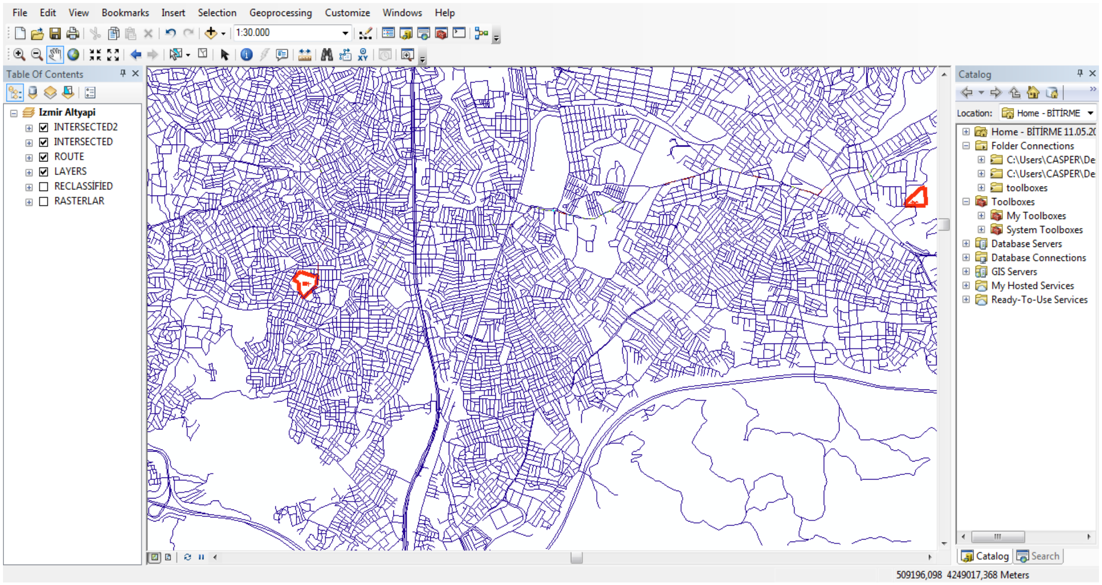

Figure 4.2 : Open street map network data and substations.

One of the problem the unbonded parts of the road network are combined. The sensitivity is 0.1m. The intersection of the end point of each piece and the parts should be a node. In other words, the two line segments intersecting in a planar diagram must have a node at the point of intersection. This creates network dataset and junctions.

A network consists of line segments that are connected between them in various ways. Each line segment is defined by its known starting and ending points. Each piece contain known intermediate points whose coordinates are between the starting and ending points. Topological relationships defined by node points determine the connectivity of a network. A typical network structure created from the streets in open street map data (Figure 4.3). The points in the figure represent the nodes.

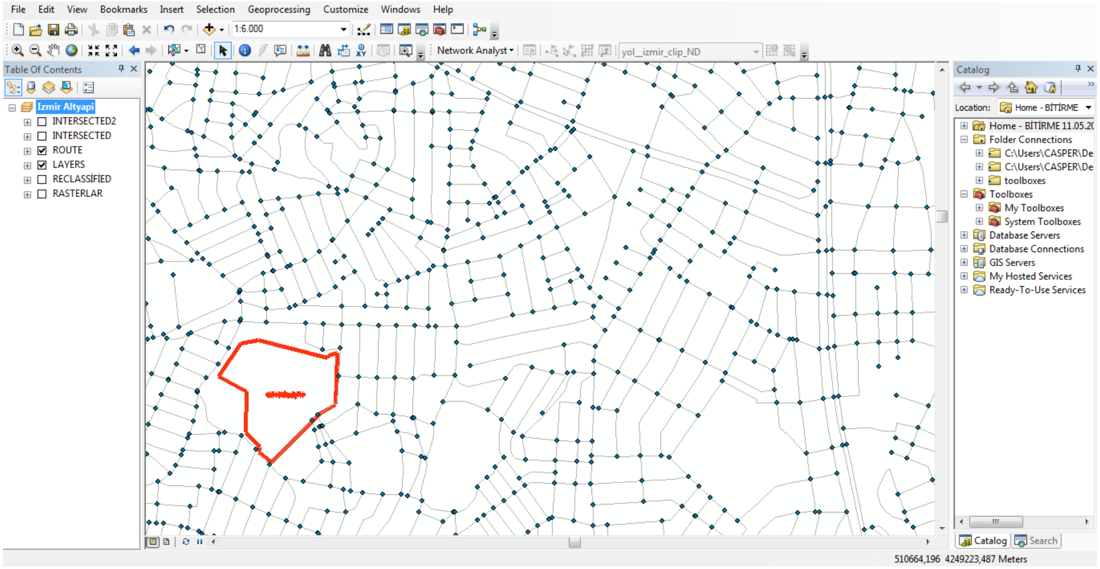

Figure 4.3 : Junction points and nodes of network.

Entering the network dataset to the new route, the start and end points of the route are added. Substations are introduced as starting and ending points of the route (Figure 4.4).

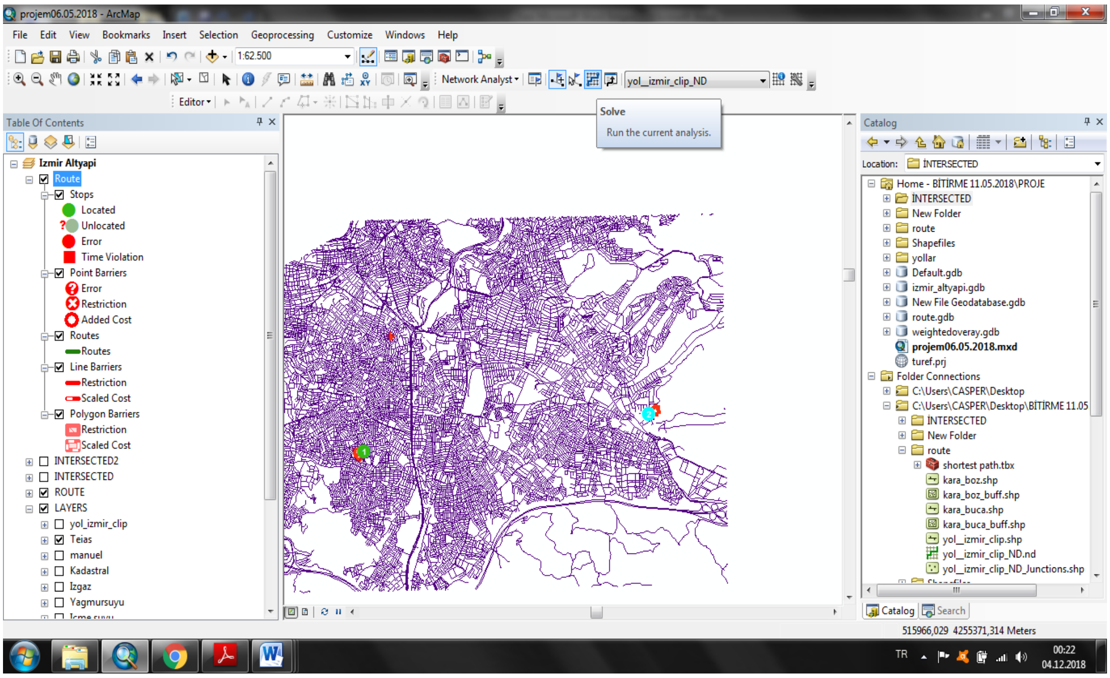

Figure 4.4 : Adding start and end points of route.

Then, click "solve" to create the route. In order to select the start and end points independent of the network, the snap to position along the network option is disabled (Figure 4.5).

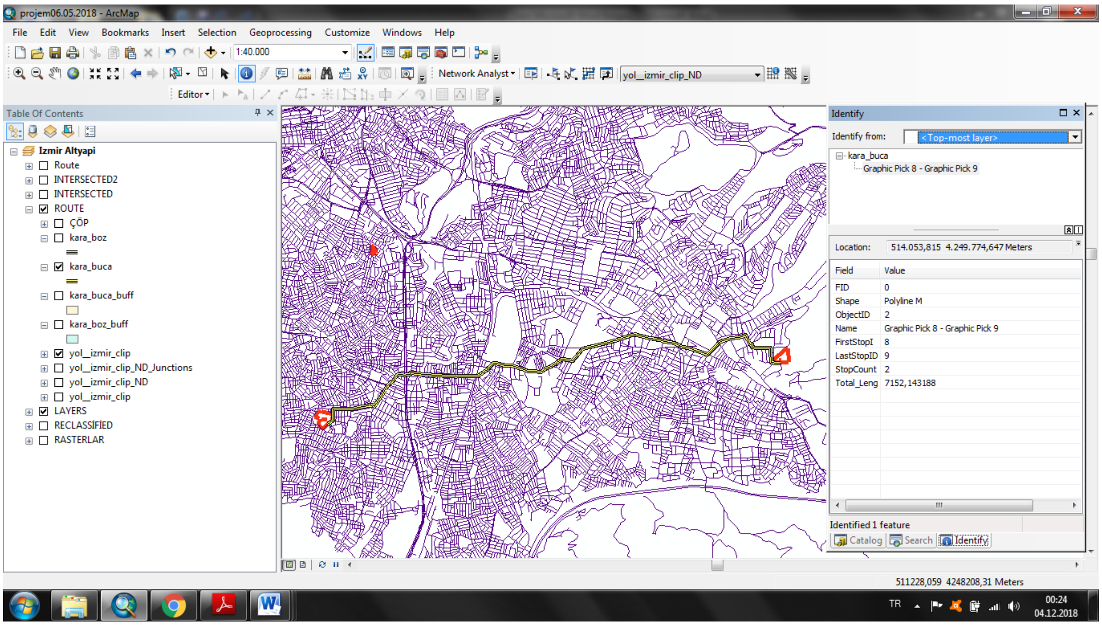

Figure 4.5 : Route output of software.

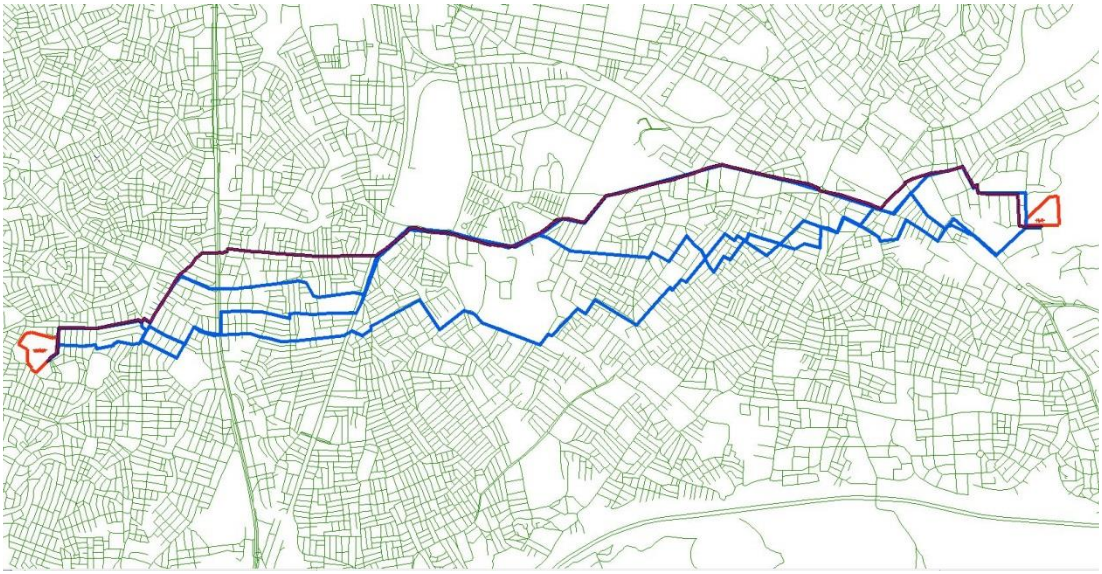

Figure 4.6 : Routes between Karabağlar and Buca substations.

The red polygons seen in the city are the boundaries of the karabağlar and buca transformer centers. Green lines represent the streets taken from the open street map data. The study is the route determination between these two substations. The route determined by the algoritm (which is navy) and the manually determined routes (blue) by different users have been added to the same project. As can be seen from the, software and some users have determined the route using the same streets (Figure 4.6).

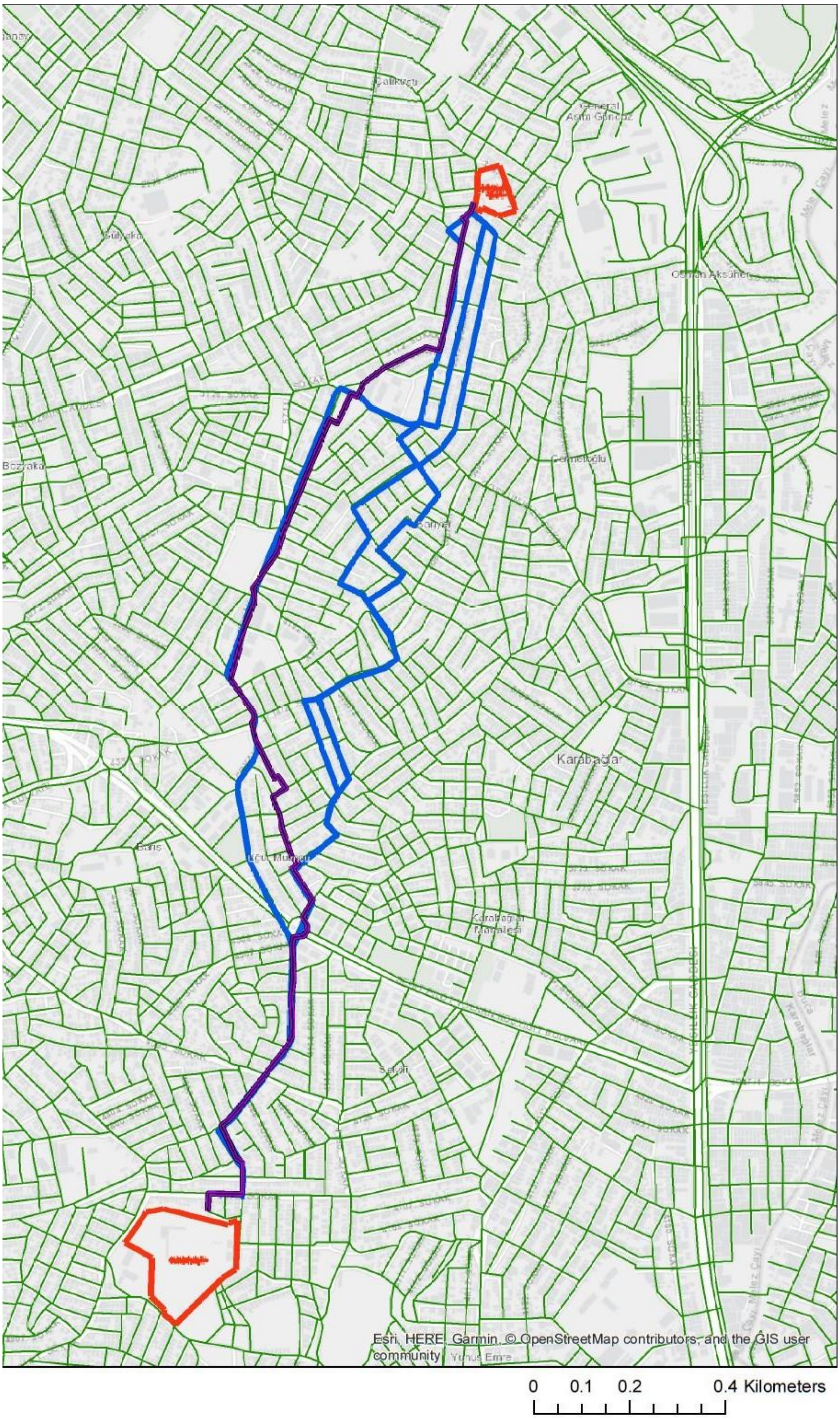

Figure 4.7 : Routes between Karabağlar and Bozyaka substations.

The same study was carried out between the karabağlar and bozyaka transformer centers. The software (navy line) and users (blue line) are determined by using the same streets (figure 4.7).

Table 4.1 : Result table of route length.

LAYER	LENGTH (METER)
KARABAĞLAR - BUCA MANUAL 2	7847.09
KARABAĞLAR - BUCA MANUAL 3	7702.87
KARABAĞLAR - BUCA MANUAL 1	7171.12
KARABAĞLAR - BUCA AUTOMATIC	7152.14
KARABAĞLAR - BOZYAKA MANUAL 2	2720.11
KARABAĞLAR - BOZYAKA MANUAL 3	2663.26
KARABAĞLAR - BOZYAKA MANUAL 1	2656.69
KARABAĞLAR - BOZYAKA AUTOMATIC	2537.82

Lengths of the routes which are the output of the software and lengths of the manually determined routes are shown (Table 4.1). Both two routes are manually detected by three different route engineers and compared with route output of the software.

Taking everything in to consideration, its clear from the result table, the automatic software routes are shorter than the manual routes. The length averages of the manually determined routes were calculated and the automatic routes were found to be about 6% shorter than the manual routes.

5. CONCLUSION

Throughout engineering history, GIS technology has been used for different purposes in various engineering disciplines. Route detection is one of the largest users of GIS technology. For this purpose, GIS aims to make route analysis, save the data spatially, manage the network, perform network analysis to make route planning. Therefore, all layers are stored in a geodatabase and aim to perform a different type of network analysis.

The main purpose of this study is to determine the primary route of the underground power cable with the help of the GIS and to show the usability of the shortest path algorithm. In this study, the stages of the classical route determination technique were examined and it became possible to select a route between two substations with the criteria of route selection process.

Urbanization and population growth increased by electricity needed. Electricity transmission is increasing in parallel with this need. The spread of urbanisation prevented the use of overhead lines, in terms of electricity transmission in urban areas. This event, necessitates use of high cost crosslinked polyethylene (XLPE) kısaltma listesine ekle insulated cables. Taking everything in to consideration, the underground power cable’s most important cost element is route length. The study is also a cost reduction study. With automation, it is aimed to reduce the dependence of the route to the user.

In this study, the route was determined with the help of the Dijkstra’s algorithm used for the shortest path solution. Software output route is compared with the routes which manually set by three different users. Since the study was also a cost study, the lengths of the routes were compared.

When the results were examined, it was seen that the route determined by the software was shorter than the average length of the route determined by the users.

5.1 Discussions

Software-independent, man-made data collection is still more reliable than made by atomatic. Examples of such operations are the estimation of the satellite image and the detection of structures. These processes require complex processes that can be done by man. In this context, the traditional route selection problem is still valid comparing with the automatic route selection. In the literature, on the shortest route selection problem, cable route follows public transportation roads, the underground cable is thought to follow the shortest distance. Routes made by the expert and produced by the software reach almost the same solution.

In this study, rough primary route was determined. The determination of the rough route is made by using a single criterion according to the exact final route and forms the basis of the study. The process of determining the exact final route is carried out within the decision-making set within many criteria. In this data set, there are digital routes of the zoning plan, cadastral plan and other infrastructures as raster. The exact route determination process is done by editing the rough route.

Due to the complexity of the exact route, the manual intervention of the user becomes compulsory. The user decides with the help of different data sets. In integrating the data sets into the software in the final route automation process, it is difficult to introduce the criteria used by the user in decision making to the software. This complicates the applicability of the exact route automation.

Considering these reasons, in the software automation process, rough primary route was preferred instead of the exact route.

5.2 Future Studies

In this study, a different approach with the help of GIS has been introduced to the determination of the underground power cable route. The use of geographic information systems, make solution of the the shortest route selection problem more applicable.

In the study, the layer of streets with vector data type will be used graphically in the network analysis method. The alternation of the streets brings the route closer to the best result. The starting and ending points of the route must be selected from the substations, the closest points to substations.

The model created for operation can be used for solution in single criteria route selection problems. With small variations, this model can be made compatible with other route selection solutions. Computer - based saves time.

REFERANCES

[1] Dorigo, M., & Stützle, T. (2001). *An experimental study of the simple ant colony optimization algorithm.* Paper presented at the 2001 WSES International Conference on Evolutionary Computation (EC'01).

[2] Rolf, A., & de By, R. (2000). Principles of geographic information systems. *The International Institute for Aerospace Survey and Earth Sciences (ITC), Hengelosestraat, 99*.

[3] Jiang, H., & Eastman, J. R. (2000). Application of fuzzy measures in multi-criteria evaluation in GIS. *International Journal of Geographical Information Science, 14*(2), 173-184.

[4] Cheng, M.-Y., & Chang, G.-L. (2001). Automating utility route design and planning through GIS. *Automation in Construction, 10*(4), 507-516.

[5] Dijkstra, E. W. (1959). A note on two problems in connexion with graphs. *Numerische mathematik, 1*(1), 269-271.

[6] Yang, S., & Li, C. (2010). *An enhanced routing method with Dijkstra algorithm and AHP analysis in GIS-based emergency plan.* Paper presented at the Geoinformatics, 2010 18th International Conference on.

[7] Hong, I., & Murray, A. T. (2016). Assessing Raster GIS Approximation for Euclidean Shortest Path Routing. *Transactions in GIS, 20*(4), 570-584.

[8] Scaparra, M. P., Church, R. L., & Medrano, F. A. (2014). Corridor location: the multi-gateway shortest path model. *Journal of Geographical Systems, 16*(3), 287-309.

[9] Collischonn, W., & Pilar, J. V. (2000). A direction dependent least-cost-path algorithm for roads and canals. *International Journal of Geographical Information Science, 14*(4), 397-406.

[10] Hong, I., & Murray, A. T. (2016). Assessing Raster GIS Approximation for Euclidean Shortest Path Routing. *Transactions in GIS, 20*(4), 570-584.

[11] Eroğlu, H., & Aydin, M. (2015). Optimization of electrical power transmission lines' routing using AHP, fuzzy AHP, and GIS. *Turkish Journal of Electrical Engineering & Computer Sciences, 23,* 1418-1430. doi:10.3906/elk-1211-59

[12] Eroğlu, H., & Aydin, M. (2018). Solving power transmission line routing problem using improved genetic and artificial bee colony algorithms. *Electrical Engineering*, 1-14.

[13] Fang, Z., Li, L., Li, B., Zhu, J., Li, Q., & Xiong, S. (2017). An artificial bee colony-based multi-objective route planning algorithm for use in pedestrian navigation at night. *International Journal of Geographical Information Science, 31*(10), 2020-2044.

[14] Abousaeidi, M., Fauzi, R., & Muhamad, R. (2016). Geographic Information System (GIS) modeling approach to determine the fastest delivery routes. *Saudi J Biol Sci, 23*(5), 555-564. doi:10.1016/j.sjbs.2015.06.004

[15] Jewell, W., Grossardt, T., Bailey, K., & Gill, R. S. (2009). A New Method for Public Involvement in Electric Transmission-Line Routing. *IEEE Transactions on Power Delivery, 24*(4), 2240-2247. doi:10.1109/tpwrd.2009.2027490

[16] Matrood, Z. M. a. G., Loay E and Mahmood, Faleh H. (2014). A Simple GIS Based Method for Designing Fiber-Network. *International Journal of Engineering and Innovative Technology, 4,* 49--57. [17] Salah, A.M. & D. Atwood, *Pipeline alignment optimization: Automated GIS-based approach.* Journal of Pipeline Systems Engineering and Practice, 2010. 2(1): p. 2-13.

[18] Wang, S., Xiong, L., Zhang, C., Chen, J., & Jin, L. (2017). An optimization model of a highway route scheme in permafrost regions. *Cold Regions Science and Technology, 138*, 84-90. doi:10.1016/j.coldregions.2017.03.010

[19] Yeh, E.-C., Sumic, Z., & Venkata, S. (1995). APR: A geographic information system based primary router for underground residential distribution design. *IEEE Transactions on Power Systems, 10*(1), 400-406.

[20] Gomez, J., Khodr, H., De Oliveira, P., Ocque, L., Yusta, J., Villasana, R., & Urdaneta, A. (2004). Ant colony system algorithm for the planning of primary distribution circuits. *IEEE Transactions on Power Systems, 19*(2), 996-1004.

[21] Gündoğdu, C. E. (2011). *GIS tabanlı karar verme* (Vol. 1. bs). İstanbul: Hiperlink.

[22] Lepoglavec, K., Pentek, T., Papa, I., Sporcic, M., Landekic, M., & Nevecerel, H. (2015). Influence of existing secondary forest road network on the selection of timber extraction technologies at the tactical level of planning. *Glasnik Sumarskog fakulteta*(suppl.), 63-74. doi:10.2298/gsf15s1063l

[23] Dijkstra, E. W. (1959). A note on two problems in connexion with graphs. *Numerische mathematik, 1*(1), 269-271.

[24] Demircan, S. (2009). *Çoklu etmenler kullanılarak enerji nakil hattı güzergâh optimizasyonu.* (master's thesis) Retrieved from http://acikerisim.selcuk.edu.tr:8080/xmlui/handle/123456789/7540

[25] Demirkol, Ö. E., & Demirkol, A. (2003). Dıjkstra Ve Bellman-Ford En Kısa Yol Algoritmalarının Karşılaştırılması. *Sakarya Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 7*(3), 55-62.

[26] Karaboga, D., & Basturk, B. (2007). A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algorithm. *Journal of global optimization, 39*(3), 459-471.

[27] Ebrahimnejad, A., Tavana, M., & Alrezaamiri, H. (2016). A novel artificial bee colony algorithm for shortest path problems with fuzzy arc weights. *Measurement, 93*, 48-56.

[28] Goss, S., Aron, S., Deneubourg, J.-L., & Pasteels, J. M. (1989). Self-organized shortcuts in the Argentine ant. *Naturwissenschaften, 76*(12), 579-581.

[29] Dorigo, M., & Di Caro, G. (1999). *Ant colony optimization: a new meta-heuristic.* Paper presented at the Proceedings of the 1999 congress on evolutionary computation-CEC99 (Cat. No. 99TH8406).

[30] Saeedi, S., & Mahdavi, I. (2016). Using Ant Colony Optimization For Shortest Path Problem. *Algorithmica, 64*(4), 643-672.

[31] Monteiro, M., Fontes, D. B., & Fontes, F. A. (2012). Ant Colony Optimization: a literature survey. GIS spatial analysis applied to electric line routing optimization. *IEEE Transactions on Power Delivery, 20*(2), 934-942.

[32] Katiyar, S., Ibraheem, N., & Ansari, A. (2015). Ant colony optimization: a tutorial review. *MR International Journal of Engineering and Technology, 7*(2), 35-41.

[33] Warshall, S. (1962). A theorem on boolean matrices. *Journal of the ACM (JACM), 9*(1), 11-12.
[34] Floyd, R. W. (1962). Algorithm 97: shortest path. *Communications of the ACM, 5*(6), 345.
[35] Sharma, P., & Khurana, N. (2013). Study of optimal path finding techniques. *International Journal of Advancements in Technology, 4*(2), 124-130.
[36] Bukhori, D., & Dengen, N. (2018). *Floyd-warshall algorithm to determine the shortest path based on android.* Paper presented at the IOP Conference Series: Earth and Environmental Science.
[37] Wang, X. Z. (2018). *The Comparison of Three Algorithms in Shortest Path Issue.* Paper presented at the Journal of Physics: Conference Series.
[38] Chen, T., Zhang, G., Hu, X., & Xiao, J. (2018). *Unmanned aerial vehicle route planning method based on a star algorithm.* Paper presented at the 2018 13th IEEE Conference on Industrial Electronics and Applications (ICIEA).
[39] Benato, R., Balanuye, İ., Köksal, F., Ozan, N., & Özdemirci, E. (2018). Installation of XLPE-Insulated 400 kV Submarine AC Power Cables under the Dardanelles Strait: A 4 GW Turkish Grid Reinforcement. *Energies, 11*(1), 164.
[40] Nakagawa, H., Tanizawa, K., Ono, M., & Takehana, H. (1983). Installation of 275 kV XLPE cables in the long and steep slope tunnel. *IEEE Transactions on Power Apparatus and Systems*(12), 3720-3727.
[41] Ergüzel, A. T. (2002). Orta Gerilim Yer Altı Kablolarında Derinligin Akım ve Gerilim Taşıma Kapasitesine Etkisi. *Sakarya Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 6*(2), 7-9.
[42] Metwally, I., Al-Badi, A., & Al Farsi, A. (2013). Factors influencing ampacity and temperature of underground power cables. *Electrical Engineering, 95*(4), 383-392.
[43] Pamuk, N. (2013). Enerji İletim Hatlarının Optimal Güzergah Seçiminde Coğrafi Bilgi Sistemlerinin (CBS) Kullanımı. *Akademik Bilişim*(Akademik Bilişim Konferansı Bildirileri).
[44] Kemp, K. (2007). *Encyclopedia of geographic information science*: SAGE publications.

CURRICULUM VITAE

BARAN YILDIZ

PERSONAL INFORMATION

E-mail :	yildizbar@itu.edu.tr baran.yildiz@teias.gov.tr baranyildiz@mail.com
Address:	Turkey/ İzmir / Bornova
Phone number :	+90 (506) 935 07 63

PERSONAL DETAILS

Experience :	4 Years
Working status:	Still working
Education :	Master student
Marital status:	Not married
Nationality :	Turkey
Born date :	01.11.1989
Driving liecence :	B class (2014)

EXPERIENCES

Turkish Electricity Transmission Corporation Izmir (08.2015- Continuing)

- Detecting the route of Hing-Voltage Transmission Lines, Underground – Electric Transmission Cables and location selecting of transformer center
- Management of As-Built Survey for Electric Transmission Cables and High-Voltage Transmission Lines
- Generating of exprópration maps and their confirmation procedures
- Generating the alignment sheets of High-Voltage Transmission Lines
- Spatial Database Design for Land Acquisition

The General Directorate of State Hydraulic Works (Hatay) 02.2015-08.2015 (6 month)

- Reyhanlı dam ve Büyükkaraçay dam management engineering
- Generating of expropration maps of dams and irrigaion systems
- Generating of Regional site and watershed management plannes
- Computing volume of excavation work for dams and stream reclamation
- Management of As-Built survey for of water treatment plant and dams
- Cut - Fill Calculations

Zend Engineering Company 07.2014-01.2015 (6 month) İstanbul

- Generating of expropration maps, alignment maps, Field application of projects, generating alignment sheets
- As-build survey of pipelines

Dicle Survey Company 07.2012-10.2012 (3 month) Diyarbakır

- Generating contour lined map for tram Project

EDUCATION INFORMATION

Master Degree

İzmir Kâtip Çelebi Üniversity

Institute of Science, Geomatics Engineering, %100 English Education (02.2016-Continuing)

Bachelor's Degree

İstanbul Technical Üniversity (ITÜ)

Civil Engineering Faculty, Geomatics Engineering, %30 English Education (09.2009-06.2014)

LANGUAGES

Competence on a scale of 1 to 5 (1- basic; 5 - excellent)

LANGUAGE	Reading	Speaking	Writing
English	4	4	4
Turkish(native)	5	5	5

SOFTWARE INFORMATION

Microsoft Office Package
Netcad
Autocad
Arcgıs
Qgıs (Quantum Gıs)
Erdas Imagıne

SEMINERS AND WORKSHOPS

Chamber Of Survey And Cadastre Engineers 14. Scientific and Technical Congress 14.05.2014 - 17.05.2014
International Geodetic Students Meeting (Jaén-Spain) IGSO - 22.04.2012 - 28.04.2012
Chamber Of Survey And Cadastre Engineers 13. Scientific and Technical Congress 18.04.2011 - 22.04.2011
PROJETS

Bachelors Thesis Project: An Investıgatıon Of Height Accuracy Which Was Produced From Multıple Data By 3 Dımesıonal Model (Remote Sensing and Photogrammetry)

OTHER INFORMATION

Concerns: Photography, Cycling.