

DOKUZ EYLUL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

**WEB GIS BASED INFRASTRUCTURE
INFORMATION SYSTEM DEVELOPMENT**

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October, 2011
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WEB GIS BASED INFRASTRUCTURE INFORMATION SYSTEM DEVELOPMENT

**A Thesis Submitted to the
Graduate School of the Natural and Applied Sciences of Dokuz Eylül University
In Partial Fulfillment of the Requirements for the Degree of Master of Science in
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**by
Burcu UŞUN**

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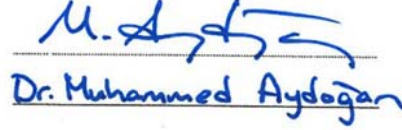
M.Sc THESIS EXAMINATION RESULT FORM

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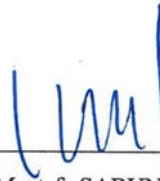
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WEB BASED GIS INFRASTRUCTURE INFORMATION SYSTEM DEVELOPMENT

ABSTRACT

Definitely, universities are the institutions where information flow and share occurs at highest levels. Information related with new buildings and units which are constructed regarded with developments and needs of university are in continuous change. Evaluation, updating and acquiring information from those data is inevitable for institutions development. Therefore formation of systems based on information technologies is very important for universities to serve in modern administration point of view.

As a reflection of transition period of information age; using information technologies for administration of spatial information came into prominence like Geographical information systems. Internet which is the most effective global mass medium brought a new dimension to usage style of spatial information of organizations and mapping applications began to be active on web.

Computer medium is widespread preferred for getting faster information flow in rapid developing world. One part of this preference is performed by Geographical information systems (GIS). GIS is the whole of hardware and software system which have got many features like presenting data, developing models, analyzing, changing, correcting, managing, storing and gathering spatial data in the real world.

GIS based Software has been developed in order that Geographical Information System enables spatial analysis and interrogation. Also, an internet based system in which foreign people can obtain spatial and visual information about campus and departments has been created. Users can reach the information about campus not with any GIS software but with internet scanner. It is aimed that more users can reach the information after study is transferred to the internet.

Keywords: GIS, 3D Modelling, Web

WEB TABANLI COĞRAFI BİLGİ SİSTEMLERİ İLE ALTYAPI BİLGİ SİSTEMLERİNİN GELİŞTİRİLMESİ

ÖZ

Kuşkusuz bilgi akışının ve paylaşımının en yoğun olduğu kurumlardan biri de üniversitelerdir. Üniversitelerdeki gelişmeler ve ihtiyaçlar dikkate alınarak yapılan yeni binalara ve açılan yeni birimlere ait bilgiler ile akademik ve idari personellere ait bilgiler sürekli değişim içindedir. Mevcut bilgilerin değerlendirilip, güncellenmesi ve bunlardan yeni bilgilerin elde edilmesi de bu kurumların gelişimi için kaçınılmazdır. Dolayısı ile üniversitelerin çağdaş yönetim anlayışında hizmet verebilmeleri için, bilgi teknolojisine dayalı sistemleri oluşturmaları oldukça önemlidir.

Bilgi Çağına geçiş sürecinin bir yansıması olarak konumsal bilginin yönetiminde Coğrafi Bilgi Sistemleri gibi bilgi teknolojilerinin kullanımı ön plana çıkmıştır. En etkili küresel iletişim aracı olarak İnternet, organizasyonların konumsal (spatial) bilgiyi kullanma şekline yeni bir boyut getirmiş ve haritacılık uygulamaları web üzerinde etkin olmaya başlamıştır.

Hızla gelişen dünyada daha hızlı bir bilgi akışı için bilgisayar ortamına yönelinmektedir. Bu yönelimin bir parçası da Coğrafi Bilgi Sistemleri (CBS) ile gerçekleşmektedir. CBS, gerçek dünyadaki farklı büyüklükte olan mekansal verileri toplamak, depolamak, yönetmek, düzeltmek, değiştirmek, analiz yapmak, modeller geliştirmek ve elde edilen yeni verileri sunmak gibi bir çok özelliğe sahip bir yazılım ve donanım sistemleri bütünüdür.

Coğrafi Bilgi Sistemi mekânsal analizlere ve sorgulamalara olanak sağladığı için CBS tabanlı bir yazılım geliştirilmiştir. Aynı zamanda kampüse yabancı kişilerin de kampüsün ve içindeki birimlerin konumsal ve görsel bilgilerini edinebilecekleri internet tabanlı bir sistem oluşturulmuştur. Kullanıcılar kampüs ile ilgili istedikleri bilgiye bir CBS yazılımına gereksinim duymadan, sadece internet tarayıcısı ile

ulařabileceklerdir. alıřmanın internete aktarılmasıyla da daha fazla kullanıcıya ulařmak amalanmıřtır.

Anahtar Kelimeler: CBS, 3 Boyutlu Modelleme, Web

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CHAPTER ONE

INTRODUCTION

The importance of spatial data related with social life increased because of developing technology and needs related with this development. Geographical Information System has created new usage areas every passing day from the point that many disciplines need spatial analysis and solve main problems while organizing and managing data. Basic meaning of GIS; is a tool for determining, analyzing, processing, modeling and visualization of spatial information and its relationships.

GIS is the only system which meet the whole functions. Structuring plan of universities, development and best performance of research studies besides education depends on proper and rapid using of current information. Bringing information about universities' current physical situation and essential information for staff and students into use has great importance in order to meet requirements at right time.

Besides acquiring necessary information; since we live in 3D world it is essential to use 3D information in computer medium for presentation and visualization. In current technology; 3D spatial modeling and the opportunity of virtual navigation inside it has great importance for GIS.

By means of modern information technologies, university information systems became a revocable tool for campus universities which they use for several purposes and they are used by more and more universities day by day. According to Yomralioglu(2000), especially campus information systems increases efficiency of education and is whole which is formed data, staff, software and hardware which are brought together for collecting spatial and non spatial information(both academic and administrative) related with university and its sub-units; and after analyzing, storing, questioning, analyzing and transferring into computer of those information and lastly presenting results as both graphically and non graphically reports to the last users. Such an integrated structure can be provided by a geographical information system (GIS) optimally.

In application part of study 3D buildings were drawn by 3D studio max software for providing projects visualization. In other stage; these studies were transferred into ArcScene for spatial analyses and internet web studies were examined for providing more accessibility of campus' spatial information by people.

Since problems occurred during internet publishing via ArcGIS server; 2.5D (isometric) study was done with Adobe Flash Professional CS5. This study was published over internet in next stage.

The application phase of the research was analyzed in three parts. In first part Library and Graduate School of Natural and Applied Sciences buildings which were chosen as application area; were three dimensional modelled with 3D Studio Max software.

In the second part, 3D drawings were transferred to ArcScene environment in which spatial analyze can be done also data can be viewed and managed in 3D environment.

In the third part, An Isometric (2.5d) research was done with Adobe Flash Professional CS5 program because some problems regarding publishing of the research on the internet with ArcGIS Server were emerged. In the next phase, this research was published on the internet.

1.1 Goal of the Research

The goal of this research is the design and development of a data model for management of 3D spatial data and their relationships on a 3D web-based environment.

1.2 Research Objectives

The research objectives are to:

- 1- Investigate current and existing concepts and approaches for web-enabled 3D GIS.
- 2- Design and develop a practical spatial data model for web-orientated 3D geo information in campus environments 3D GIS.
- 3- Develop and implement a prototype system including necessary web-based 3D GIS-Services based on the developed spatial data model and the constructed system architecture.
- 4- Query 3D spatial model for outdoor and also indoor via web.
- 5- Analysis and evaluation of the results of 3D Spatial queries after applying them on the proposed 3D spatial data model.

1.3 Thesis Organization

The aim of this proposal is to introduce the research subject in detail. The thesis is divided into the following chapters.

Chapter 2: Web Based GIS Technology

The second chapter gives detailed information about the Web Based Geographic Information Systems and Internet Technologies. Analysing Internet and webgis architecture, applications and web gis development cycle.

Chapter 3: 3D Modelling

In this Chapter we have explained our designed 3D model along with the architecture of the system developed in this research.

Chapter 4: Case Study

In this chapter it has been determined case study area and design and build the “Interactive Campus Map” application. It is explained step by step in details.

Chapter 5: Conclusion and Future Works

In this chapter summary of the project and telling the benefits of the final throughput applications and dealing with future works for the application and future of Web based GIS band 3D modelling also 3D spatial query.

CHAPTER TWO

WEB BASED GEOGRAPHIC INFORMATION SYSTEM

Nowadays, with the rise and generalized use of web applications and graphical hardware evolution, one of the most interesting problems deals with realistic real-time visualization of virtual environments on web browsers. This project shows an on-line application to dynamically visualize a large campus on the World Wide Web.

The Campus Information System for “Dokuz Eylul University Interactive Campus Map” collects university’s various data consisting of education, management components and topography, land use. “Dokuz Eylul University Interactive Campus Map” is designed and built with usual GIS phases. Web technologies are examined. A web based campus information system has been developed with the using of developing web technologies. By using this system, communication among departments and services started. This system aims to help the university’s image and services with updated data and continuously developing interfaces. The main users including managerial officers, campus planners, personnel, students, other people outside the university can reach this system via Internet.

2.1 GIS on The Internet

The use of Geographical Information System (GIS) and the Internet has changed the way organisations use geographic information. Therefore, GIS is expanding into new industries. Local governments, businesses, utilities, higher education institutes are some examples of industries that have started to implement GIS in daily job routines. [Gonzalez, 2001] University is one of these application areas. They began to comprehend these technologies’ advantages. Web-based programs are being using in facility management, admission, enrollment, campus image and so on today. The role of GIS has also been understood in universities recently. GIS has become more than a program since GIS is a visual and analytical tool and helps the users to understand or visualize this information in a map form and enables the users to manage these information interactively and analytically. This contributes to increase the use of GIS. Therefore, a web based GIS system can be built as a decision making

system in universities. It informs and presents data as a result of answering spatial questions.

The Campus Information System of a university collects graphic and non-graphic data related to university and its sub-departments and then transforms this data to a computer platform, store, query, analyze, present this data to the user with various formats web-based views with the aim of increasing the efficiency and progress of university.

2.2 GIS and Internet Technology

Web-based Geographic Information Systems facilitate the widespread use and dissemination of spatial information and services and promote the technology to a much greater audience than it has ever been introduced before. The utility of the Internet allows information to be exchanged in a rapid and efficient manner, thereby helping individuals make important decisions quicker. The applications running on the Internet, known as the World Wide Web (WWW) give Internet users countless powers for obtaining and disseminating information and services. In the field of Geographic Information Systems, the Internet has played a significant role in the development of new facets of the technology that open many doors for expanding the options for building spatially-enabled web applications. The software developed for building these types of systems varies in terms of cost, efficiency, scalability, robustness, security, support and ease of use.

Creating web applications on the Internet has become a current topic recently. GIS systems have been a platform which is expensive, dependent, and slow. Different approaches depending on web technologies appeared. Because of large amounts of data and map images, the software and data locations are important to create the most optimum system architecture. Various system architecture have appeared on the Internet GIS. Since Internet is an effective solution, departments can use GIS together with web technologies unlock the location components of their data in one centralised place or contributed places such as information departments.

The only text and images could be browsed over the Internet some years ago. HTTP (Hyper Text Transfer Protocol) and CGI (Common Gateway Interface) programming technologies initiated preliminary applications. The first internet mapping application called Xerox PARC Map Viewer (<http://mapweb.parc.xerox.com/map7>) was published in 1994. While Internet technologies are improving, Web based GIS applications continue to develop. New technologies like Java, ActiveX provide alot of new opportunities for web based GIS. A variety of programs which different vendors have created are available nowadays. Web based GIS vision, therefore, is developing on different environments. ESRI (Environmental Systems Research Institute, Inc.) has many products including ArcIMS, MapObject IMS, and so on. These programs work with ArcXML specified XML (eXtensible Markup Language) programming language or use Java-based and Active-X extensions. ArcXML named as ESRI's XML is designed as a protocol data exchange between ArcIMS program components. (ArcIMS Architecture will be explained in application section) Autodesk Inc. uses MapGuide working with a plug-in or an Active-X control. Intergraph Corp. uses Geomedia Web Map working with a plug-in in different formats. MapXsite and MapXtreme produced by MapInfo Corp. are server-side Java products for application development. There are different web based GIS programs developed by different companies. But, these Internet applications generally have different standards, so the sharing of data is impossible. As a result of this, The Open GIS Consortium, Inc. (OGC) (<http://www.ogc.org>) was founded to develop a standardized framework for the interaporability of GIS based services. OGC created The Geography Markup Language (GML). "GML is an XML encoding for the transport and the storage of geographic information, including both the geometry and properties of geographic features." [OGC, 2000]

General working principles have to be explained to understand application components. To illustrate this, in client and server architecture, Client and server communicates across a computer network either on Internet or Intranet by means of a HTTP. It lies in creating software systems that are platform independent and run on open TCP/IP (Transmission Control Protocol/ Internet Protocol) based networks. A

web browser is a usual client program. The browser program sends a request to the server and finally a file is transmitted from the server to the client by means of URL (Uniform Resource Locator). Different strategies having advantages and disadvantages appeared for employing Internet GIS. These are server side, client side strategies or hybrid strategy including the common features of other strategies. [Footh,Kirvan, 1998]

Internet Mapping has many technical advantages. Data can be maintained and be updated in a centralized location or be integrated with many sources on broad spectrum platforms. A web-based map can be used both privately and publicly. Access can be regulated and redundancy eliminated. The end-user software is an easy and cheap web browser, not an expensive and complex GIS program. The web browser provides a much more dynamic map tool than a static map display. System may support various the end users. When people save and publish these data on the Internet, other people can access and browse these data simultaneously. Maps can be copied easily on the Internet and be downloaded for a more detailed use. [Tsou, 2002] As a result of this, GIS on the Web is an inexpensive method for reaching a vast audience.

Web GIS Applications can be used in many different areas. Location services, routing and directing services, electronic atlases, database query, changing phenomena maps, demographic data viewers, environmental condition maps and data distributing sites are some current examples of web based GIS applications.

Recent advances in information technology, including hardware, software and networks, provide potential solutions to the problems of data accessibility. Current advances in computational speed, storage, World Wide Web (WWW) and software provide great opportunities to develop Decision Support Systems (DSS) with the advantage of information dissemination for decision-makers and program integration (Shim et al. 2002).

Web Based GIS provides access to interactive mapping, spatial analysis, and geographic data for many users both inside your organization and on the internet for particular clients. GIS Dynamics can provide complete, customizable online mapping solutions without the high cost of hardware, maintenance or personnel. These solutions can range from simple interactive mapping to complex analysis all on a web based application that is secure and accessible year round and 24 hours a day. GIS Dynamics hosts and monitors all of the applications associated with Web Based GIS.

2.3 Why Use Web Based GIS

Web-based GIS is becoming more and more prevalent as time passes. The following is a brief description of what web-based GIS is about.

The World-Wide-Web (WWW) is a useful tool for the gathering and manipulation. Most information that is available in the world is now available over the Internet. Now much the same is true concerning GIS information.

Where formerly an individual would have to buy an expensive software package to use and manipulate the data needed for GIS, the same is not so today. With the advent of Java based programming, software applications for web-based GIS work are now available. Some of these programs require the user to buy some software, and others require plug-ins to be added to web browsers, but some require no special software additions at all. These use only the capabilities of your existing web browsers.

Because of these advancements, many people who were not able to easily get information they may want or need before can now have it at their fingertips. People who have an interest in gathering information can find it accessible like never before. For the first time, the public can examine the same information as the policy makers, for hands-on examination of GIS material. Talk about citizen involvement.

Another useful facet of using web-based GIS is that the people giving the information are completely in charge of the amount of information made available to the public. If there were privacy issues surrounding certain bit of information, don't make it accessible to others. It is that simple. People cannot use or abuse information that they do not have. With web-based information distribution, you never need to worry about information falling into "the wrong hands".

With Internet connections getting faster and faster, the amount of information that can be transferred over the Internet is staggering. Soon people will be able to examine GIS data while in a foreign country in order to make a purchasing decision on property that he or she has never seen. Analysis of data by a widely scattered group can also be accomplished in a faster, more efficient manner when the information is available almost everywhere in the world.

2.4 Web GIS Technologies

Distributing geospatial information on the Internet is an enforcing factor for information providers. Internet allows all levels of society to access geospatial information, and provides a media for processing geo-related information with no location restrictions. Web-based GIS is evolved from different Web maps and client-server architecture to distributed ones. As such, Internet reshapes all functions of information systems including: gathering, storing, retrieving, analyzing, and visualizing data. The high cost of GIS system, the release of system specific databases, and the enormous software developer efforts on upgrading the system are fading with the introduction of web-based GIS. Moreover, disseminating spatial information on the Internet improves the decision-making processes.

GIS software has enabled users to view spatial data in its proper format. As a result, the interpretation of spatial data has become easy and increasingly simple to understand. Unfortunately, everyone does not have access to GIS, nor would he be able to spend the time necessary to use it efficiently. Web GIS becomes a cheap and easy way of disseminating geospatial data and processing tools. Many organizations are interested to distribute maps and processing tools without time and

location restriction to users. Internet technology has made its way to many government organizations as well as numerous households. The ability to get information through Internet made spatial data providers to explore the Internet resources for disseminating spatial information. To provide a successful web GIS implementation it is required to consider the implementation as a process rather than a step. The implementation should also respect the available technology and the application requirements.

In this paper an overview of the current Web GIS technologies is presented. Available Internet GIS software is compared. A web GIS development cycle has been proposed and tested through publishing Iranian road information.

Development of the Web and expansion of the Internet provide two key capabilities that can greatly help geoscientists. First, the Web allows visual interaction with data. By setting up a Web Server, clients can produce maps. Since the maps and charts are published on the Internet, other clients can view these updates, helping to speed up the evaluation process. Second, because of the near ubiquitous nature of the Internet, the geospatial data can be widely accessible. Clients can work on it from almost any location. Both of these features alters the way geoscientists do their work in the very near future. The combination of easy access to data and visual presentation of it addresses some of the primary difficulties in performing geosciences evaluations (Gillavry, 2000). Web GIS is not without its faults. The primary problem is speed; GIS relies on extensive use of graphics. Connection speeds over the Internet can make heavy use of graphics intolerably slow for users. It will not match the complexity of dedicated GIS programs such as "ArcView & ArcInfo", or "MapInfo" in near future. On the other hand, Web GIS does not require the same resources as these programs. Powerful computers, extensive training, and expensive site licenses are not required for a site wide GIS solution (Strand, 1998).

2.5 Transferred Geo Data

Except attribute data, a decisive question for using GIS in the Internet is the data format (vector or raster), which is used to transfer data to client. For data transmission to the client, map is converted in to no space raster or a suitable vector format. When raster data is transferred, a standard Web browser without extension can be used, since Web browser displays GIF and JPEG. That means the data on the server has to be converted to a raster format. The data volume due to the known image size and the original data on the server is safe as only an image is sent to the client. The disadvantage of using raster data is the lack of comfort of handling and regarding cartographic aspects, like font problem. Moving over an object with mouse cannot highlight single objects. In addition, a server contact is necessary per each request from the client. Because of low vector data volume, it transmits faster than raster. Vector data handled by a standard Web browser with extended functionality (e.g. using plug-ins). The user gets a more functionality with vector data. For example, single objects can be selected directly or highlighted. One more advantage of using vector data is the possibility of local processing; it is not necessary to contact the server per executed browser action. The amount of vector data sent over Web could be three to four times less than the amount of raster data needed for equivalent resolution resulting in faster response time and greater productivity (Nayak, 2000). Disadvantages of vector data are manufacturer dependence, as well as, changing data volume; the amount of data varies with the selected area. To avoid data redundancy in client side, dynamic generalization must be provided. Distributing vector data may also endanger copyright rules. The choice of transferring data form (vector or raster) varies with applications and the existing infrastructures. Software products, which offer optional transferring of vector or raster data, may provide advantages. They may allow a pre-selection with raster data, and afterwards, loading of the actual vector data with the possibility of subsequently local process (Leukert & Reinhardt, 2000). Different consortia are developing future standard formats for transferring data over the Internet. The Open GIS consortium, for example, presents Geography Markup Language (GML). GML shall enable the transport and storage of geographical information in eXtensible Markup Language (XML). Geographic information includes both properties and the geometry of

geographic features (www.opengis.org). The W3C submits Scalable Vector Graphics (SVG), which is a language for describing two dimensional vector and mixed vector/raster graphics in XML (www.w3.org).

2.6 Web GIS Development Cycle

Developing a Web GIS is more than simply buying the appropriate hardware and software. Several strategies have been proposed to provide successful implementation (Alesheikh & Helali 2001). The implementation strategies have been scientifically assessed and modified so that the requirement of the TTO project can be met with minimum cost and time. Figure 6 shows the Web GIS development cycle, which is described in terms of 8 major activities starting with the requirement analysis and ending with on-going use and maintenance of the Web GIS system.



Figure 2.1 Web GIS Development Cycle

2.6.1 Requirement Analysis

While progressing of the GIS project, firstly it is necessary to make a list of the general functions and the functions that are special to the project. The necessary functions are the main visualization functions such as Pan and Zoom, besides them, the developed functions such as the object information, spatial query and the shortest way.

2.6.2 Conceptual Design

At the conceptual design process of the web GIS project, after the requirements are determined, it is necessary to determine how and in which style the result production will be and it is also necessary to decide on which groups will be included and how the service will be provided, at the same time necessary data and data models must be determined. Which architecture will be chosen at the Client/server architecture must also be decided.

2.6.3 Hardware & Software

Deciding on the software is the most significant process while developing a WEBGIS application. Chosen software must be functional, performative and independent from the hardware and operating system. At this application, a big amount of data is downloaded by the users. At the web GIS applications, first of all it is necessary to have a fast internet speed both for the client and the server.

2.6.4 Database Design And Construction

The primary purpose of this phase of the Web GIS development process was to specify "how" the Web GIS performs the required applications. Database design involved defining how graphics files will be structured, how non graphic attribute files will be structured.

2.6.5 Acquisition of GIS Hardware And Software

The designs of the procedures and the physical database can not be defined without choosing a special GIS hardware and software, at the same time this choosing can not be finished without displaying that the GIS project with the chosen GIS hardware and software, has the ability to fulfill the necessary functions of the information. These three activities (design, testing, acquisition) are related to each other with synchronous and feedbacks.

While choosing GIS hardware and software, the scope of gis project and the necessities of it must be taken into consideration. In a GIS program, which needs high scoped information storage, the physical features of the hardware reveal the capabilities of middleware softwares when a large scaled analysis is made.

2.6.6 Web GIS System Integration

At this point in the Web GIS development process the Web GIS hardware and software have been acquired and data conversion is complete. The object of this phase was then to integrate different components of the hardware and software, to test them to make sure they work as expected, and to initiate all procedures necessary to use the GIS.

2.6.7 Application Development

At this process the application is developed by using the programs that are developed and acquired above. There are two processes while developing the application; these are interface design and programming processes. The functions used change in accordance with the complexity of the application. The application must be user friendly.

2.6.8 Web GIS Use And Maintenance

The final step in web GIS implementation was to put the system to use. With system integration and testing completed and all applications available for use, the system was released to users.

2.7 Web GIS Architecture

The internet based interactive map was first presented by XeroxAlto Research Center in 1993. Following this presentation, thenumber of internet based GIS

applications dramatically increased (Su et al., 1999). There are generally two main architectures of these applications: Thin Client and Fat Client (Abel et al., 1998).

In performing the GIS analysis tasks, Web GIS is similar to the client/server typical three-tier architecture. The geoprocessing is breaking down into server-side and client-side tasks. A client typically is a Web browser. The server-side consists of a Web Server, Web GIS software and Database (Figure 2) (Helali, 2001).

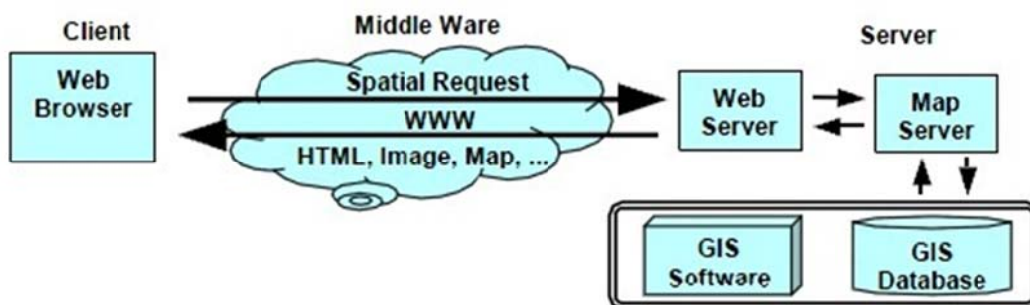


Figure 2.2 How a typical Web GIS model Works

This model of network widely exists within enterprises, in which some computers act as servers and others act as clients. Sever simply have the proprietary GIS running, and add a client interface at the client side and a middleware at the server side to communicate between the client and the proprietary GIS software. Recent development in object oriented programming make it possible to produce software components, and send them to the client before running it in the client machine, such as Java classes, ActiveX components and plug-ins. This comes out to the thick client GIS. The thick-client architecture let the client machine do the most processing works locally. Both thin and thick-client systems have some advantages and drawbacks, but they are not the best solution in terms of taking advantage of network resources.

2.7.1 Thin Client Architecture (Server Side Applications)

The thin client architecture is used in typical architecture. In a thin-client system, the clients only have user interfaces to communicate with the server and display the

results. All the processing is done on the server actually as shown in Figure 2. The server computers usually have more power than the client, and manage the centralized resources. Besides, the main functionality is on the Server side in this architecture there is also the possibility for utility programs at the server side to be linked to the server software. Figure 3 shows schematic communication between Web browser, Web Server and GIS server. On the Web Server side, there are some possibilities to realize the GIS connection to the World Wide Web; CGI Web Server Application Programming Interface (API), Active Server Pages (ASP), Java Server Pages (JSP) and Java-Servlet. The descriptions of the five possibilities mentioned above are in Helali, (2001).

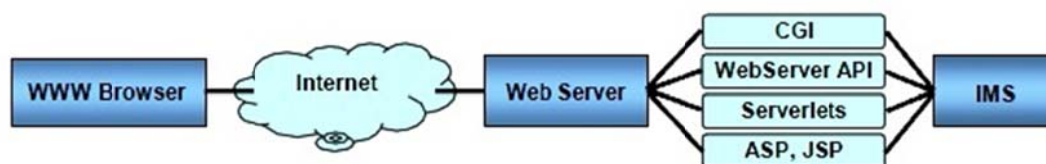


Figure 2.3 Server Side Applications

The user on the client side does not need any knowledge about the linkage of the IMS at the server side, but the system administrator or application developers should be familiar with these techniques. This Architecture used in ESRI ArcView IMS, MapObjects IMS and MapInfo MapXtreme systems.

Major advantages of this model driven form Data Base centralization and are:

- Central control
- Easy for data eminence/updating
- Keep the latest version
- Generally cheaper
- Integration possibilities
- Regarding some cartographic aspects such as font

And disadvantage are:

- o Not responsive to local needs: users have different invokes
- o No local accountability: accountability need application in client side
- o Large data volume (size of the database)
- o Response time slow: users use a browser and it take long time to download new HTML frame

- o Less interactive: in client side there is limited application and browsers abilities
- o Vector data does not appear in client side: browsers without additional plug-in can not read vector files

2.7.2 Thick Client Architecture (Client Side Applications)

In general, a Web browser can handle HTML documents, and embedded raster images in the standard formats. To deal with other data formats like vector data, video clips or music files, the browser's functionality has to be extended. Using exactly the same client server communication in Thin Client architecture, vector files format could not be used. To overcome this problem most browser applications offer a mechanism that allows third tier programs to work together with the browser as a Plug-in. The user interface functionality has progressed from simple document fetching to more interactive applications. This progress is as follows: HTML, CGI, using HTML forms and CGI, Java script to increase user interface capabilities, Java applets to provide client-side functionality. Currently user interface capabilities combined with remote invocations (Figure 4) (Byong-Lyol, 1998).

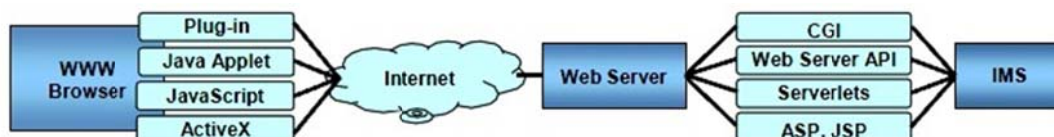


Figure 2.4 Client Side Applications

Major advantages of this model are:

- Document/graphics standards are not required
- Vector data can be used
- Image quality not restricted to GIF and JPEG
- Modern interface is possible; it is not restricted to single-click Operations

And disadvantages to Client Side GIS

- o Nonconformance cans limits
- o User base
- o Users require to obtain additional software
- o Platform/browser are incompatible

2.7.3 Medium Client Architecture

For avoiding vector data in client side and reducing problems of previous architectures, Medium Client is suggested. With using extensions in both client and server side, clients may have more functionality than Thin client architecture. In Figure 5 these four components in interactive map are pictured as services, each with interfaces, which can be invoked by clients of that service.

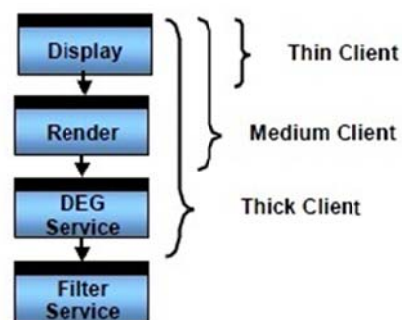


Figure 2.5 Medium Client position in Open GIS point of view

In other words, if a user's computer contains just the display service, then that user would be said to be using a thin client. If the user's computer additionally contained a render service, then that user would be said to be using a medium client. And finally, if the user's computer also contained the display element generator service that would indicate the user is using a thick client. After some consideration, it was decided that while this distinction may be somewhat helpful in describing web mapping, the terms "thick client" and "thin client" were already encumbered by very imprecise definitions used in marketing literature and were therefore not suitable for continued use in some cases (Doyle, 1999)

2.7.4 Distributed Architecture

Recent developments in information technology have resulted in a number of distributed object architectures that provide the framework required for building distributed applications. The framework also supports a large number of servers and applications running concurrently. Many of such frameworks provide natural

mechanism for interoperability (Kafatos,1999). For example, Distributed Component Object Model architecture in windows platform and Java Remote Method Invocation (RMI) in Java Virtual Machine (JVM) are the most popular protocols that are used in different cases. These architectures may be applied to GIS to improve the traditional client/server GIS model and develop scalable distributed GIS model. Some attempts have been made in the academic area (Zhang, 1998). The general idea of the distributed GIS service model is that a client program, in either an Internet browser or an independent application, should be able to access the resources distributed in the entire network. The resources here refer to both geodata and geoprocessing components available in the network. The client and the server in this context do not refer to a specific machine. Any machine, when it requests the remote resources during the processing, is a client, and any machine that provides such resources is a server. In a specific program, a client may connect to several servers if needed and a specific machine may be the client at one time and the server at another time. An ideal distributed GIS service model should be a "geodata anywhere, geoprocessing anywhere" model, which means the geodata and geoprocessing tools could be distributed with the largest flexibility virtually anywhere in the network. The geodata and geoprocessing components do not have to be in the same site, but they should be able to cooperate or integrate whenever they are needed to finish a specific task (Yuan, 2000).

2.8 Client-Server Architectures for GIS

We have already discussed the basic client-server model, involving an exchange between a single client application and a single server. This simple picture, however, belies the complex structure that distributed systems can exhibit. For example, a client requesting a service from another application could simultaneously act as a server for a third application.

In this section we explore various structures that might be applicable for model integration with GIS.

2.8.1 Basic GIS Client-Server Architecture

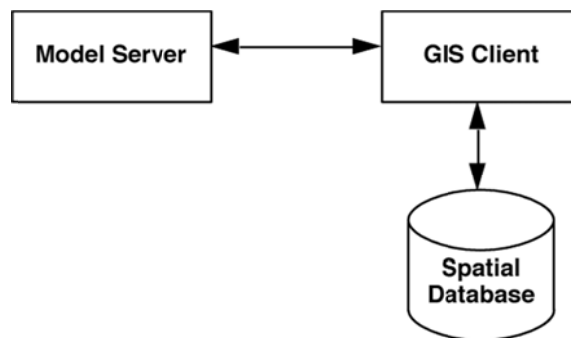


Figure 2.6 Basic GIS Client-Server Architecture

Using the simple client-server model introduced earlier, one can construct a system similar to that shown in Figure 2, whereby a modelling package is linked using IAC to the GIS. Clearly an essential requirement for a GIS to be used in this way is that it must be IAC-capable. As several off-the-shelf systems have this capability this is not a problem. Data representation is also an issue for which there are two possible solutions. Either the model server must be able to read the raw GIS data or the data must be converted to the appropriate format from within the GIS. The latter can only be adequately handled by a macro language.

The final task is that of integrating the user interfaces and providing execution control to the user. This would involve selecting the appropriate data within the GIS and choosing the type of model to run before performing the analysis. This task would also be carried out through a macro language. At the request of the user, the appropriate macro subroutines are executed, which extract the required data from the spatial database and send them to the model server, where the data are processed and returned to the subroutine for display.

The chief advantage of this arrangement is its simplicity. A certain degree of flexibility is achieved through the use of the built-in macro language and, additionally, it is quite possible for several types of GIS to integrate with the same model server provided the data conversion is done from within the GIS.

We have built an experimental Macintosh-based application for spatio-temporal analysis using the above arrangement. The *GeoAnalyser* system is composed of two

components, *GeoClient* and *GeoServer*. *GeoClient* is responsible for data management and display of spatial information. The display options include thematic maps, data tables (from where the data may be altered manually) and time series graphs. Movies may also be displayed to show the time evolution of spatial variables plotted on a thematic map. Besides stepping forwards and backwards in time over the supplied data, the user is also presented with the facility to project *forwards* in time using a spatial model based on the nonlinear logistic growth equation. This modelling component is contained within *GeoServer*. *GeoClient* also contains a Genetic Algorithm to optimise the model parameters for a particular set of data.

Upon initialisation, *GeoClient* requests the user to identify the server application (which must be running somewhere on the network) and it then dispatches the necessary data to that *GeoServer*. When a model run is requested, *GeoClient* sends the appropriate message and model parameters to *GeoServer* and the newly generated set of spatial data is returned to *GeoClient* for displaying. Except for the initial stage where the server application must be specified the entire process is completely transparent to the user since the modelling interface is contained wholly within *GeoClient*.

2.9 Web Mapping Technologies

The potential number of technologies to implement web mapping projects is almost infinite. Any programming environment, programming language and serverside framework can be used to implement web mapping projects. In any case, both server and client side technologies have to be used. Following is a list of potential and popular server and client side technologies utilized for web mapping.

2.9.1 Server Side Technologies

- **Web server** – The webserver is responsible for handling http requests by web browsers and other user agents. In the simplest case they serve static files, such as HTML pages or static image files. Web servers also handle authentication, content negotiation, server side includes, URL rewriting and forward requests to

dynamic resources, such as CGI applications or serverside scripting languages. The functionality of a webserver can usually be enhanced using modules or extensions. The most popular web server is Apache, followed by Microsoft Internet Information Server and others.

- **CGI (common gateway interface)** applications are executables running on the webserver under the environment and user permissions of the webserver user. They may be written in any programming language (compiled) or scripting language (e.g. perl). A CGI application implements the common gateway interface protocol, processes the information sent by the client, does whatever the application should do and sends the result back in a web-readable form to the client. As an example a web browser may send a request to a CGI application for getting a web map with a certain map extent, styling and map layer combination. The result is an image format, e.g. JPEG, PNG or SVG. For performance enhancements one can also install CGI applications such as FastCGI. This loads the application after the web server is started and keeps the application in memory, eliminating the need to spawn a separate process each time a request is being made.
- Alternatively, one can use **scripting languages built into the webserver** as a module, such as PHP, Perl, Python, ASP, Ruby, etc. If built into the web server as a module, the scripting engine is already loaded and doesn't have to be loaded each time a request is being made.
- **Web application servers** are middleware which connects various software components with the web server and a programming language. As an example, a web application server can enable the communication between the API of a GIS and the webserver, a spatial database or other proprietary applications. Typical web application servers are written in Java, C, C++, C# or other scripting languages. Web application servers are also useful when developing complex realtime web mapping applications or Web GIS.
- **Spatial databases** are usually object relational databases enhanced with geographic data types, methods and properties. They are necessary whenever a web mapping application has to deal with dynamic data (that changes frequently) or with huge amount of geographic data. Spatial databases allow spatial queries,

sub selects, reprojections, geometry manipulations and offer various import and export formats. A popular example for an open source spatial database is PostGIS. MySQL also implements some spatial features, although not as mature as PostGIS. Commercial alternatives are Oracle Spatial or spatial extensions of Microsoft SQL Server and IBM DB2. The OGC Simple Features for SQL Specification is a standard geometry data model and operator set for spatial databases. Most spatial databases implement this OGC standard.

- **WMS server** are specialized web mapping servers implemented as a CGI application, Java Servlet or other web application server. They either work as a standalone web server or in collaboration with existing web servers or web application servers (the general case). WMS Servers can generate maps on request, using parameters, such as map layer order, styling/symbolization, map extent, data format, projection, etc. The OGC Consortium defined the WMS standard to define the map requests and return data formats. Typical image formats for the map result are PNG, JPEG, GIF or SVG. There are open source WMS Servers such as UMN Mapserver and Mapnik. Commercial alternatives exist from most commercial GIS vendors, such as ESRI ArcIMS, ArcGIS Server, GeoClip, Intergraph Geomedia WebMap, and others.

2.9.2 Client Side Technologies

- **Web browser** – In the simplest setup, only a web browser is required. All modern web browsers support the display of HTML and raster images (JPEG, PNG and GIF format). Some solutions require additional plugins (see below).
 - **ECMAScript support** – ECMAScript is the standardized version of JavaScript. It is necessary to implement client side interaction, refactoring of the DOM of a webpage and for doing network requests. ECMAScript is currently part of any modern web browser.
 - **Events support** – Various events are necessary to implement interactive client side maps. Events can trigger script execution or SMIL operations. We distinguish between:
 - **Mouse events** (mousedown, mouseup, mouseover, mousemove, click)
 - **Keyboard events** (keydown, keypress, keyup)

- **State events** (load, unload, abort, error)
- **Mutation events** (reacts on modifications of the DOM tree, e.g. DOMNodeInserted)
- **SMIL animation events** (reacts on different states in SMIL animation, beginEvent, endEvent, repeatEvent)
- **UI events** (focusin, focusout, activate)
- **SVG specific events** (SVGZoom, SVGScroll, SVGResize)
- **Network requests** – This is necessary to load additional data and content into a web page. Most modern browsers provide the XMLHttpRequest object which allows for get and post http requests and provides some feedback on the data loading state. The data received can be processed by ECMAScript and can be included into the current DOM tree of the web page / web map. SVG user agents alternatively provide the getURL() and postURL() methods for network requests. It is recommended to test for the existence of a network request method and provide alternatives if one method isn't present. As an example, a wrapper function could handle the network requests and test whether XMLHttpRequests or getURL() or alternative methods are available and choose the best one available. These network requests are also known under the term Ajax.
- **DOM support** – The Document Object Model provides a language independent API for the manipulation of the document tree of the webpage. It exposes properties of the individual nodes of the document tree, allows to insert new nodes, delete nodes, reorder nodes and change existing nodes. DOM support is included in any modern web browser. DOM support together with scripting is also known as DHTML or Dynamic HTML. Google Maps and many other web mapping sites use a combination of DHTML, Ajax, SVG and VML.
- **SVG support or SVG image support** – SVG is the abbreviation of "Scalable Vector Graphics" and integrates vector graphics, raster graphics and text. SVG also supports animation, internationalization, interactivity, scripting and XML based extension mechanisms. SVG is a huge step forward when it comes to delivering high quality, interactive maps. At the time of

writing (2007–01), SVG is natively supported in Mozilla/Firefox >version 1.5, Opera >version 9 and the developer version of Safari/Webkit. Internet Explorer users still need the Adobe SVG viewer plugin provided by Adobe. For a German book on web mapping with SVG see^[17] and for an English paper on SVG mapping see.^[18]

- **Java support** – some browsers still provide old versions of the Java virtual machine. An alternative is the use of the Sun Java Plugin. Java is a full featured programming language that can be used to create very sophisticated and interactive web maps. The Java2D and Java3D libraries provide 2d and 3d vector graphics support. The creation of Java based web maps requires a lot of programming know how. Adrian Herzog discusses the use of Java applets for the presentation of interactive choroplethe and cartogram maps.
- **Web browser plugins**
 - **Adobe Acrobat** – provides vector graphics and high quality printing support. Allows toggling of map layers, hyper links, multimedia embedding, some basic interactivity and scripting (ECMAScript).
 - **Adobe Flash** – provides vector graphics, animation and multimedia support. Allows the creation of sophisticated interactive maps, as with Java and SVG. Features a programming language (ActionScript) which is similar to ECMAScript. Supports Audio and Video.
 - **Apple Quicktime** – Adds support for additional image formats, video, audio and Quicktime VR (Panorama Images). Only available to Mac OS X and Windows.
 - **Adobe SVG viewer** – provide SVG 1.0 support for web browsers, only required for Internet Explorer Users, because it doesn't yet natively support SVG. The Adobe SVG viewer isn't developed any further and only fills the gap until Internet Explorer gains native SVG support.
 - **Sun Java plugin** provides support for newer and advanced Java Features.

2.10 Web Mapping for GIS

The terms Internet GIS and Internet Mapping are defined after the definition of the base terms as Information Technologies, Geographic Information Technologies, Information Systems, GIS, and Internet Maps. A parallel between GIS and Internet GIS is done and the differences are indicated.

The Internet Maps are investigated. They are classified at two levels: the first level consists of static and dynamic maps and the second level contains non-interactive maps and interactive maps.

2.10.1 Definition and Technical Realization

To give a definition and description of the terms Internet GIS and Internet Mapping it is necessary to define some related basic terms as Information Technologies, Geographic Information Technologies, Information Systems, GIS, Internet Maps.

The term **Information Technologies** is a sum of terms itself. The information technologies are “technologies for collating, saving, processing, transferring and presenting of information in different forms”. What concrete belongs to the term Information Technologies modifies in time as new necessities and requirements appear which leads to development of new products and services. **Geographic Information Technologies (GIT)** is part of information technologies that treats space related information. Geomatic and Geoinformatic are applied with such meaning as Geographic Information Technologies. Many classic geographic related sciences and technologies have connection with GIT, for example:

- ⌚ Surveying
- ⌚ Cartography
- ⌚ Photogrammetry
- ⌚ Remote Sensing
- ⌚ Geographic Information Systems

- ⌚ Geostatistic
- ⌚ etc.

The term **Information System** can be defined as a system of humans, machinery and methods which target is to collate, proceed, analyze and spread information. The information system consists of data, hardware, software and users.

Geographic Information Systems (GIS): Geographic Information Systems are automated systems that support, collate, manage, analyze modulate and visualize space related data for the solution of different problems. The conclusion, after thus defined basic terms, is that Internet GIS can be examined as an addition to ordinary GIS that uses Internet for providing access to GIS.

Internet Maps: Essentially each map which is accessible via Internet can be named Internet map including from ordinary scanned maps to such that offer different GIS functions.

Therefore:

Internet GIS: are Internet based systems and services which have the task of saving, analyzing and visualizing space related data. It has functions of ordinary GIS but the access to it is via internet.

Internet Mapping: Creation, dissemination and use of maps via Internet is named Internet mapping.

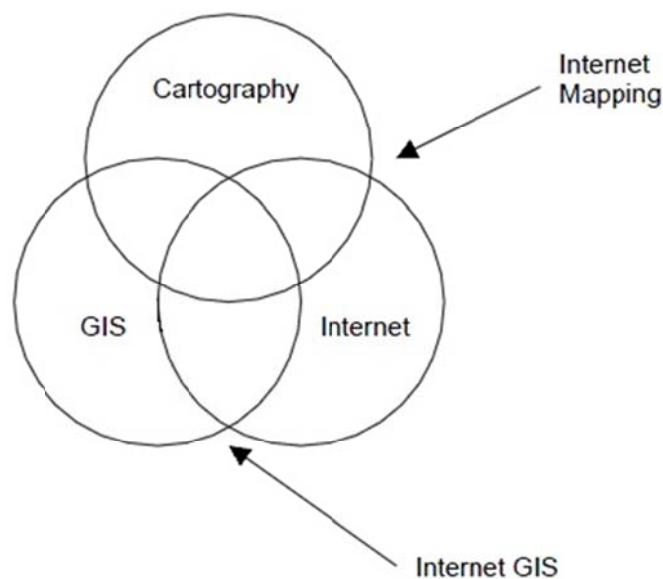


Figure 2.7 Cartography, GIS, Internet

The main differences between desktop GIS and Internet GIS are explained in the model of realization. GIS are usually monolith structures, which integrate all necessary functions, opposite to Internet GIS, where different elements – the interface, the application for processing and the data base are shared between several machines, the so called - client-server structure.

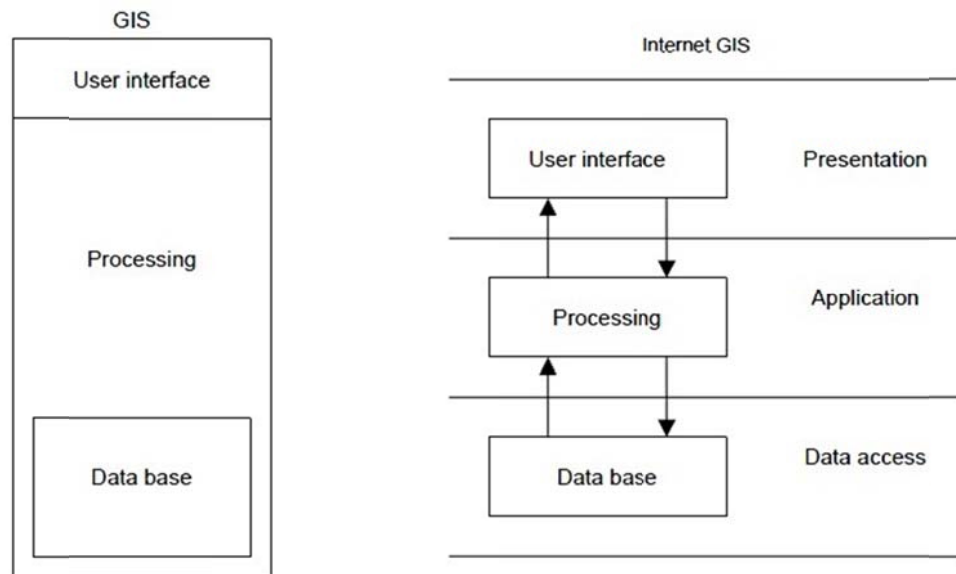


Figure 2.8 Comparison between GIS and Internet GIS

The concept of client-server structure includes a division of the given application into tasks dispensed between the client and the server. An application based on this idea consists usually of three main parts – a client, a server and a network for communication. Each one of these elements consists of certain software and hardware.

In most cases Internet GIS have client-server structure in which standard GIS software is installed on the server and in addition user client interface and communication protocol. In general currency architecture of Internet GIS includes also a separate map server. The map server is every server with installed software for processing of queries for maps. For example an architecture of Internet GIS is presented on Figure 2.9.

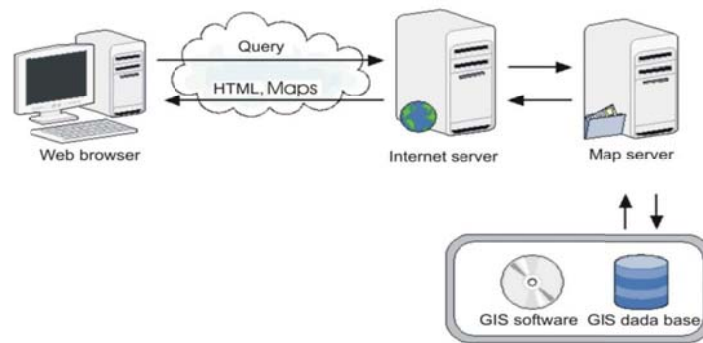


Figure 2.9 Traditional structure of Internet GIS

2.10.2 Interactive Web Maps

There are several technology levels to publish map data on the Web, ranging from sites that simply publish static Web maps to more sophisticated sites which support dynamic maps, interactively customized maps and multiple computer platforms and operating systems. In terms of Web GIS, the most challenging map is the interactive one. Within the Open GIS Consortium, a Special Interest Group (SIG) for WWW Mapping is working on issues of Web-based GIS publishing. This group has recently developed an essential model of interactive portrayal.

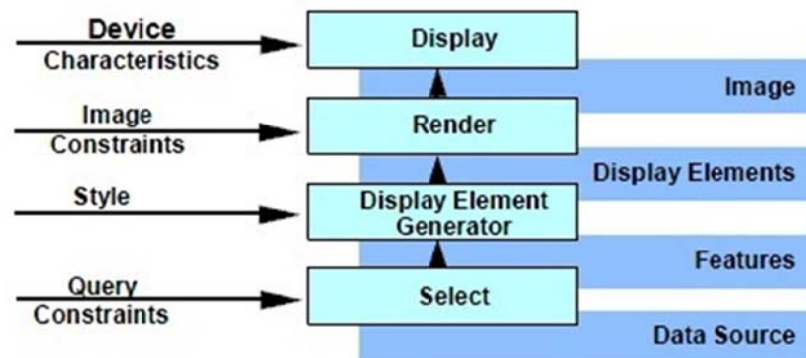


Figure 2.10 OpenGIS model of portrayal workflow (Doyle, 1999)

This model is a very useful tool to analyze and compare different architectures for Internet Map Servers and other Internet based GIS applications. Moreover, it is more precise than the common expression, which often leads to misunderstandings. The interactive portrayal model has four tiers:

- The Selection process retrieves data from a geospatial data source according to query constraints such as a search area or thematic selections

- The Display Element Generator process turns the selected geospatial data into a sequence of display elements. It attaches styles such as symbols, line styles, fill styles to spatial features, generates annotation from alphanumeric attributes, sorts the display elements in a certain order and does other graphical processing
- The Render takes the display elements and generates a rendered map. Examples of rendered maps are In-memory display lists, GIF-files or postscript files
- The Display process makes the rendered map visible to the user on a suitable display device

Between these four tiers, there are three different types of data:

- Features and coverage's (e.g. raster data) retrieved from the Selection process
- Display elements generated from the Display Element Generator
- Images produced by the Render

The next capability for interactive Web maps is to allow users to add new themes to the map from a catalog of available data sources. This can be accomplished by specifying the entire theme, or by querying the spatial or attribute data and returning all those features that satisfy the query criteria (Strand, 1998). When maps are comprised of multiple themes, each theme being displayed as a graphical layer in the map image, the displayed map can become too complex to be of value, unless users are allowed to select which themes are displayed.

2.10.3 Internet Map Servers

Internet Map Server (IMS) applications allow GIS database custodians to easily make their spatial data accessible through a web browser interface to end-users. High-speed corporate intranets make an ideal network for distributing data in this manner, given the fact that bandwidth requirements can be high. Making data available to the entire world is certainly feasible and any organization that has a public website can certainly add an IMS without opening up too many additional security holes.

For a working IMS, software requires two components to function. A geospatial data processing engine that runs on the server side as a service, Servlet or Common Gateway Interface (CGI) application, and processes the raw spatial data into a map and a standard web server that manages the incoming requests and replies with the proper map data back to the client side browser or application window. The end product is either a JPEG or GIF image or vector, which is transmitted back to the client browser or a stream of data that is interpreted by a plug-in to the client browser. IMS that transmit back an image have a limited capability that does not extend much beyond pan, zoom, and basic vector attribute query. The feature streaming IMS requires a downloadable plug-in, but allows for advanced buffer, query, labeling and sub setting operations to be performed. Some IMS sites offer both a plug-in and a simple HTML version, which is nice for plug-in weary surfers. An overview of the eight most commonly used Internet Map Servers is provided in Table 2.1.

Table 2.1 Selected internet map servers

Internet Map Server	Transferred Geo data	Platform of IMS	Browser Extension	Data Interface
ArcView IMS 1.0a (ESRI)	Raster	UNIX, WIN 9X, NT	Html, Applet	Shapefiles, Coverage's, SDE Layer, ...
MapObjects IMS 2.0 (ESRI)	Raster	WIN 9X, NT	Html, Applet	Shapefiles, Coverage's, SDE Layer, ...
Arc IMS 3.1 (ESRI)	Raster, Vector, (Internal ESRI formats)	WIN 98,NT	Html, Applet	Shapefiles, Coverage's, SDE Layer, ...
MapXtreme NT Ver 2.0 (MapInfo)	Raster	WIN NT	Html, Applet	MapInfo format map, Shapefiles, SDE Layer, Raster format
MapXtreme Java Ver 2.0 (MapInfo)	Raster, Vector	WIN NT, UNIX, ...	Applet	
MapGuide 4.0 (AutoDesk)	Raster, Vector	WIN NT	Plug-in, ActiveX, Applet	DWG, DXF, DGN, Shapefiles, Coverage's, MapInfo...
GeoMedia Web Map / Enterprise 3.0 (Intergraph)	Raster, Vector	WIN NT	Plug-in, ActiveX	MGE, Shapefiles, Coverage's, MapInfo, Oracle, Access, ...
Map Server 3.5 (Minnesota DNR)	Raster, Vector	WIN 9X, NT WIN 2K	Html, Applet	Shapefiles, SDE Layer, Raster format

In the Internet Map Servers product suite contains: IMS as out-of-the-box but customizable and expandable tool or IMS as development environment. When deciding for IMS, one should pay attention to the offered data interface to use existing geodata without problems.

2.10.3.1 Static and dynamic maps in internet

Opposite to the conventional maps, the digital maps can be changed dynamically as an answer to different interactive operations. Using appropriate design of such operations the expressiveness of maps can be raised vastly. The possibilities for interaction with maps or with its elements are from simple graphic transformation to date base access or use of different tools for analysis.

The first level of classification splits Internet maps in static and dynamic, the second level – each of these kinds is divided into maps for examination only and interactive maps. The maps for examination can't be changed, whereas the interactive ones offer some opportunities for interaction and changes of the map.

2.10.3.2 Static maps

The static maps are functionally and conceptually similar to the paper maps. In most cases they are regular maps, scanned in GIF or JPEG format saved as static raster images, but they can be also vector images. Usually they do not offer any interactivity but are very suitable for preservation and offering some rare historical maps to the general public, for example. There are possibilities for giving some function of this kind of static maps, for example zoom function, but for this purpose we need a number of static images of the maps in different scales. The scaling (Zoom) and moving (Pan) however are not considered as interactive functions because a similar action can be done with the regular maps. For example a map can be examined at hand or from distance. This type of maps is easy for realization and this is the reason for its participation from the beginning of Internet.

2.10.3.3 Static interactive maps

They are similar to the static maps but offer some kind of interactive level. The most widespread types of static interactive maps are images with defined different active areas that are connected to related information given in different formats.

2.10.3.4 Dynamic maps for examination only

The dynamic maps are created individually for each map request and they differ from one another. They are created on the map server that processes the request and makes the needed map.

The map is generated in raster image format (for example GIF or JPEG format) and is sent to the user. There are two main advantages. From one side the user can always receive actual maps and from the other side he cannot consider explicit software for its examination. The disadvantages are that the interactivity in the dynamic maps for examination is missing and every time when the view is changed (zoom or pan) it is necessary lots of information to be transferred in Internet. In other words, the user has to connect the map server every time for the generation of a new map.

2.10.3.5 Dynamic interactive maps

The dynamic interactive maps are generated in a similar way as described above but here it is possible to change the content of already generated map. They offer high level of GIS functionality especially concerning management and analysis of information – they give an opportunity for using, analyzing and exploring of any kind of space information and support the user in determination of the content and design of the map elements.

CHAPTER THREE

3D MODELLING

3.1 General Information About 3D Modelling

Nowadays, spatial modelling has mainly used 2D GIS. In applications like architecture or urban planning, data are defined in a 3D space. However, there are few spatial models suitable to the specificity of 3D geographical data. Such models describe geographical environment, where objects are contiguous and are of different nature (lines, surfaces or volumes). Connections between objects –also called topological relationships-, like adjacency or intersection, gives an abstraction of global organization of spatial objects. For this reason, topological models are the most prevalent in 2D GIS. Some authors have defined 3D topological models, but if those models are well adapted to CAD applications, they do not allow for the specificity of geographical data. Adjacency can be specified by horizontal or vertical direction. Hence, an object may be close to its neighbours, while in the vertical direction one object may support another one. This reflection led us to define a pragmatic topological model to describe object connections, independently of their nature.

Most commercial GIS products only support 2D data and 2D processings, even if they sometimes offer restricted extensions to 3D (as the visualization of stereo images or of Digital Terrain Models). A 3D GIS should provide a support for creating, analyzing and processing 3D geographical data. This should be based on a model of these data. Therefore, to define a 3D spatial data model, we study connected areas such as geometrical modelling and 3D CAD. However, the geographical world presents some particularities and an adequate modelling has to be defined.

Spatial information system or GIS deals with spatial data collection, processing, manipulation, databasing, and visualization as well as the derived information. GIS evolves from spatial data of 2D to 2.5D data type. Today, more and more advanced

applications requires more functionality from such spatial system, e.g. applications in advanced urban planning, geology, oil and minerals exploration, and underground mapping including utility mapping. Present commercial systems are hardly able to offer solutions for advanced analysis like 3D spatial analysis. This project describes some efforts towards the realization of 3D GIS and what needs to be done for next generation GIS. And also also highlights some of the issues and problems associated in developing such advanced GIS system. The findings of research in this problem domain reveal an exciting new paradigm for next generation of GIS software and system, beyond 3D domain.

3.2 N-Dimensional Modelling

Until today, GIS remain one of the exciting tools to manipulate geospatial data. Systems offered by various vendors are growing in terms of functionalities and all of these systems are basically two-dimensional (2D) based and at the most just able to manipulate another data layer like contours or heights to the existing datasets or layers. Having this system around means we have 2.5D based GIS. Now, GIS users are getting more complex datasets and need to manipulate these datasets and generate information as we perceived in the real world, i.e. in 3D environment. This environment provides much better understanding of the geospatial pattern and phenomena, either in small or large scale areas. The aim of this paper is to examine the current GIS software developments and some research efforts towards realizing the new breed of GIS systems or software that able to provide 3D spatial information. This paper also attempts to look further on the possibility of extending the current spatial data modeling techniques to 4D and beyond, n-dimensional (nD).

3.2.1 Two-Dimensional (2D) GIS

In general, most of the spatial data modeling engine of any GIS software is based on spatial primitives of points, lines, and surfaces or polygons. The modeling technique is quite straight forward where the notation, convention and the formalism mechanisms are fully understood by many GIS users and software developers. It is

not the intention of this paper to describe those 2D modeling formalisms since they have been solved and fully developed. Tremendous efforts have been done and the 2D systems are being utilized and implemented in various GIS applications. The systems are being well received by the GIS community as a whole.

3.2.2 Two and a Half-Dimensional (2.5D) GIS

This is an extension of the system discussed in the preceding section that is by adding height to the existing datasets such as height data from contours, heights from photogrammetric workstation or any other acquisition techniques like GPS or Lidar data acquisition system. At the moment some GIS software offers surface data manipulation module as part of the typical GIS modules or programs. The module is just to manipulate heights and do some surface analysis like contouring, slope and aspect and other computations on top of the typical 2D data layers. The author considers 2.5D GIS is the starting point that one should consider in developing such 3D system. The modeling component is very interesting to look at. Many research efforts have been done in this spatial data modeling domain such as Molenaar (1991), Pilouk (1996), Zlatanova, and Peng (1997). Molenaar proposed a Formal Data Structure (FDS) to link between various primitives as illustrated in Figure 3.1. The basic relationships of object primitives is quite clear and could be utilized to certain extent but not quite suitable for GIS data with heights as we have in digital terrain model (DTM). The model then has been modified by Pilouk (1996) for a spatial system as we called it a 2.5D GIS. As a result, several GIS software or systems are based on this model. Manipulation of terrain data together with other features is now possible by using the 2.5D data model.

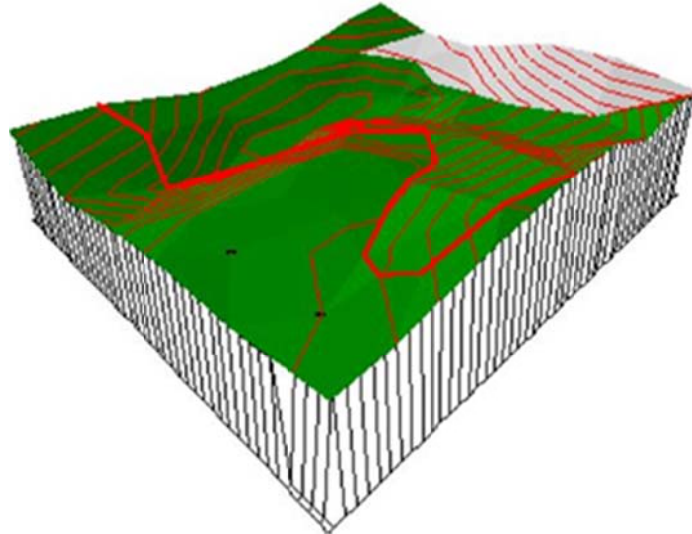


Figure 3.1 2.5D data model (Courtesy of Pilouk)

3.2.3 Three-Dimensional (3D) GIS

It is interesting to note that the Molenaar's data model could be extended for 3D GIS software development. Several researchers like Zlatanova (2000) and Abdul-Rahman (2000) have utilized the model for manipulating 3D spatial objects in their works. The development of 3D GIS is growing and many works are being done in several research centers and universities as indicated by Abdul-Rahman (2006).

3.2.3.1 Beyond 3D GIS

The researchers believe that one day GIS will have a true 3D GIS in near future. This is based on the current pace of research efforts that being done in various centers and universities in some parts of the globe. Current trends clearly show that GIS users demand more than the current technology could offer. Here, future users would like to have information of a particular object in a certain regions or areas in a split of seconds, very accurate, and easy to access either standalone or Web/Internet solution (Hunter and Tao, 2002). Although theoretically, the spatial modeling of objects could be extended to multi-dimensional (nD), the computing visualization systems only permit up to 3D environment. This section attempts to highlight some possible research works that could lead to the "future" GIS or ubiquitous GIS. The author believe that this is the future trend of GIS where every component in GIS like

data collection, data manipulation, databasing, and reporting (and visualization) were done seamlessly and they are highly dependent on mobile computing environment. We have seen several research groups are working on this direction e.g. GeoICT Lab, York University, Toronto, Canada; GIS Section at TU Delft, The Netherlands, and Fraunhofer Institute (IGD), Darmstadt, Germany. This newly established research initiative in GIS focuses on components integration and mobile, thus the system could end up in small size with some intelligence-built in components. The following figure shows basic configuration for the ubiquitous geospatial system. In general, voice sensor, small display, small power unit, precise location finder (like GPS or Galileo), wireless communication system, and equipped with compact size computer could be parts of the whole system.

3.3 Why does 3D GIS Matter?

Next generation of Geo Information System (GIS) requires a new way of spatial data modelling. We call the next generation of GIS 3D GIS. Fundamentally, a new digital model has to be developed or established. Exploiting digital computing technology to improve the quality of life, or to prevent or mitigate hazards or disasters, would first require the construction of a model in digital form of the part of the earth and its environment.

Geographical Information Systems (GISs) represent a powerful tool for capturing, storing, manipulating, and analysing geographic data. This tool is being used by various geo-related professionals, such as surveyors, cartographers, photogrammetrists, civil engineers, physical planners (urban and rural), rural and urban developers, geologists, etc. They use the tool for analysing, interpreting, and representing the real world and understanding the behaviour of the spatial phenomena under their respective jurisdictions. Almost all of the systems used by the geoinformation community to date are based on two-dimensional (2D) or two-and a half-dimensional (2.5D) spatial data. In other words, one may find difficulty processing and manipulating spatial data of greater dimension than 2 in the existing systems, resulting in inaccurate or at least very incomplete information. Furthermore,

manipulating and representing real world objects in 2D GIS with relational databases are no longer adequate because new applications demand and increasingly deal with more complex hierarchical spatial data. The limitations of the current 2D GISs, especially in geoscience, have been reported in the literature by Jones (1989), Raper and Kelk (1991), Rongxing Li (1994), Houlding (1994), Bonham-Carter (1996), and Wei Guo (1996). The limitations mentioned relate to data dimensionality and data structures. Single valued z-coordinate data such as a point (x, y coordinates) with the z-coordinate representing height presents no data handling difficulty in such systems, but it is inadequate for data with multiple z-values (Bonham-Carter, 1996; Raper and Kelk, 1991) such as ore bodies and other important three-dimensional real world entities. A major impediment to establishing 3D GISs is associated with inappropriate spatial data structures, as reported in Jones (1989) and Rongxing Li (1994). These two authors have proposed voxel data structures for 3D data as a solution to the data structuring problem, but no real operational system was developed based on the structure. The problem was also highlighted in the geological field by Houlding (1994). True representations and spatial information, for example sub-surface 3D objects, could not be successfully achieved with 2D systems. 3D visualisation tools alone (for example Advanced Visualization System (AVS), Voxel Analyst of Intergraph, and other Digital Terrain Model (DTM) packages) were not able to truly manage such data as demanded. For example Wei Guo (1996) experimented with the 3D modelling of buildings by using Molenaar's (1992) formal data structure in the relational database environment together with Auto-Cad as a 3D visualization tool; AutoCad was used to generate the building models. In the literature, a common suggestion has been that the existing GISs were able to handle most of the 2D spatial data, but had difficulty in handling 3D spatial data and beyond, therefore, an extension of the existing than previously supported by the relational model. It has been suggested in the literature that the abstraction of complex spatial data could be handled more effectively in object-oriented rather than in relational database environment (Egenhofer and Frank, 1989; Worboys, 1995).

The limitations of the current 2D GISs, especially in geoscience, have been reported in the literature by Jones (1989), Raper and Kelk (1991), Rongxing Li

(1994), Houlding (1994), Bonham-Carter (1996), and Wei Guo (1996). The limitations mentioned relate to data dimensionality and data structures. Single valued z-coordinate data such as a point (x, y coordinates) with the z-coordinate representing height presents no data handling difficulty in such systems, but it is inadequate for data with multiple zvalues (Bonham-Carter, 1996; Raper and Kelk, 1991) such as ore bodies and other important three-dimensional real world entities. A major impediment to establishing 3D GISs is associated with inappropriate spatial data structures, as reported in Jones (1989) and Rongxing Li (1994). These two authors have proposed voxel data structures for 3D data as a solution to the data structuring problem, but no real operational system was developed based on the structure. The problem was also highlighted in the geological field by Houlding (1994). True representations and spatial information, for example sub-surface 3D objects, could not be successfully achieved with 2D systems. 3D visualisation tools alone (for example Advanced Visualization System (AVS), Voxel Analyst of Intergraph, and other Digital Terrain Model (DTM) packages) were not able to truly manage such data as demanded. For example Wei Guo (1996) experimented with the 3D modelling of buildings by using Molenaar's (1992) formal data structure in the relational database environment together with Auto-Cad as a 3D visualization tool; AutoCad was used to generate the building models. In the literature, a common suggestion has been that the existing GISs were able to handle most of the 2D spatial data, but had difficulty in handling 3D spatial data and beyond, therefore, an extension of the existing systems to at least a third-dimension (3D) is one of the solutions suggested by GIS researchers.

Another observation is that the literature cites no work on threedimensional GIS coupled with object-oriented technology. Given that the weakness of conventional off-the-shelf 2D or 2.5D GISs are revealed when three-dimensional real world entities are considered, it is understood that object-orientation and three-dimensionality are not more often jointly considered. Some works have focussed on 3D issues such as work reported in Fritsch and Schmidt, 1995; Kraus, 1995; and Fritsch, 1996. But all of these attempts were based on the relational database

environment. Therefore, this research monograph looks at both 2D and 3D spatial data modelling and the development of a geoinformation system using relational and object-oriented technology to attempt to solve 3D problems in the GIS environment.

3.4 The Need for 3D GIS

We live in a three dimensional (3D) world. Earth scientists and engineers have long sought graphic expressions of their understanding about 3D spatial aspects of reality in the form of sketches and drawings. Graphical descriptions of 3D reality are not new. Drawings in perspective view date from the Renaissance period (Devlin, 1994). 3D descriptions of reality in perspective view change with the viewing position, so their creation is quite tedious. Traditional maps overcome this problem by using orthogonal projections of the earth. However, they offer a very limited 3D impression.

These traditional drawings and maps reduce the spatial description of 3D objects to 2D. Using computing technology, however, knowledge about reality can be directly transferred into a 3D digital model by a process known as 3D modelling. A 3D description of reality is independent of the viewing position.

3.5 Who Needs 3D GIS?

As in the popular 2D GIS for 2D spatial data, 3D GIS is for managing 3D spatial data. Raper and Kelk (1991), Rongxing Li (1994), Förstner (1995), and Bonham-Carter (1996) present some of the three dimensional application areas in GIS, including:

- ecological studies
- environmental monitoring
- geological analysis
- civil engineering

- mining exploration
- oceanography
- architecture
- automatic vehicle navigation
- archaeology
- 3D urban mapping
- landscape planning
- defence and intelligence
- command and control

The above applications may produce much more useful information if they were handled in a 3D spatial system, but 3D spatial objects on the surface and subsurface appear to demand more complex solutions (e.g. in terms of modelling, analysis, and visualization) than the existing systems can offer.

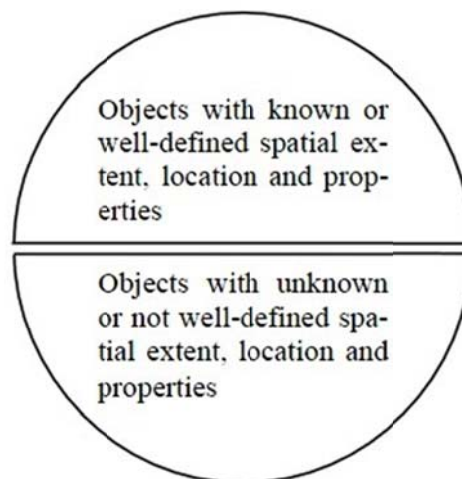


Figure 3.2 Two types of real world objects with respect to their spatial extent.

3.6 Problems Associated with Spatial Modelling for 3D GIS

Establishing a 3D GIS while taking into account the integration of the necessary components and different types of objects requires the solution of the following problems related to the spatial model representing reality:

3.6.1 Design of a Spatial Model

Design of an integrated data model, or a scheme, permitting the derivation of a unified data structure capable of maintaining all the components of the geometric representation of real world objects, whether obtained from direct measurements or from derivations, in the same database. Each geometric component must be capable of representing a real world object differently understood by different people.

3.6.2 Construction of a Spatial Model

Development of appropriate means and methods for 3D data acquisition.

Coordinate transformation into common georeferencing when different components are to be included into one database.

Development of a data structuring method that unites the data from various inputs of multi sources into an integrated database capable of being maintained by a single database management system.

Design of thematic classes to organize representation of real world objects with common aspects into the same category.

Solving the uncertainty arising from discrepancies from different data sets during the integration process and converting the uncertainty into a 'data quality' statement to be conveyed to the end user.

3.6.3 Utilization of a Spatial Model

Utilization of existing components, such as 2D data and DTM (backward compatibility) and preparation of those components for future incorporation into the higher-dimension model (forward compatibility) to save the costs of repeating data acquisition.

Development of additional spatial operators and spatial analysis functions.

Development of maneuverable graphic visualization permitting the selection of appropriate viewpoints and representation enabling convenient, adequate uncovering of the details of objects stored in the database.

Design of 3D cartographic presentation of information, including name placement, symbol, generalization, etc.

Design of a user interface and query language allowing users access to the integrated database.

Development of a spatial indexing structure that speeds up data retrieval and storage processes for the integrated database, including specific (database) views for each user group and guidelines keeping these views updated according to the core database.

Development of tools for navigating among different models stored in databases at different sites and computing platforms.

3.6.4 Maintenance of Spatial Model

Design of updating procedures, including the development of consistency rules ensuring the logical consistency and integrity of the integrated database, especially during the updating process.

3.7 Three Dimensional GIS Development

In this section, several types of two dimensional (2D) GIS systems which are related to the development of 3D GIS will be further discussed. Some well established systems which are currently available in the market will be reviewed. Since data structures, data modelling and database management are important aspects of system development, all the discussions and system overview will focus on these aspects.

3.7.1 GIS Functions

Any GIS system should be able to provide information about geo spatial phenomena. Principally, the tasks or the functions of a GIS system are to:

1) capture, 2) structuring, 3) manipulation, 4) analysis, and 5) presentation (Raper and Maguire, 1992).

- *Capture*. Capturing is inputting spatial data to the system. Many different techniques and devices are available for both geometric and attribute data. The devices in frequent use for collecting spatial data can be classified as manual, semiautomatic or automatic, and the output either in vector or raster format. Detailed discussion on data capturing is not covered here.
- *Structure*. Structuring is a crucial stage in creating a spatial database using GIS. This is because it determines the range of functions which can be used for manipulation and analysis. Different system may have different structuring capabilities (simple or complex topology, relational or object-oriented).
- *Manipulate*. Among important manipulation operations are generalisation and transformation. Generalisation is applied for smoothing spatial data and it includes line smoothing, points filtering, etc. Transformation includes among others coordinate transformation to a specified map projection and scaling.

- *Analysis* is the core of a GIS system. It involves metric and topological operations on geometric and attribute data. Primarily, analysis in GIS concerns operations on more than one set of data which generates new spatial information of the data. Terrain analysis (e.g. intervisibility), geometric computations (volume, area, etc), overlay, buffering, zoning are among typical analysis functions in GIS.
- *Presentation* is a final task in GIS. At this stage, all generated information or results will be presented in the form of maps, graphs, tables, reports, etc. Ideally, a 3D GIS should have the same functions as a 2D GIS. However, such 3D systems are not available due to several impediments. The ensuing sections will discuss the challenges in 3D GIS development.

3.8 Three Dimensional GIS

In this section, some problems and related issues in 3D GIS software development are reviewed and discussed. 3D GIS should be able to model, represent, manage, manipulate, analyse and support decisions based upon information associated with three-dimensional phenomena (Worboys, 1995). The definition of 3D GIS is very much the same as for 2D system. In GIS, 2D systems are common, widely used and able to handle most of the GIS tasks efficiently 3D GIS very much needs to generate information from such 3D data. Such a system is not just a simple extension by another dimension on to 2D GIS. Adding this third dimension into existing 2D GIS needs a thorough investigation of many aspects of GIS including a different concept of modelling, representations and aspects of data structuring. Existing GIS packages are widely used and understood for handling, storing, manipulating and analysing 2D spatial data. Their capability and performance for 2D and for 2.5D data (that is also DTM) are generally accepted by the GIS community. A GIS package which can handle and manipulate 2D data and DTM cannot be considered as a 3D GIS system because DTM data is not real 3D spatial data. The third dimension of the DTM data only provides (often after interpolation) a surface attribute to features whose coordinates consist only of planimetric data or x, y coordinates. GIS software handling real 3D spatial data is rarely found.

3.9 Why is 3D GIS Difficult to Realise?

The difficulties in realising 3D GIS or 3D geo-spatial systems stem from:

Conceptual model: although there are several data structures available for the 2.5D and 3D data, each of them has its own strong and weak points in representing spatial objects. Spatial data can be modelled in different ways. The conceptual 3D model integrates information about semantics, 3D geometry and 3D spatial relationships (3D topology). The conceptual model provides the methods for describing real-world objects and spatial relationships between them. The design of a conceptual model is a subject of intensive investigations and several 3D models have already been reported (see Brisson 1990, Molenaar 1992, Cambrey 1993, Pilouk 1996, Pigot 1995, Zlatanova 2000, Abdul-Rahman 2000, Pfund 2001).

Data collection: Modelling in 3D drastically increases the cost of data acquisition, as compared with 2D. Despite the progress in automatic object detection and 3D reconstruction (see Gülch et al 1999, Lang and Forstner 1996), the manual work is still predominant. Methods for constructing the model combining data from various sources, automatic techniques for data acquisition (geometry and images for texturing), rules and algorithms for ensuring consistency of data, algorithms for the automatic building of 3D topology, etc., are the widely discussed topics in the literature.

Spatial analysis: Whilst thematic analysis and 2D spatial analysis are well studied, research on 3D spatial analysis is still at an intensive stage. Spatial relationships are the fundament of a large group of operations to be performed in GIS, e.g. inclusion, adjacency, equality, direction, intersection, connectivity, and their appropriate description and maintenance is inevitable. Similar to 2D variants, 3D GIS should be capable to perform metric (distance, length, area, volume, etc), logic (intersection, union, difference), generalisation, buffering, network (shortest way) and merging operations. Except metric operations, most of them require knowledge about spatial relationships. Formalism for detecting spatial relationships based on set topology

notions has already been proposed by several authors (see Pullar and Egenhofer 1988, Egenhofer and Herring 1992, Molenaar 1998).

Visualisation, navigation and user interface: Advances in the area of computer graphics have made visual media a major ingredient of the current interface and it is likely that graphics will play a dominant role in the communication and interaction with computers in the future. 3D visualisation within 3D GIS requires a number of specific issues to be investigated, e.g. appropriate means to visualise 3D spatial analysis result, tools to effortlessly explore and navigate through large models in real time, and texture the geometry. Observations on the demand for 3D City models (see Gruber et al 1995) show user preferences for photo-true texturing, due to improved model performance in terms of detail and orientation. Trading photo-true texture raises new topics for research, i.e. collection (methods, automation), storage (original images vs. separate pieces) and mapping onto the "geometry". Specific functions of objects modelled in VR systems, and referred to as behaviours, gain an increased popularity as tools for walking through the model, exploring particular phenomena and improving the cognitive perception (see Kraak 1998, Raper et al 1998).

Internet access: Remote access to 3D spatial information is one of the newest research topics. The Web has already shown a great potential in improving accessibility to 2D spatial information (raster or vector maps) hosted in different computer systems over the Internet (e.g. <http://www.visa.com>, <http://www.mapquest.com>, <http://www.mapguide.com>, etc.). New Web standard (VRML, DML) have created the ability to distribute and navigate in 3D virtual worlds. The research on spatial query and 3D visualisation over the Web has resulted in a few prototype systems (see Coors et al 1998, Lindenbeck et al 1998). The design criteria, however, are visualisation- rather than spatial analysis-oriented. Research works of Pilouk's, Zlatanova's and Abdul-Rahmans's attempt to address these major issues by investigating the possible uses of several data structures (including some 2D structures), the construction of these data structures, the utilisation of these structures in spatial modelling, the topological relationships of the 2D, 2.5D, and 3D spatial objects, the development of a database from the spatial data and the

implementation of them in the form of a software which can be seen as component of 3D GIS.

3.10 The Web and 3D GIS

Recent developments in GIS are showing a general movement towards Web-enabled GIS. The gap between desktop GIS and Web GIS is closing. Applications based on network environments have already shown great potential in relation to geo-information. Examples can be online city maps and finding places (respectively routing) between points (MAP 24, 2004). Obviously, the developments in Web-enabled GIS are driven by user requirements and technology developments. But is the third dimension sufficiently exploited by Web applications?

In general, the need of 3D geo spatial data is increasing. Professionals involved in urban and landscape planning, cadastre, real estate, utility management, geology, tourism, army, etc. are especially keen on taking advantages of the third dimension. Since real world spatial objects are in 3D, it is obvious to extend GIS to the third dimension as well. However, the acceptance of 3D applications depends heavily on its profits. Therefore, we can say that the number of users could increase with the introduction of new and additional 3D functionality to the spatial system. Technologically, side, state-of-the-art computer hardware is already offering a reasonable means of dealing with the third dimension such as improved 3D visualization techniques. Among others, there are photo-realistic texturing, advanced lighting or real-time navigation that could attract more users to use such kind of applications. We firmly believe that the Web offers the possibility to make the third dimension widely accessible.

This section aims to provide an overview about web-oriented 3D GIS. Since we consider system architecture, data management, 3D GIS functionality and visualization (respectively user interaction) critical for Web 3D GIS, we address them in detail here. The chapter explains the needed system components and their importance with respect to the requested Web 3D GIS functionality.

3.10.1 Web 3D GIS

Traditionally, any geographic information system is based on the principles of data input, management, analysis and representation. Within a Web-enabled environment, these principles are represented by or implemented within the components shown in Table 3.1.

Table 3.1 GIS principles and their corresponding Web components.

GIS Principle	Web Component
Data Input	Client
Data Management	DBMS possibly extended by a spatial component
Data Analysis	GIS Library recommended on Server
Data Representation	Client/Server

Web environment, a Web server is needed. Since geo-data is a very specific type of data, different standards, e.g. the OpenGIS Consortium (OGC) specifications have been developed and their usage has to be taken into account. A system composed of these components is called here Web GIS. The system should cover a complete GIS workflow within a Web environment. Figure 3.1 shows the general system architecture which is mostly “Client-Server”.

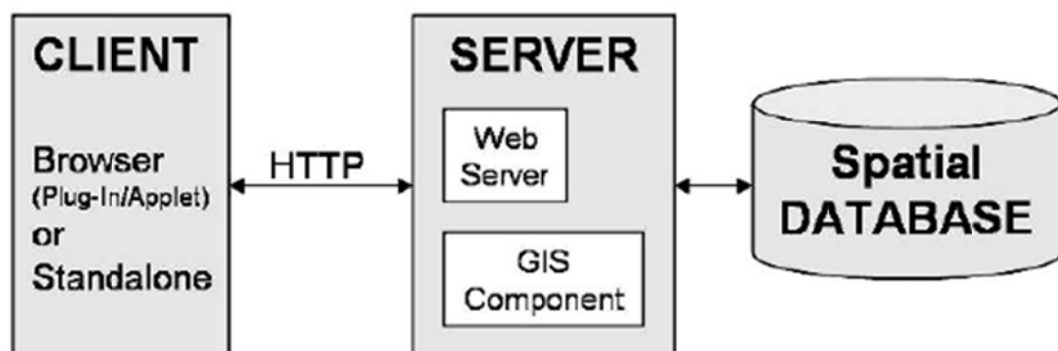


Figure 3.3 A typical Web GIS architecture.

3.10.2 GUI for 3D Visualization and Editing on The Web

In order to interact and communicate with information, a Graphical User Interface (GUI) has to be designed and created. A GUI is situated on top of the user agent. Because geographic information is usually very complex, this task is difficult to achieve. Moreover, the user interface is the most critical due to the fact that this is the “main gate” to the application. If a GUI is implemented poorly, an application will not be accepted by critical users. Compared to user interaction in 2D, a GUI for the third dimension is different (Cöltekin, 2002). To develop a GUI for 3D visualization, different aspects are important. First of all, the virtual world has to be sufficient. To do so, a set of core features of creating a 3D world are needed. The technique of visualization has to cover the state-of-the-art possibilities. In the case of 3D, these techniques include are reasonable modeling of physical objects, lighting and shadowing, definition of viewpoints, and photo-realistic texturing. As soon as interaction has to be involved, using events, linking and internal/external scripting will become more important. In fact, 3D worlds including real-time interactive navigation are a requirement today. To explore virtual worlds, a user would wants to be put into the space very closely. Therefore, characteristics similar to computer games are very popular, for instance walkthrough, flying, panning and sliding. If the target is a singular object, rotating is another important real-time navigation attribute. More advanced characteristics of virtual worlds are Levels of Detail (LOD) or multi-resolution texturing implementation. Furthermore, culling algorithms should be provided in order to make sure that invisible back-faces will not be rendered. Overall, the amount of rendered polygons is a factor for the smooth navigation. Any technique which reduces the amount while keeping the world realistic should be used (Kofler, 1998).

3.11 Interactive Campus Map Examples



Figure 3.4 Bethel College (2011).

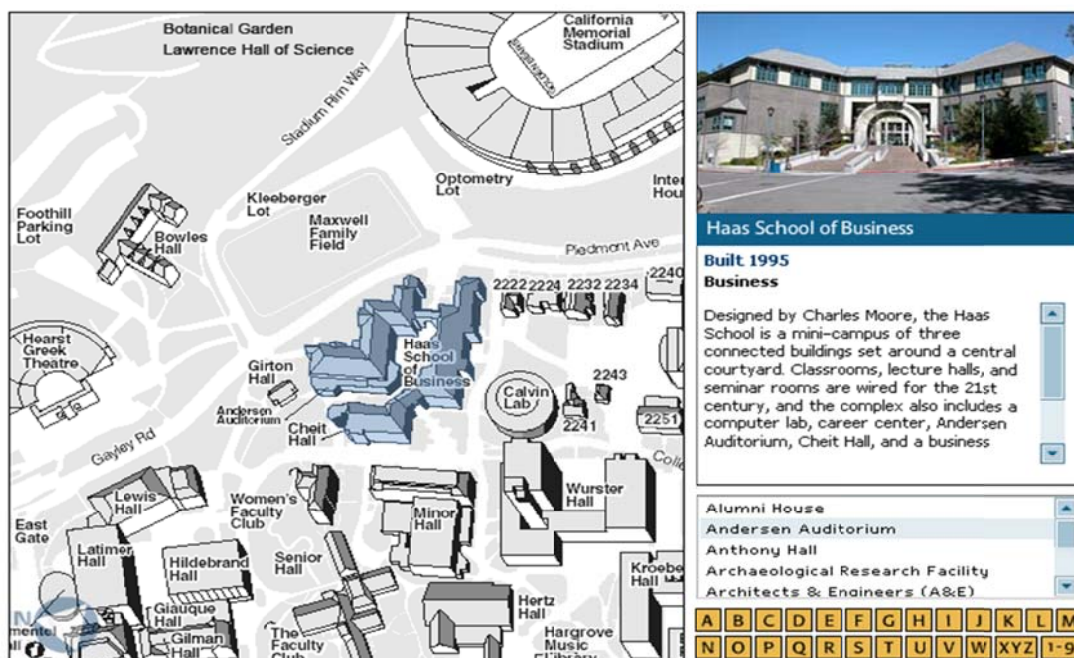


Figure 3.5 Berkeley University of California (2011).

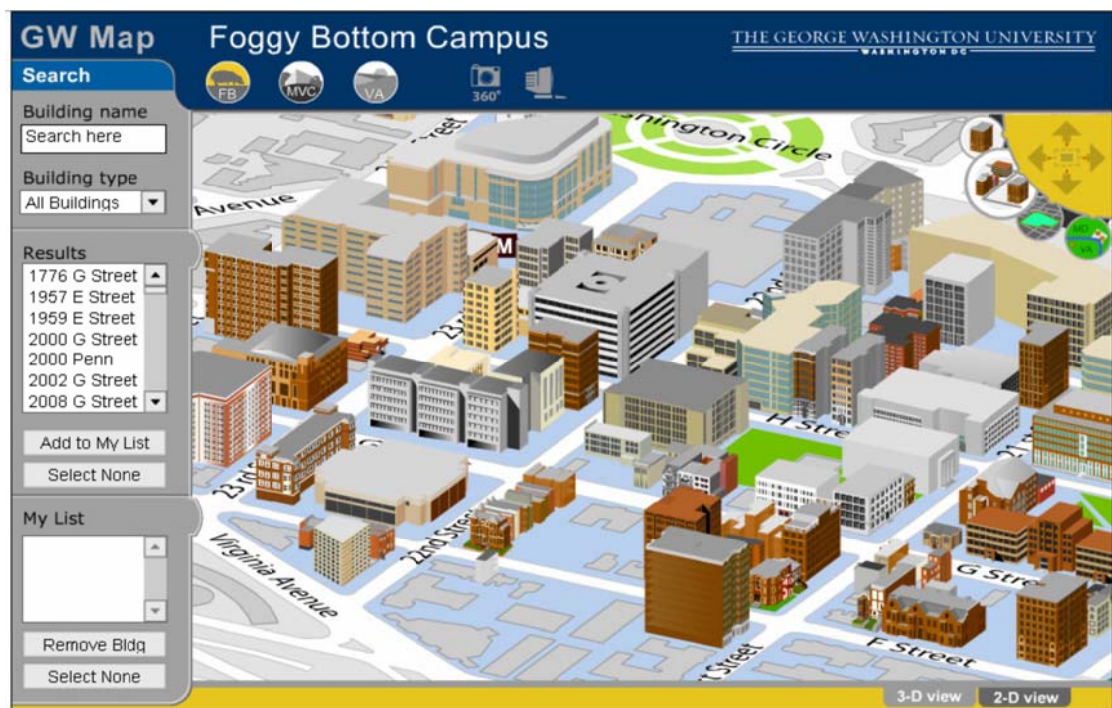


Figure 3.6 George Washington University (2011).

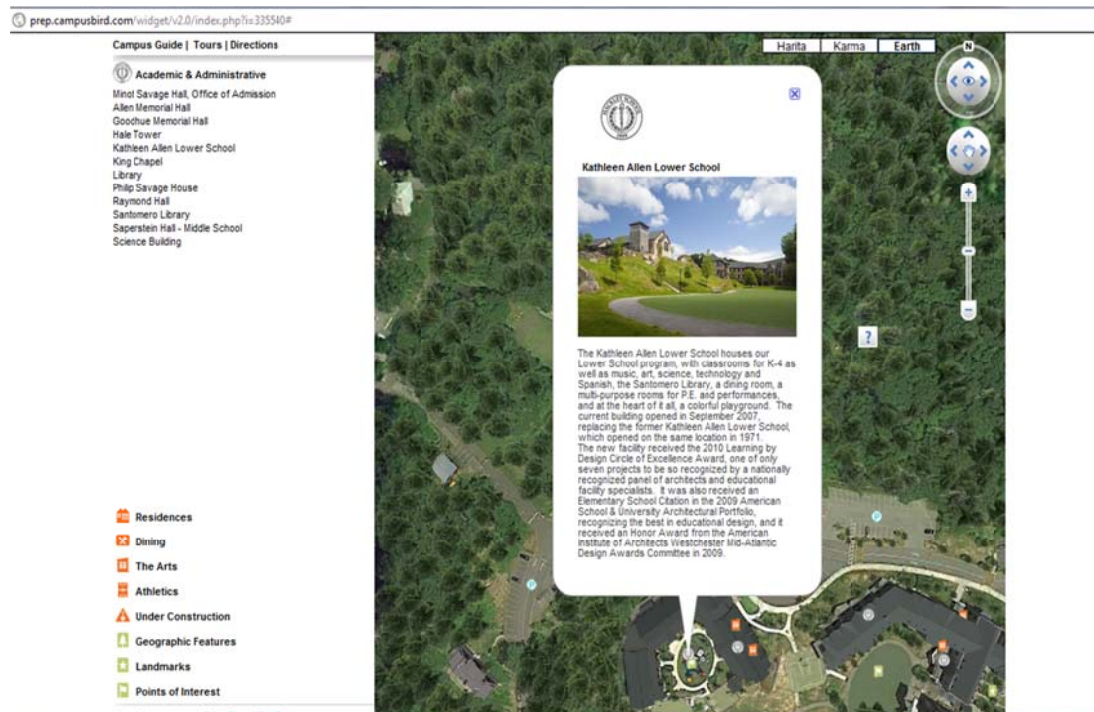


Figure 3.7 Hackley School (2011).



Figure 3.8 Anadolu University (2011).

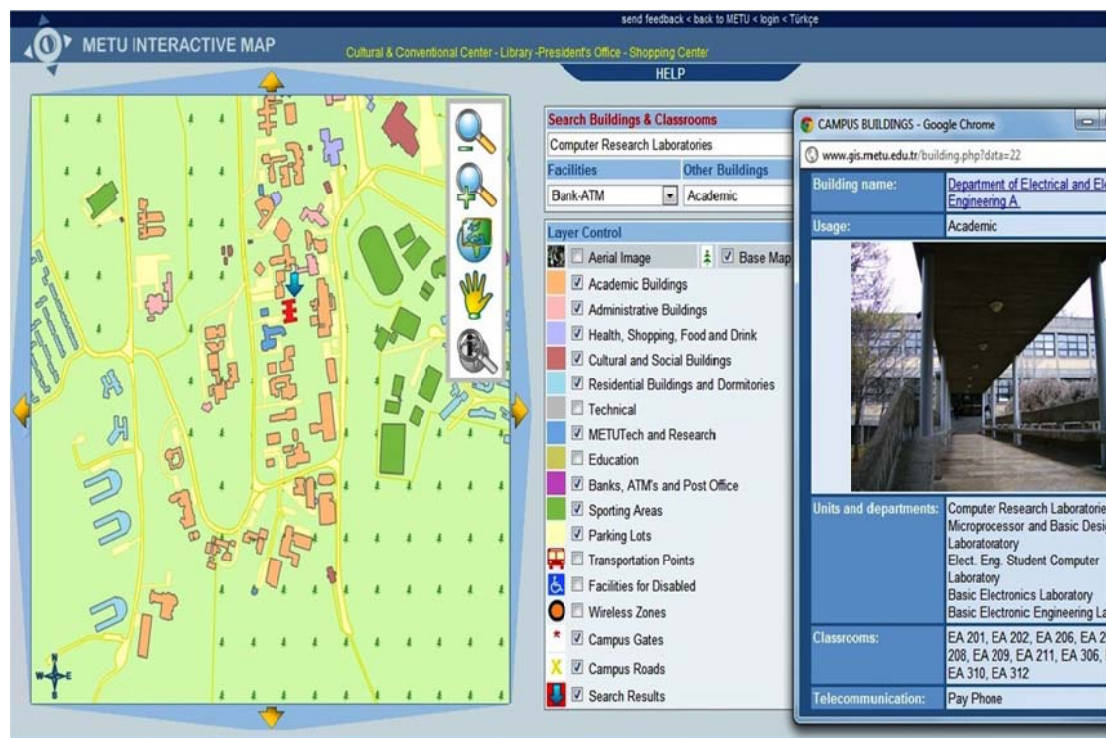


Figure 3.9 Middle East Technical University (2011).

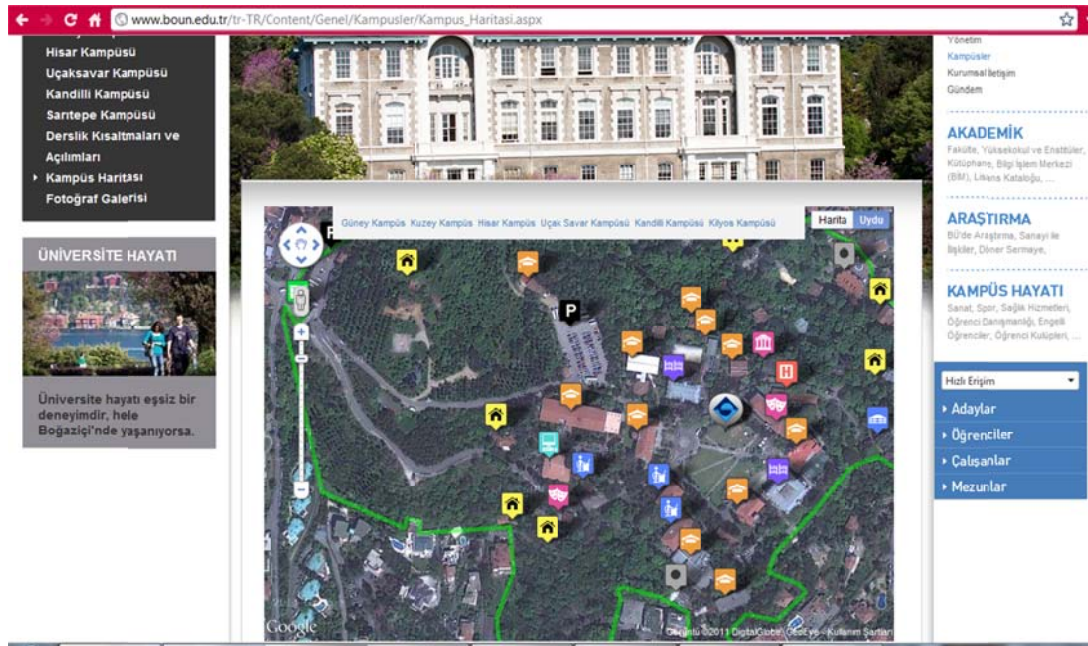


Figure 3.10 Boğaziçi University (2011).



Figure 3.11 Yıldız Technical University (2011).

3.12 The Technology Used in The Project

3.12.1. *AutoCAD*

AutoCAD is a CAD software application for 2D and 3D design and drafting. It is developed and sold by Autodesk, Inc. First released in December 1982, AutoCAD was one of the first CAD programs to run on personal computers, notably the IBM PC. At that time, most other CAD programs ran on mainframe computers or mini-computers which were connected to a graphics computer terminal for each user. Early releases of AutoCAD used primitive entities (lines, polylines, circles, arcs, and text)to construct more complex objects. Since the mid-1990s, AutoCAD has supported custom objects through its C++ Application Programming Interface (API). Modern AutoCAD includes a full set of basic solid modeling and 3D tools. With the release of AutoCAD 2007 came improved 3D modeling, which meant better navigation when working in 3D. Moreover, it became easier to edit 3D models. The mental ray engine was included in rendering, it was now possible to do quality renderings. AutoCAD 2010 introduced parametric functionality and mesh modeling.

3.12.2. *3D Studio Max*

Autodesk 3ds Max, formerly **3D Studio MAX**, is a modeling, animation and rendering package developed by Autodesk Media and Entertainment. It has modeling capabilities, a flexible plugin architecture and can be used on the Microsoft Windows platform. It's frequently used by video game developers, TV commercial studios and architectural visualization studios. It is also used for movie effects and movie pre-visualization.

In addition to its modeling and animation tools, the latest version of 3ds Max also features shaders (such as ambient occlusion and subsurface scattering), dynamic simulation, particle systems, radiosity, normal map creation and rendering, global illumination, a customizable user interface, and its own scripting language.

3.12.3. Adobe Photoshop CS5

Adobe Photoshop is a graphics editing program developed and published by Adobe Systems Incorporated.

Adobe's 2003 "Creative Suite" rebranding led to Adobe Photoshop 8's renaming to Adobe Photoshop CS. Thus, Adobe Photoshop CS5 is the 12th major release of Adobe Photoshop. The CS rebranding also resulted in Adobe offering numerous software packages containing multiple Adobe programs for a reduced price. Adobe Photoshop is released in two editions: Adobe Photoshop, and Adobe Photoshop Extended, with the Extended having extra 3D image creation, motion graphics editing, and advanced image analysis features.^[3] Adobe Photoshop Extended is included in all of Adobe's Creative Suite offerings except Design Standard, which includes the Adobe Photoshop edition.

Alongside Adobe Photoshop and Adobe Photoshop Extended, Adobe also publishes Adobe Photoshop Elements and Adobe Photoshop Lightroom, collectively called "The Adobe Photoshop Family" by Adobe. In 2008, Adobe released Adobe Photoshop Express, a free web-based image editing tool to edit photos directly on blogs and social networking sites.

Adobe support only Windows and Mac versions of this program but with Wine, CS4 version of Photoshop can work on Linux.

3.12.4. Adobe Flash Professional CS5

Adobe Flash (formerly Macromedia Flash) is a multimedia platform used to add animation, video, and interactivity to web pages. Flash is frequently used for advertisements, games and flash animations for broadcast. More recently, it has been positioned as a tool for "Rich Internet Applications" ("RIAs").

Flash manipulates vector and raster graphics to provide animation of text, drawings, and still images. It supports bidirectional streaming of audio and video, and it can capture user input via mouse, keyboard, microphone, and camera. Flash contains an object-oriented language called ActionScript and supports automation via the Javascript Flash language (JFSL).

Flash content may be displayed on various computer systems and devices, using Adobe Flash Player, which is available free of charge for common web browsers, some mobile phones and a few other electronic devices (using Flash Lite). Some users feel that Flash enriches their web experience, while others find the extensive use of Flash animation, particularly in advertising, intrusive and annoying, giving rise to a cottage industry that specializes in blocking Flash content. Flash has also been criticized for adversely affecting the usability of web pages.

3.12.5 Action Script

ActionScript is an object-oriented language originally developed by Macromedia Inc. (now owned by Adobe Systems). It is a dialect of ECMAScript (meaning it has a superset of the syntax and semantics of the more widely known JavaScript), and is used primarily for the development of websites and software targeting the Adobe Flash Player platform, used on Web pages in the form of embedded SWF files. The language itself is open-source in that its specification is offered free of charge and both an open source compiler (as part of Adobe Flex) and open source virtual machine (Mozilla Tamarin) are available.

ActionScript was initially designed for controlling simple 2D vector animations made in Adobe Flash (formerly Macromedia Flash). Initially focused on animation, early versions of Flash content offered few interactivity features and thus had very limited scripting capability. Later versions added functionality allowing for the creation of Web-based games and rich Internet applications with streaming media (such as video and audio). Today, ActionScript is suitable for use in some database applications, and in basic robotics, as with the Make Controller Kit.

Flash MX 2004 introduced ActionScript 2.0, a scripting programming language more suited to the development of Flash applications. It is often possible to save time by scripting something rather than animating it, which usually also enables a higher level of flexibility when editing.

Since the arrival of the Flash Player 9 alpha (in 2006) a newer version of ActionScript has been released, ActionScript 3.0. ActionScript 3.0 is an object-oriented programming language allowing far more control and code reusability when building complex Flash applications. This version of the language is intended to be compiled and run on a version of the ActionScript Virtual Machine that has been itself completely re-written from the ground up (dubbed AVM2). Because of this, code written in ActionScript 3.0 is generally targeted for Flash Player 9 and higher and will not work in previous versions. At the same time, ActionScript 3.0 executes up to 10 times faster than legacy ActionScript code.

Flash libraries can be used with the XML capabilities of the browser to render rich content in the browser. This technology is known as Asynchronous Flash and XML, much like AJAX. Adobe offers its Flex product line to meet the demand for Rich Internet Applications built on the Flash runtime, with behaviors and programming done in ActionScript. ActionScript 3.0 forms the foundation of the Flex 2 API.

3.12.6 ArcScene

ArcScene, the three-dimensional viewing application that is part of the ArcGIS 3D Analyst extension, allows earth scientists to create both traditional and unconventional three-dimensional displays from real-world data. Figures created from elevation and depth values are commonly used to reveal the earth's surface and expose its interior. Alternatively, other measures can represent a third dimension of earth-scientific data.

3.12.6.1 Elevation Z-Values

Elevation data is the foundation for the creation of three-dimensional displays. Data in digital elevation model (DEM) format is commonly used for storing and displaying topographic surfaces. Also, points, lines, polygons, grids, and images can be positioned in three-dimensional space with information from underlying DEM data. Alternatively, a feature can be displayed in three-dimensions with a constant z -value or a z -value derived from an attribute of a feature

CHAPTER FOUR

CASE STUDY

4.1 3D Modelling

During practice phase, details about Dokuz Eylul University campus and buildings were extracted from 2D AutoCAD drawings, and Graduate School of Natural and Applied Sciences Geographic Information Systems were extracted from R&D department. Buildings of Graduate School of Natural and Applied Sciences and Library were shown in detail and other buildings were shown representatively. For this purpose, drawings were extracted from 1/5000 scaled architectural floor plan of campus; drawing of Institute of Science building was extracted from 1/50 scaled architectural floor plan, drawing of Library building was extracted from 1/100 architectural floor plan drawing.

Firstly, Campus was organized in AutoCAD environment before it was organized as 3D. (Figure 4.1)

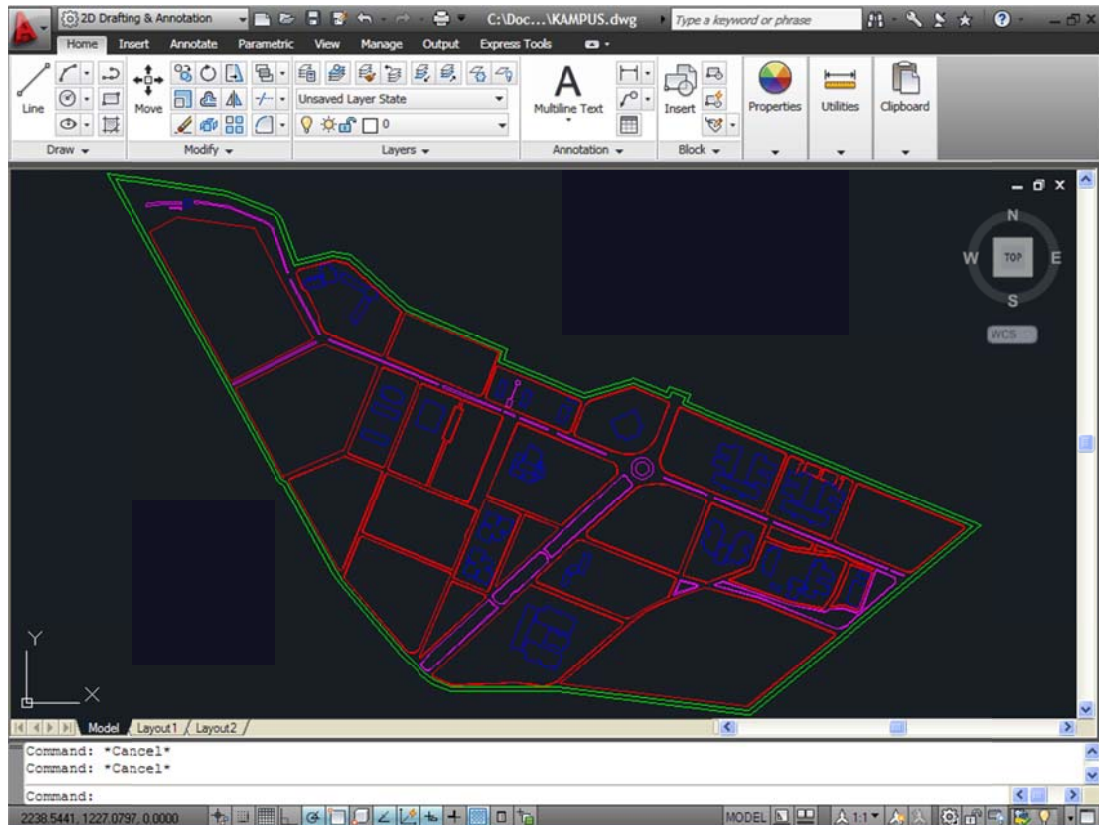


Figure 4.1 AutoCAD drawing of Campus.

2D drawings which were imported to 3D Studio Max environment should be in the shape of polyline or polygon in order that these drawings were solidified. For this purpose, all campus plan geometry is controlled, made into a covered shape with lines and it is raised with extrude. (Figure 4.2 and Figure 4.3)

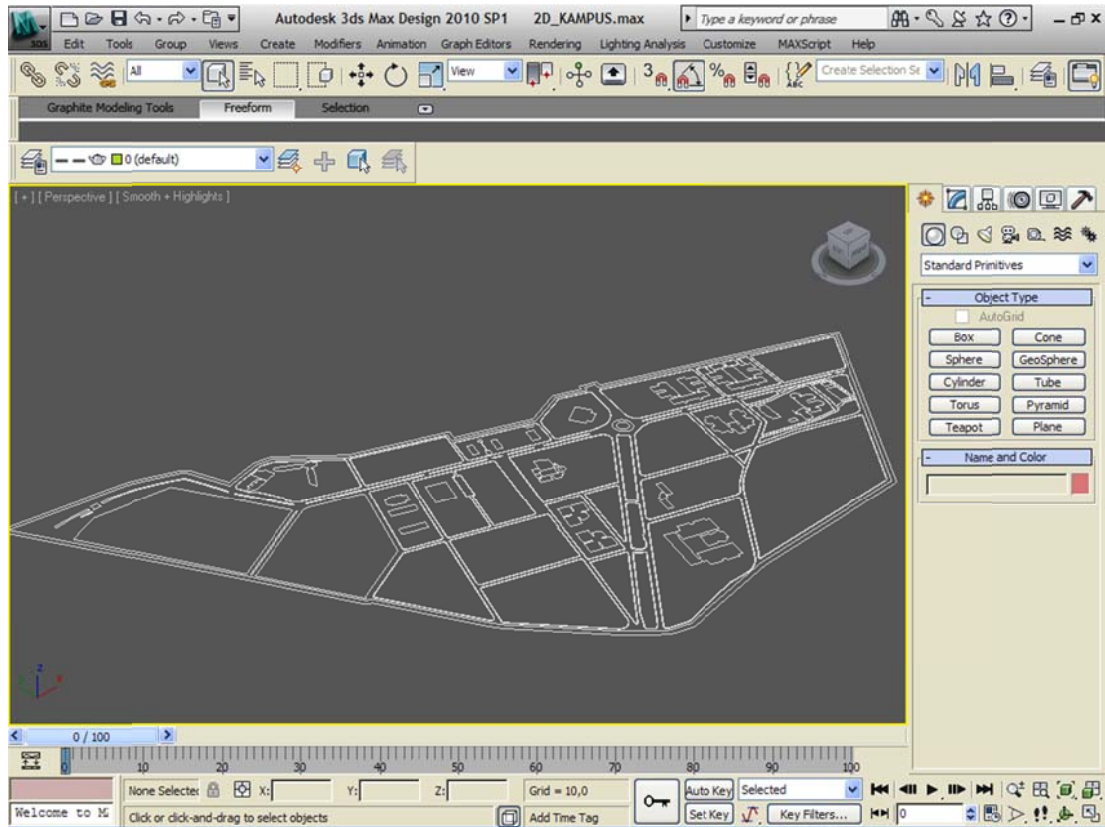


Figure 4.2 2D AutoCAD drawing is transferred to 3D Studio Max environment with Import command.

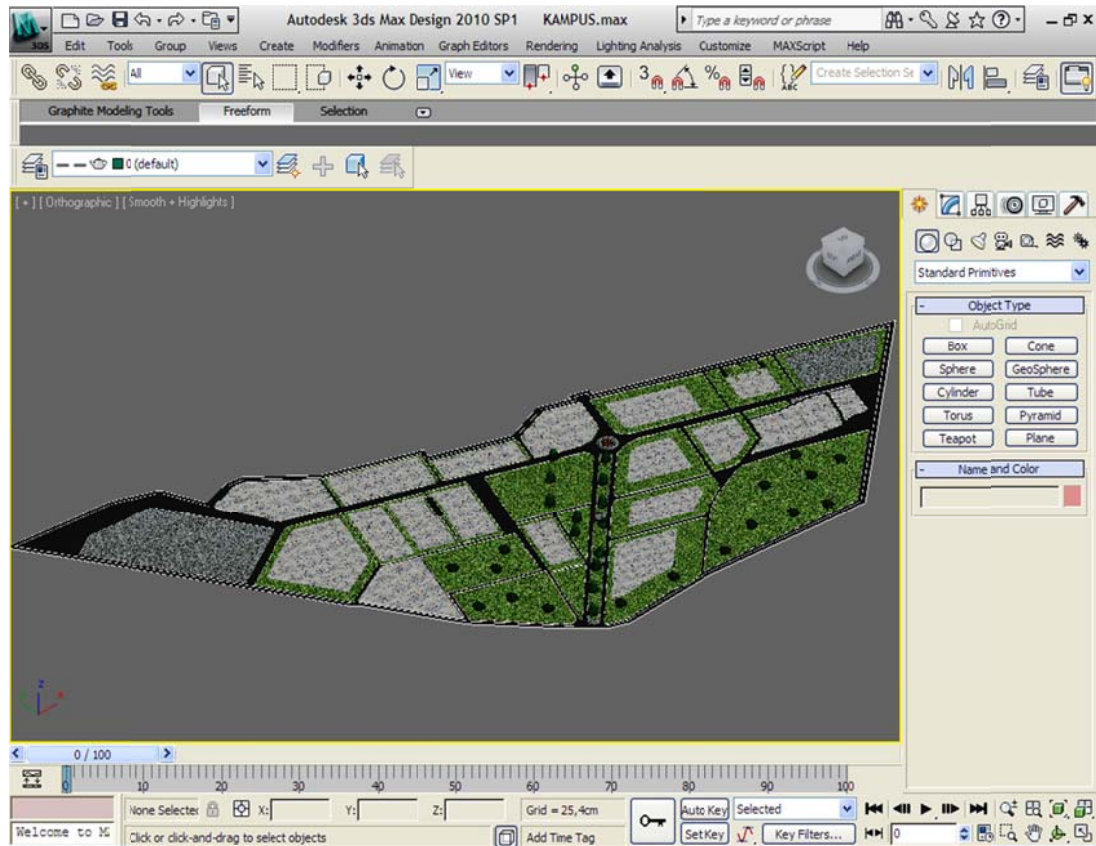


Figure 4.3 3D states of geometries organized with lines with Extrude command.

After campus was made into 3D state, buildings of Library and Institute of Science were made into 3D state respectively.

Each floor was organized properly after 2D AutoCAD drawing of Library was made. After than, as is seen in Figure 4.4, objects like wall, door, window, stairway, column of all floor were laminated in order to make working in 3D Studio Max environment easy.

CAD views of floors whose drawings were completed in AutoCAD environment are shown in Figure 4.5, Figure 4.6, Figure 4.7 and Figure 4.8.

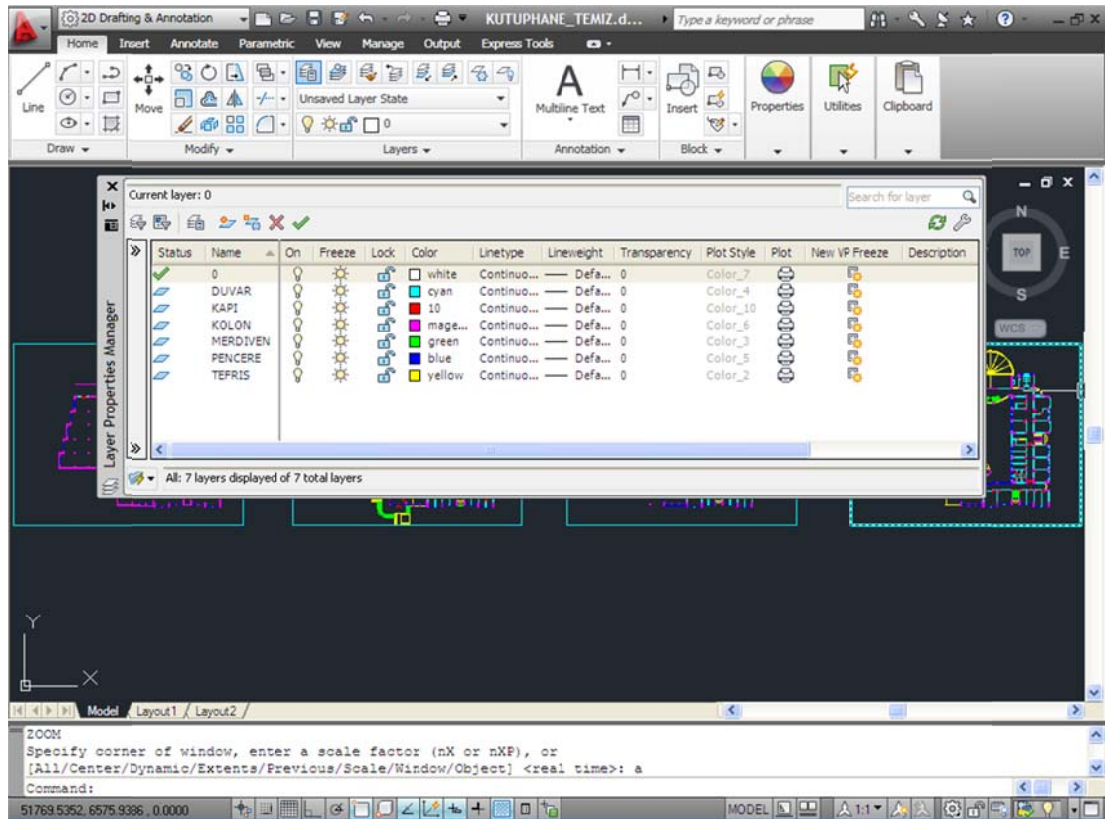


Figure 4.4 AutoCAD object layers.

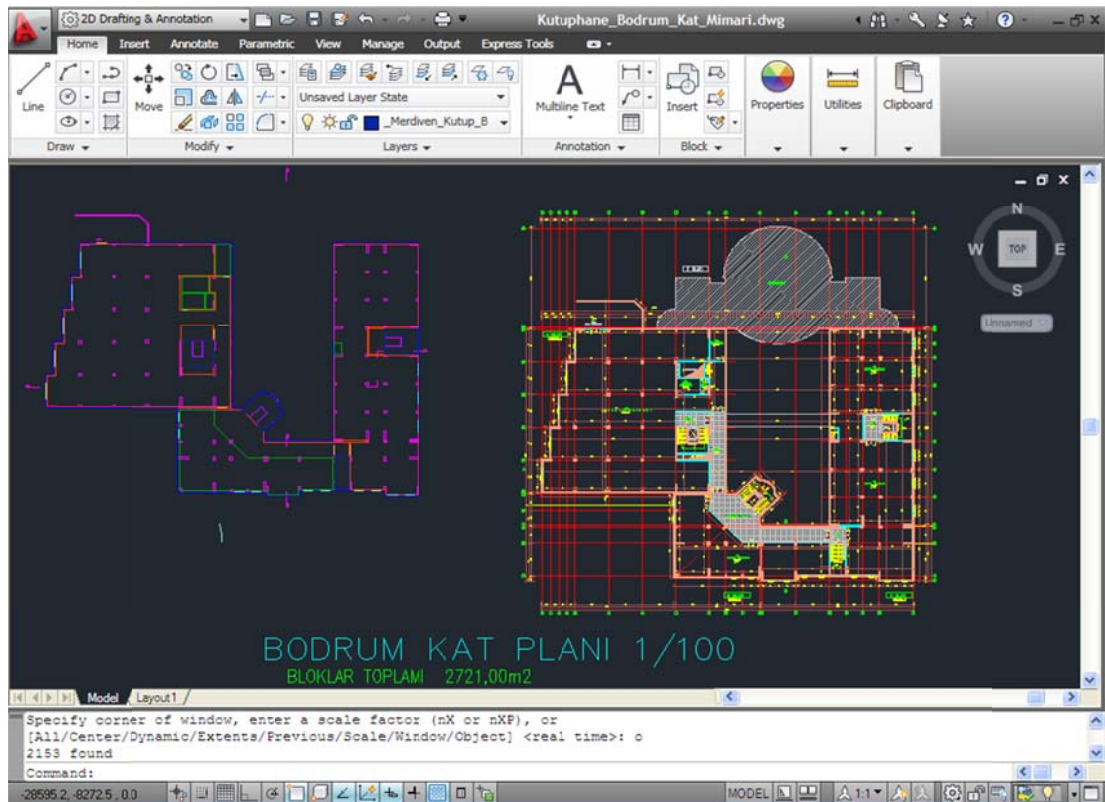


Figure 4.5 CAD view of completed cellar.

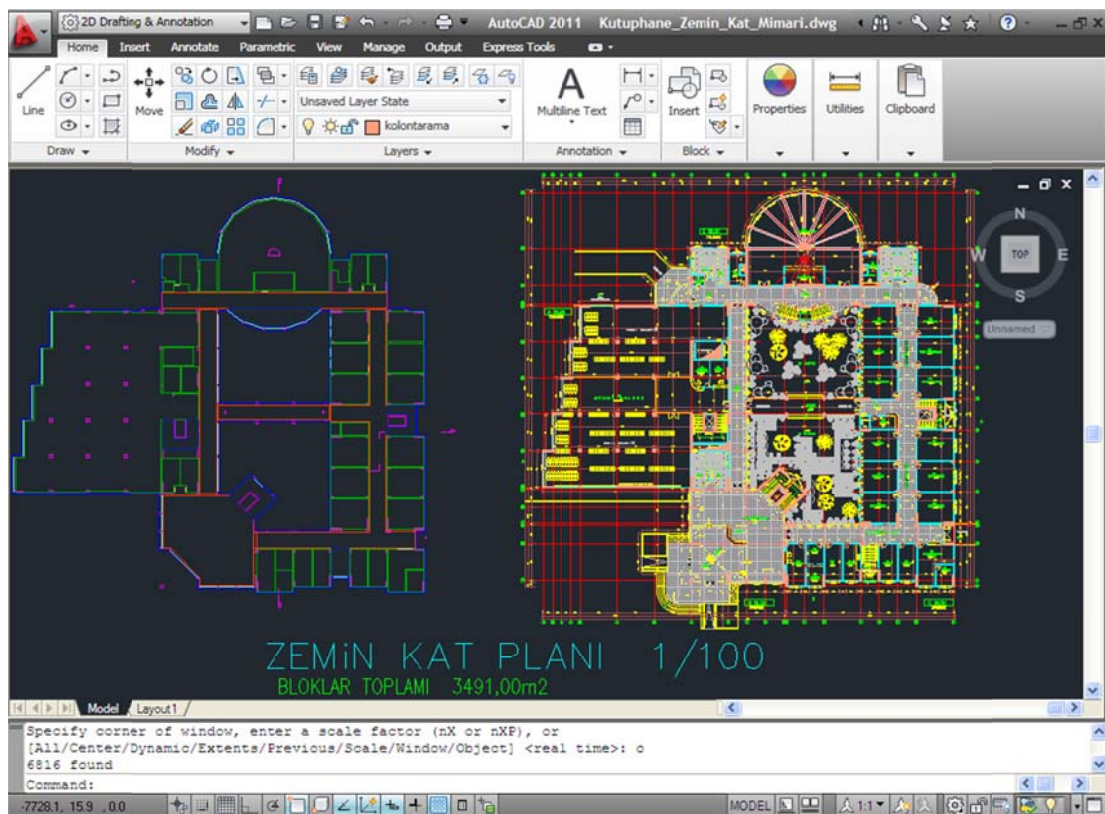


Figure 4.6 CAD view of completed ground floor.

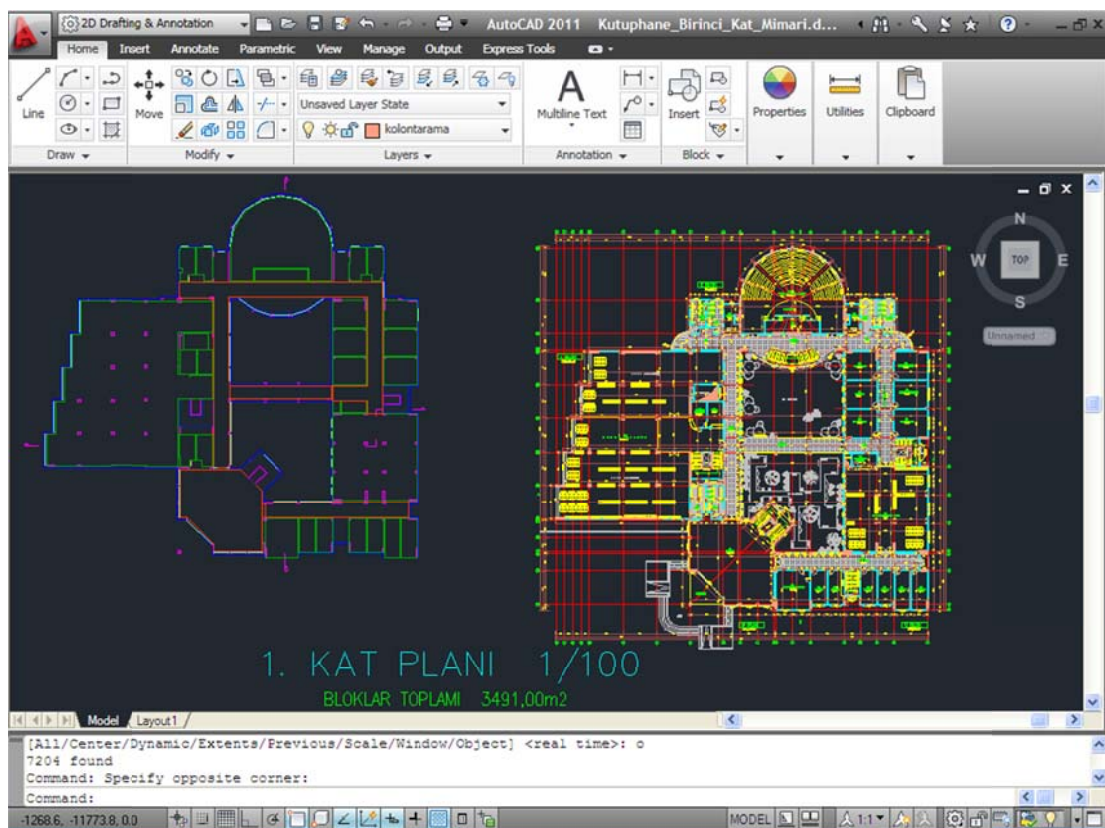


Figure 4.7 CAD view of completed first floor.

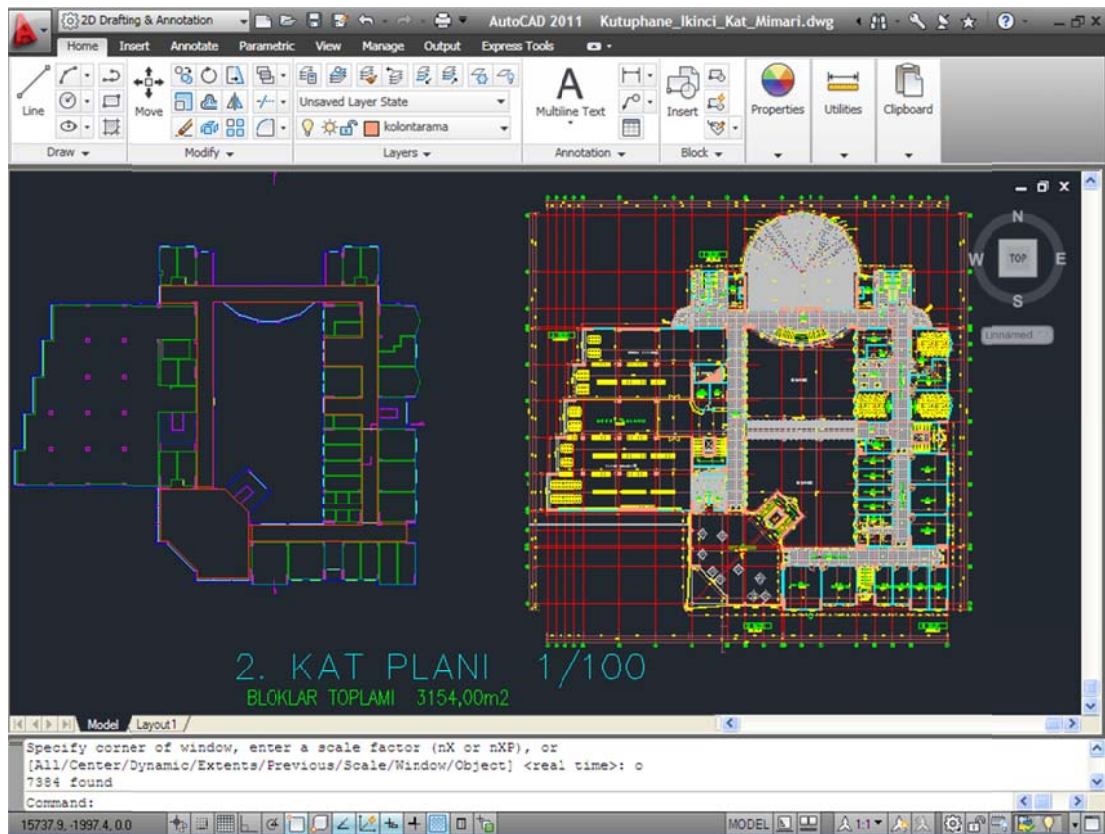


Figure 4.8 CAD view of completed second floor.

After design and drawing in AutoCAD environment were finished, studies were begun in 3D Studio Max environment and as is seen in Figure 4.9, file to be studied on was transferred to this place with File-Import commands.

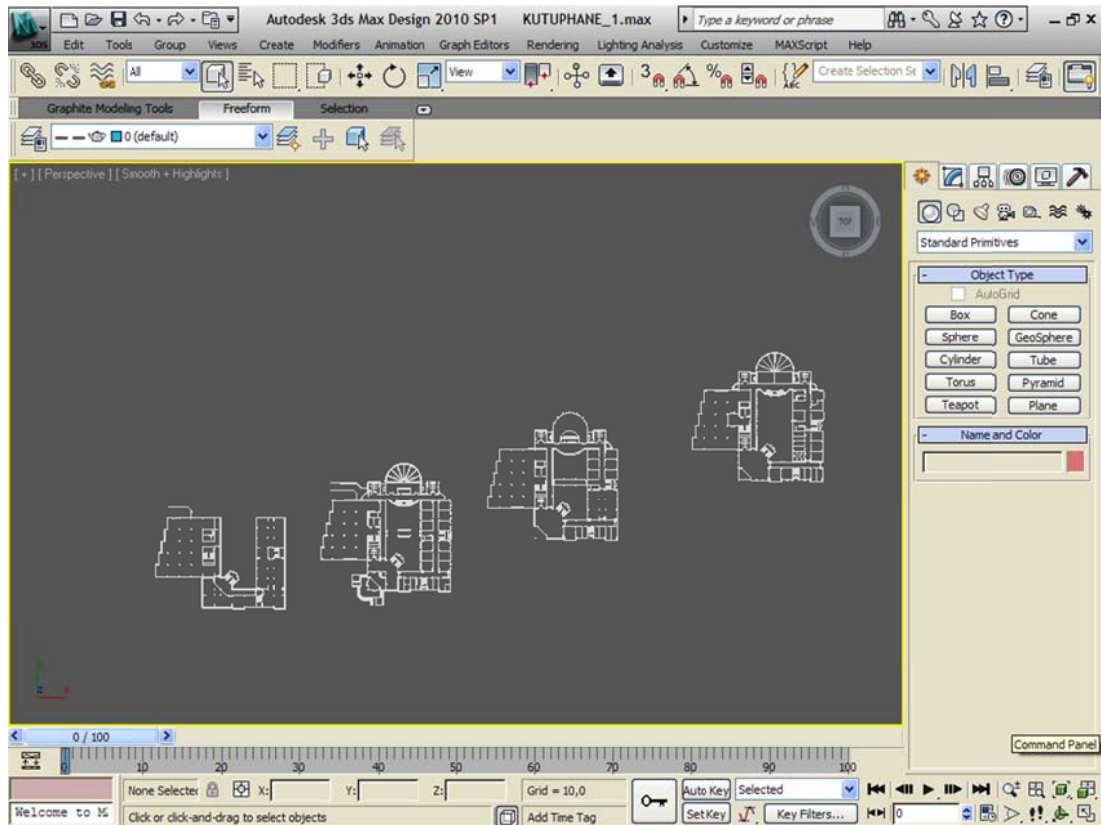


Figure 4.9 CAD view imported to 3ds Max.

When all AutoCAD drawings of library were imported to 3D Studio Max environment, Layers formed in AutoCAD environment were identified in this place automatically (Figure 4.10).

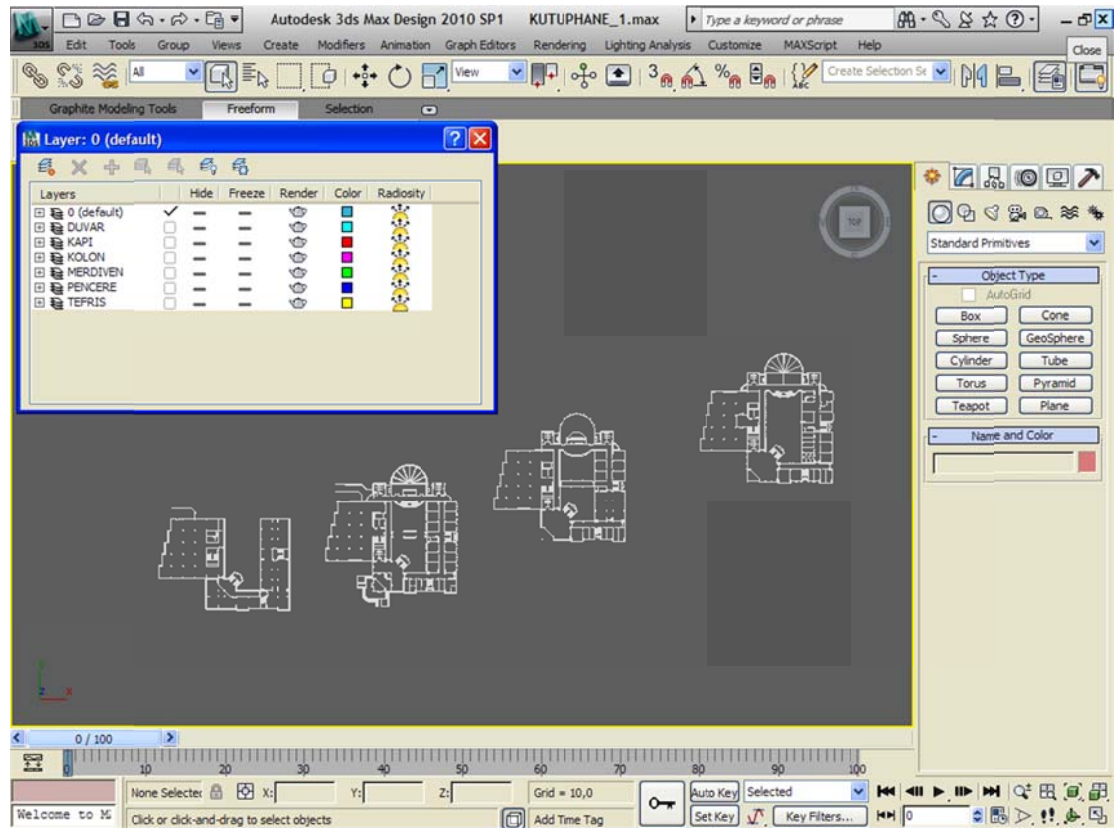


Figure 4.10 Layers in 3ds Max environment.

Firstly, columns were modeled in 2D drawing transferred to 3D Studio Max. For this, AEC Extended which is an architectural element of 3D Studio Max was prepared with Wall command. Mode of Vertex which is an element of 3D Studio Max snap was activated. Thus, studies were done on 2D drawing. Columns were replicated because these are in alignment on all floors. (Figure 4.11)

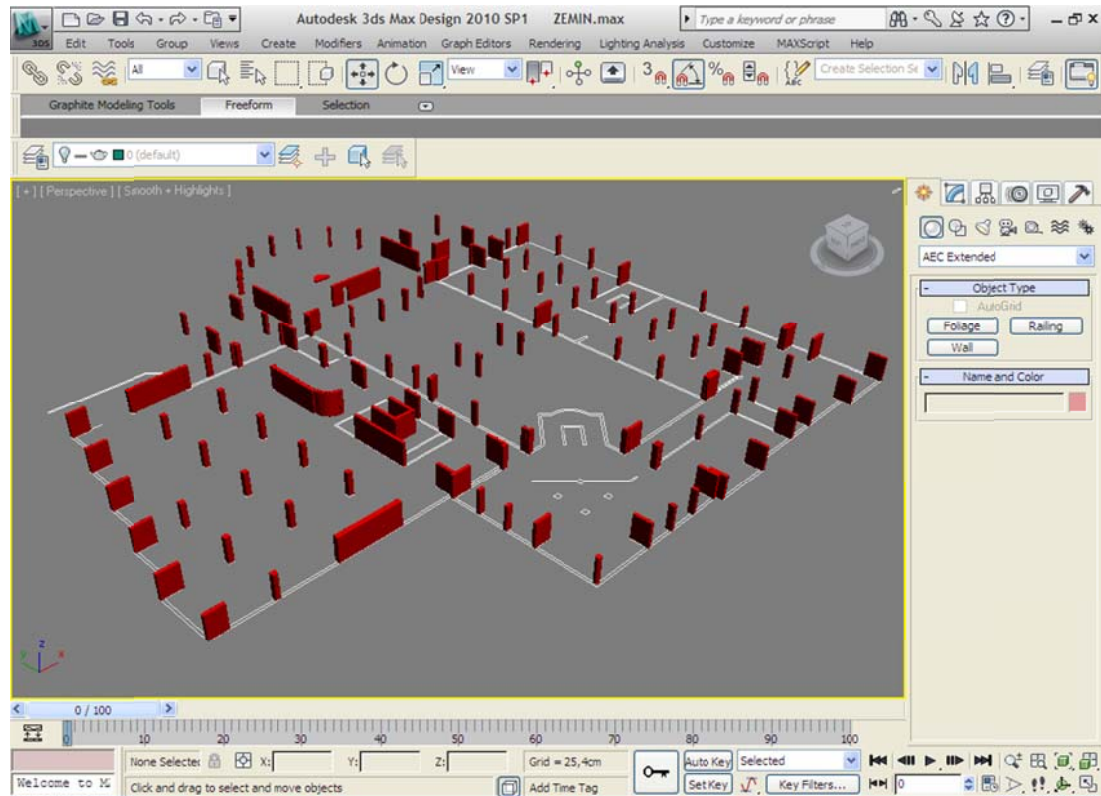


Figure 4.11 View of columns formed in ground floor with Wall command.

Like in columns, Walls were modeled. Drawings were prepared by using an architectural element, Wall command. Each floor's models were made separately because floor plans were different from each other. (Figure 4.12)

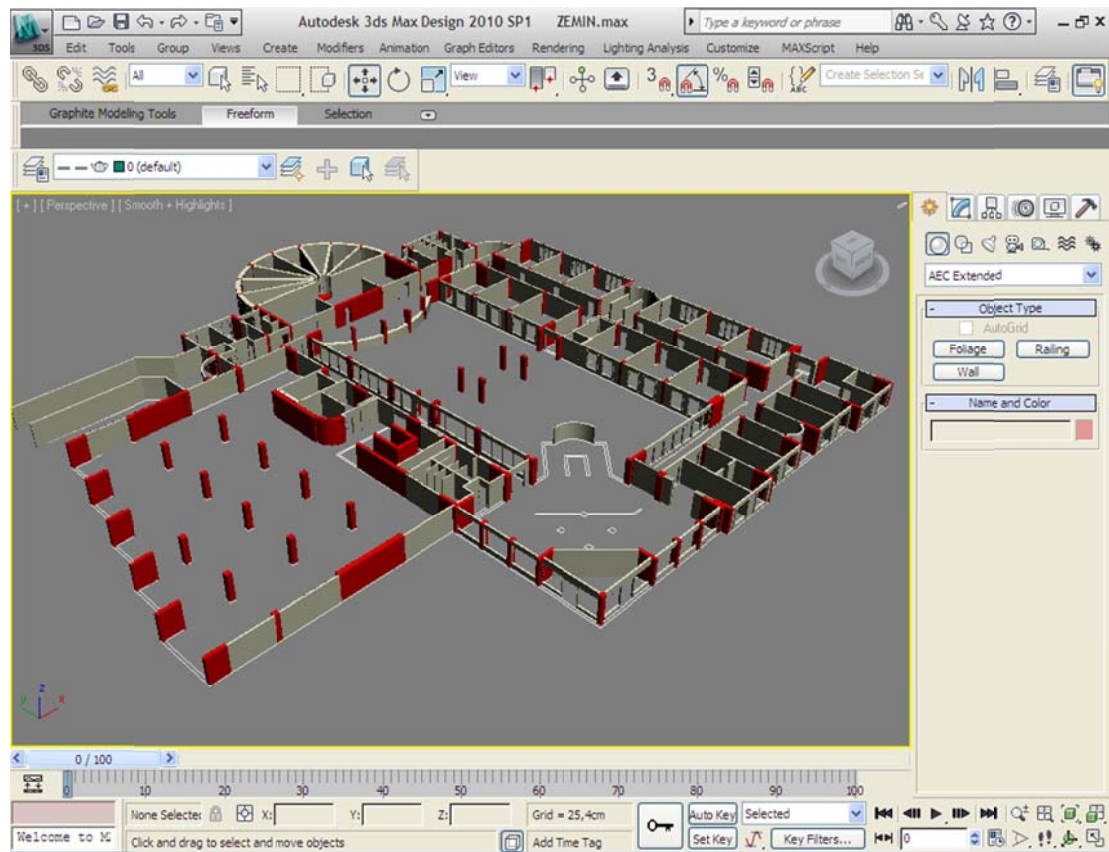


Figure 4.12 View of walls built in ground floor by using Wall command.

Doors and windows (in 3D Studio Max) were used for doors and windows. We used this system because this system enabled us to make a space while building walls automatically (Figure 4.13).

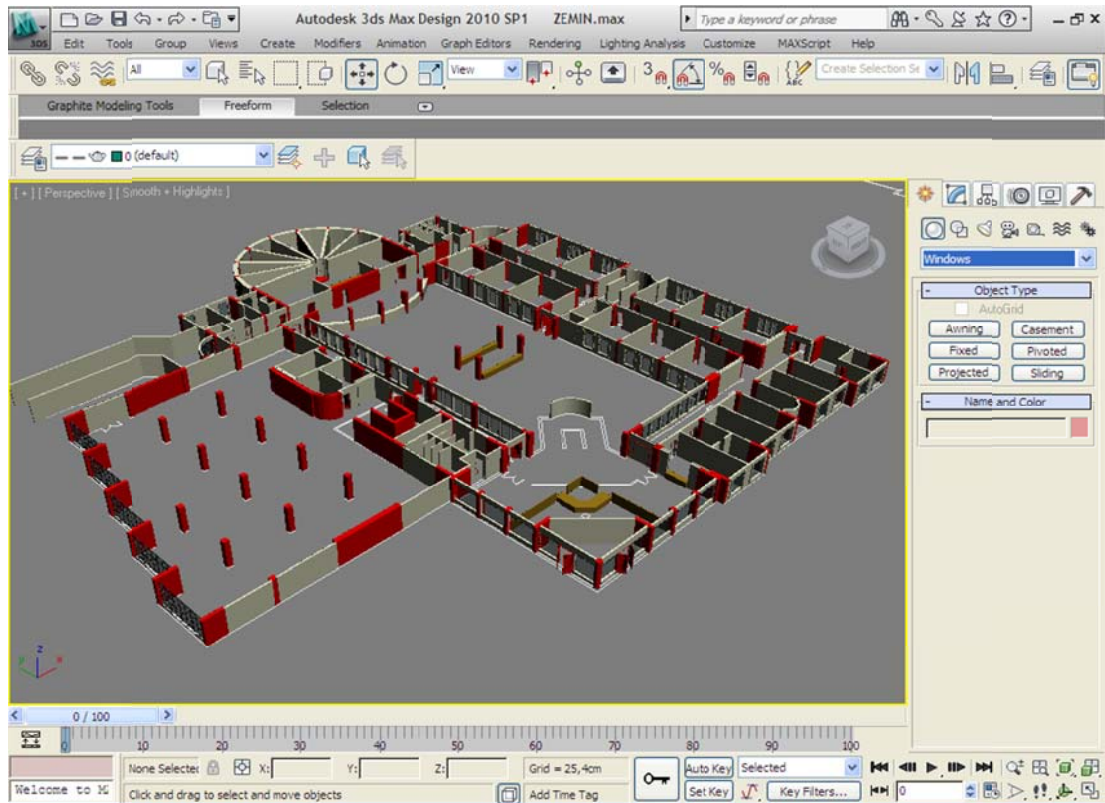


Figure 4.13 View of ground floor built with doors and windows in 3ds Max.

Stairway system (in 3D Studio Max) was used for stairs. (Figure 4.14)

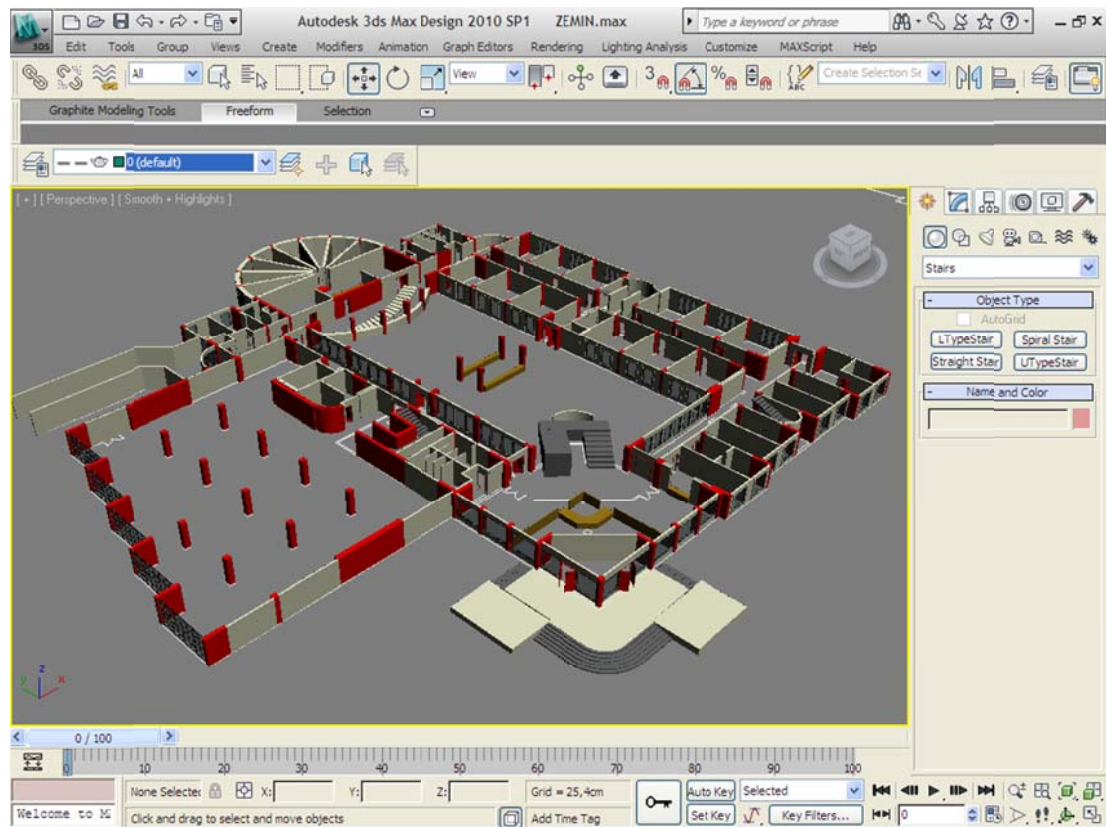


Figure 4.14 Stairs applied on ground floor with Stairs command.

For tiles and ceiling panel, floor environment was drawn with Line command and elevated with Extrude command. (Figure 4.15)

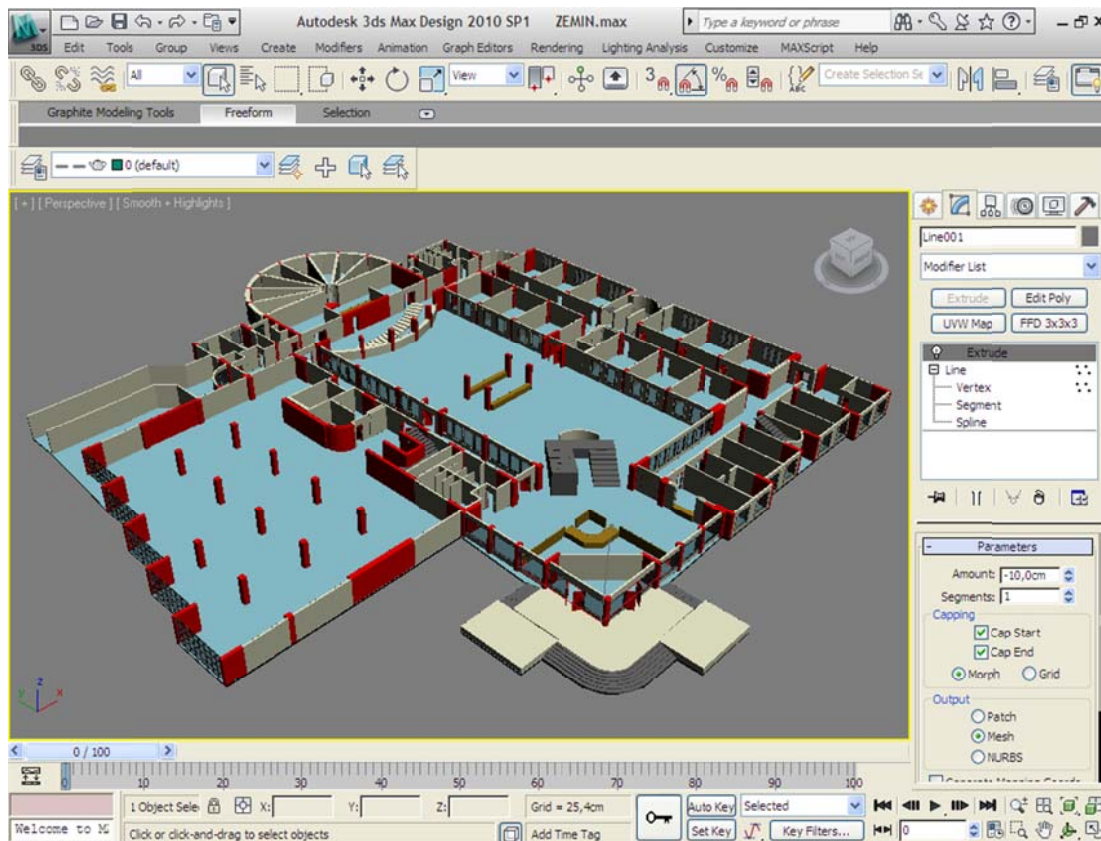


Figure 4.15 Ground floor tiles elevated with Extrude command.

As is seen in Figure 4.16, 4.17 and 4.18, all implementations (carried out on ground floor of Library) were carried out on cellar, first floor and second floor respectively.

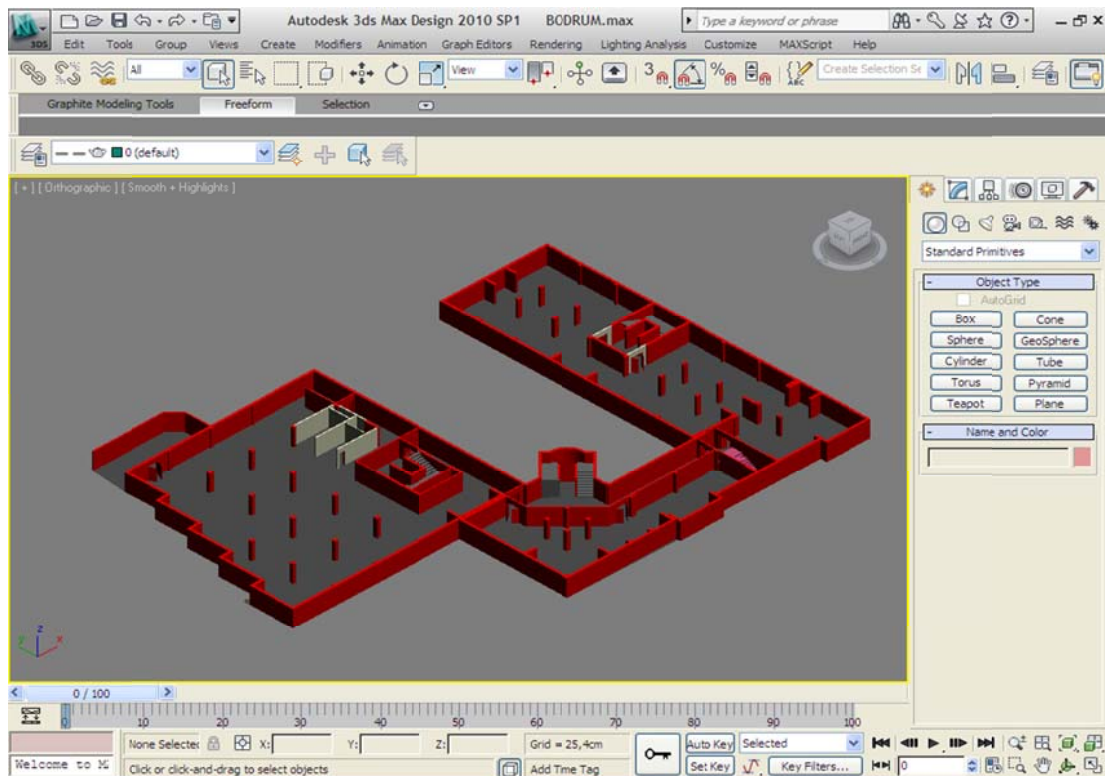


Figure 4.16 3D Studio Max view of cellar of Library.

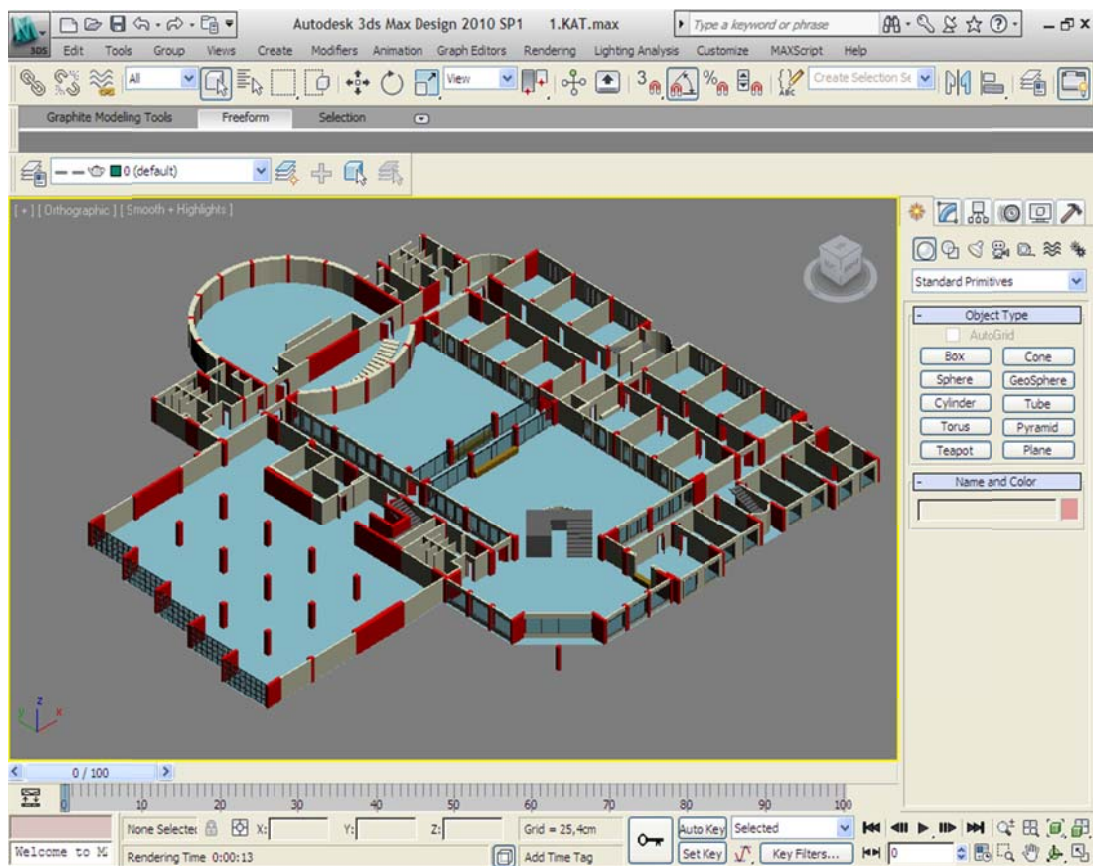


Figure 4.17 3D Studio Max view of first floor of Library.

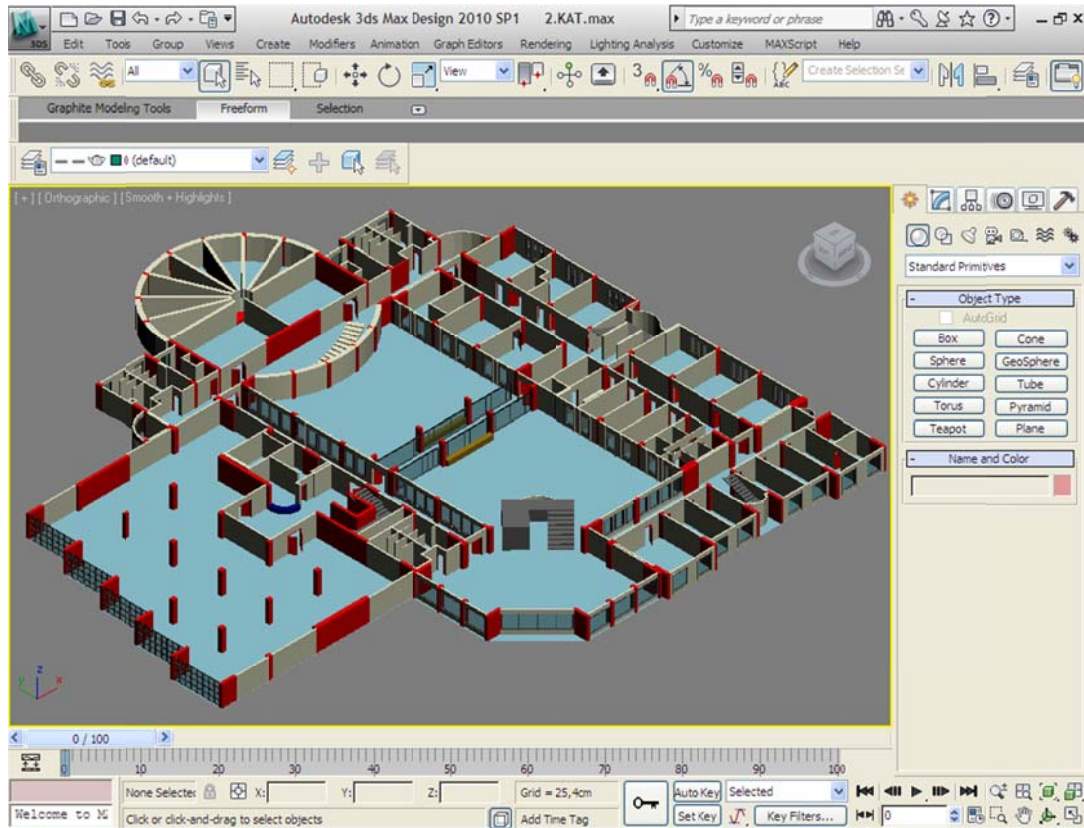


Figure 4.18 3D Studio Max view of second floor of library.

All floors were modeled and after modeling, these were combined. (Figure 4.19)



Figure 4.19 Render View of The Graduate School of Natural and Applied Sciences.

For modeling of Institute of Science, the same proceedings made for Library were carried out. 3D view of Institute of Science is shown in Figure 4.20.

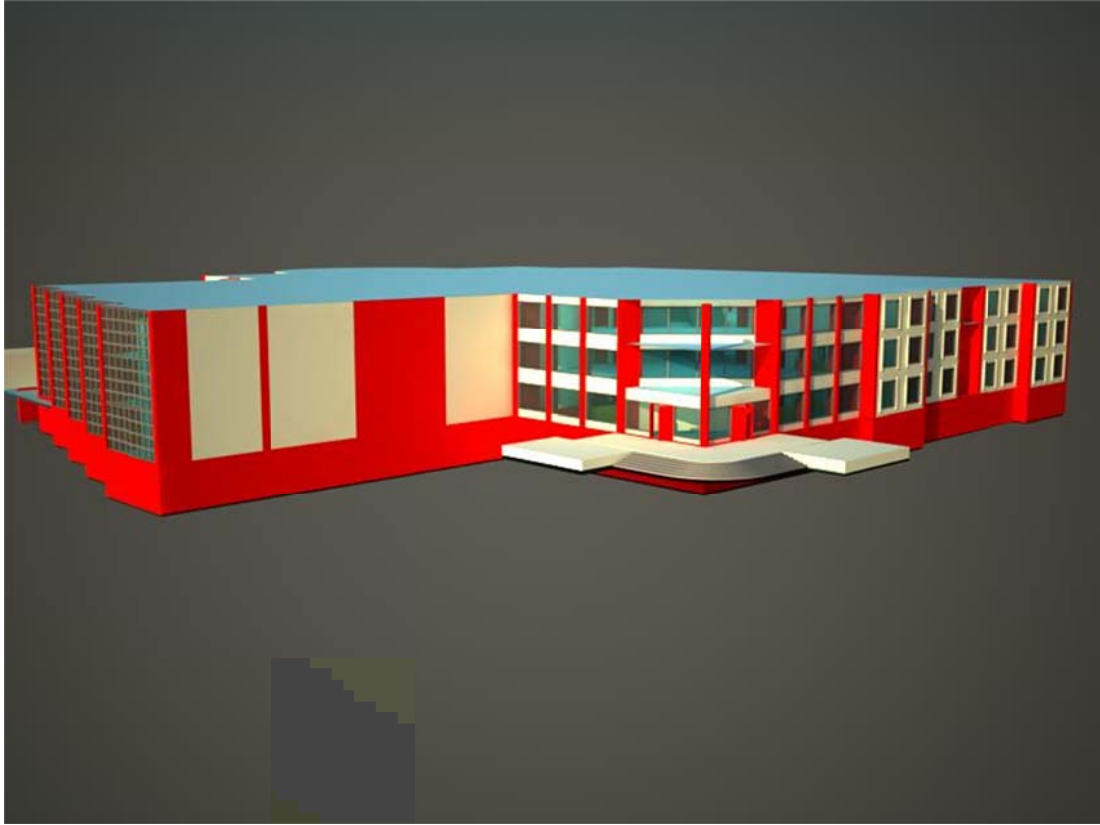


Figure 4.20 Render view of Library.

4.2 Using of 3D Model in ArcGIS Environment

Transferring of buildings modelled as 3D to ArcGIS environment.

4.2.1 Obtaining Data

CAD files of buildings in Dokuz Eylül University Tınaztepe Campus were obtained from Institute of Sciences Geographical Information Systems R&D (Arge) department.

Geodatabase and Feature Dataset should be formed in the related coordinate system in order that 3D model can be used in ArcGIS environment. Hence, a personnel Geodatabase named as Dokuz Eylül in Wokspace folder in ArcCATALOG environment and a Feature Dataset named as Tınaztepe_Kampus in this Geodatabase were created. European Datum 1950 UTM 35N was selected as coordinate system.

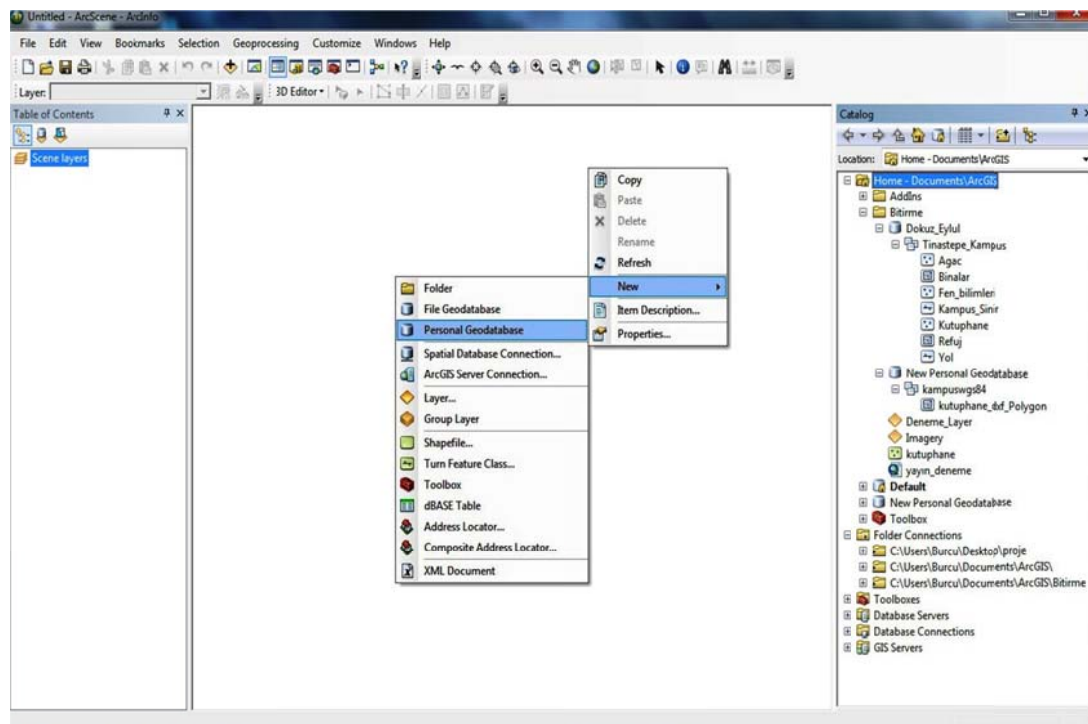


Figure 4.21 Creation of Personnel Geodatabase

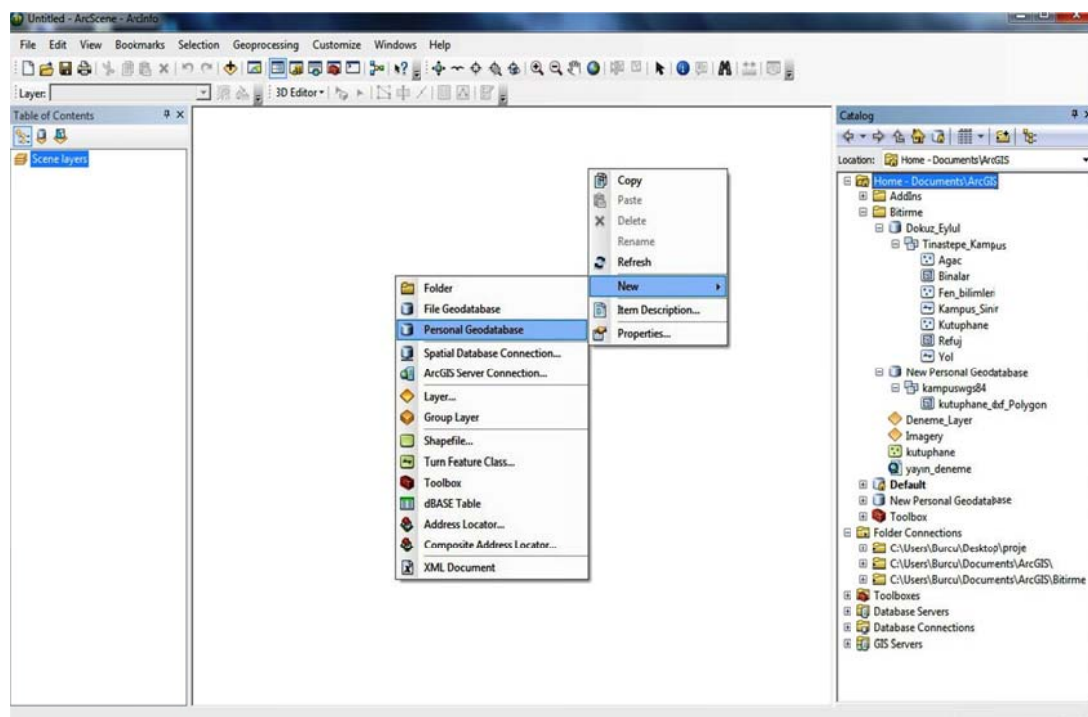


Figure 4.22 Creation of Feature Dataset and Identification of Coordinate System

There are two methods in order that 3D models of Institute of Sciences and Library prepared in Autodesk 3D Studio Max program can be imported to ArcGIS environment. However, before application of these two methods, study prepared in 3d Studio Max environment should be recorded as 3ds spanned. For this, as is seen in Figure 4.23 , files named as “Fen Bilimleri.3ds” and “kutuphane.3ds” were exported to Workspace folder by using File-Export commands in 3ds Max program menus.

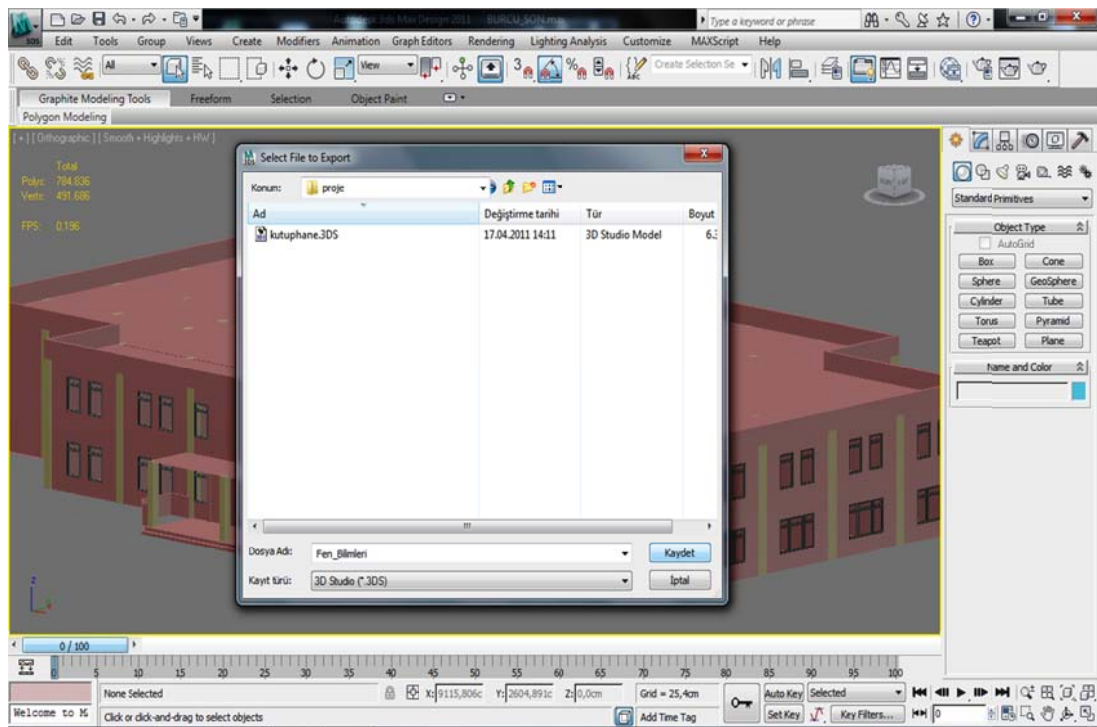


Figure 4.23 Creation of 3ds extension Max file

4.2.2 3D Data Transfer by the help of ArcToolbox

Transferring of file which was created with ArcToolbox (one of ArcGIS modules) to ArcScene or ArcGlobe programs is as follows. In window opened by ArcToolbox-3D Analyst Tools-Conversion-From File-Import 3D Files commands (Mode?) and in the part of “Input Files”, positions of files “Fen_Bilimleri.3ds” and “kutuphane.3ds” created before Browser were shown. In the part of “Output MultiPatch Feature Class” the position of Feature Dataset created beforehand was showed and the name of FenBilimleri was given to the file in order to creation of feature class. Thus, 3D model was imported to ArcScene environment.

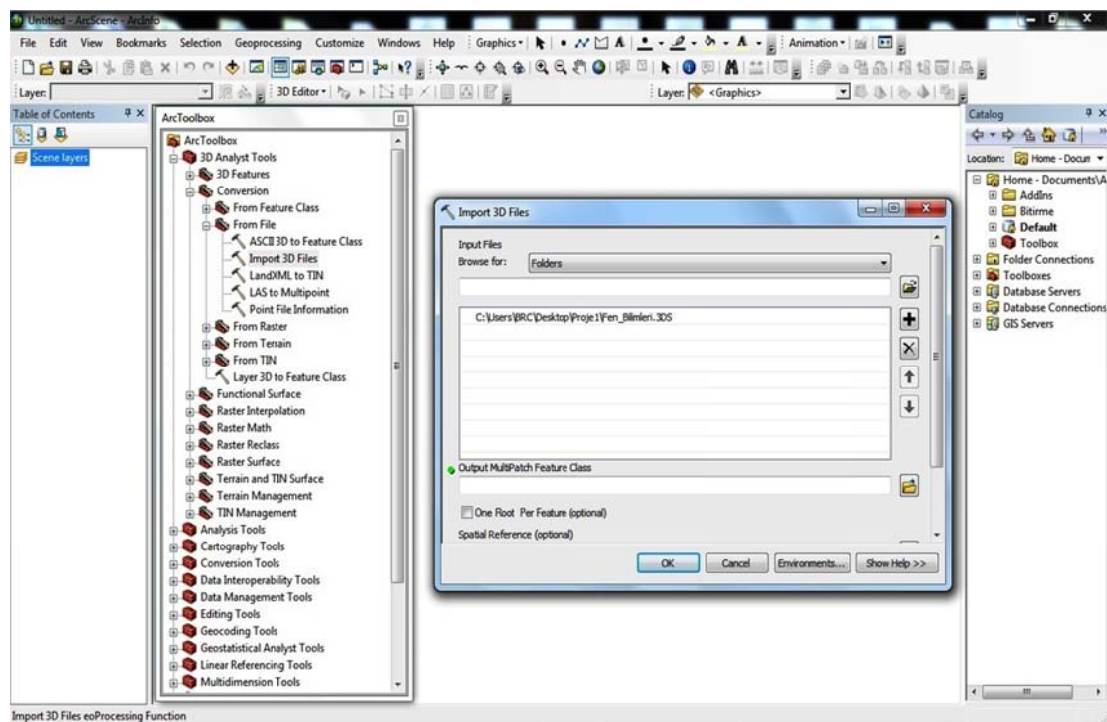


Figure 4.24 Being imported of Max file

4.2.3 Addition of 3D Model to Symbol Catalogue

In the other method of transferring 3D model to ArcScene environment, a feature class whose geometry is point was created in feature dataset corresponding to positions of Institute of Sciences and Library in ArcCatalog. This feature class was added to ArcScene as a layer. The tab of Properties was chosen by right clicking the feature class which was added to layer catalogue. The commands Symbology-Symbol-Properties-Type-3D Marker Symbol were chosen and then the position of files “Fen_Bilimleri.3ds” and “Kutuphane.3ds” which were exported from 3ds Max program was shown and written down. Followed procedure steps were showed in Figure 4.25.

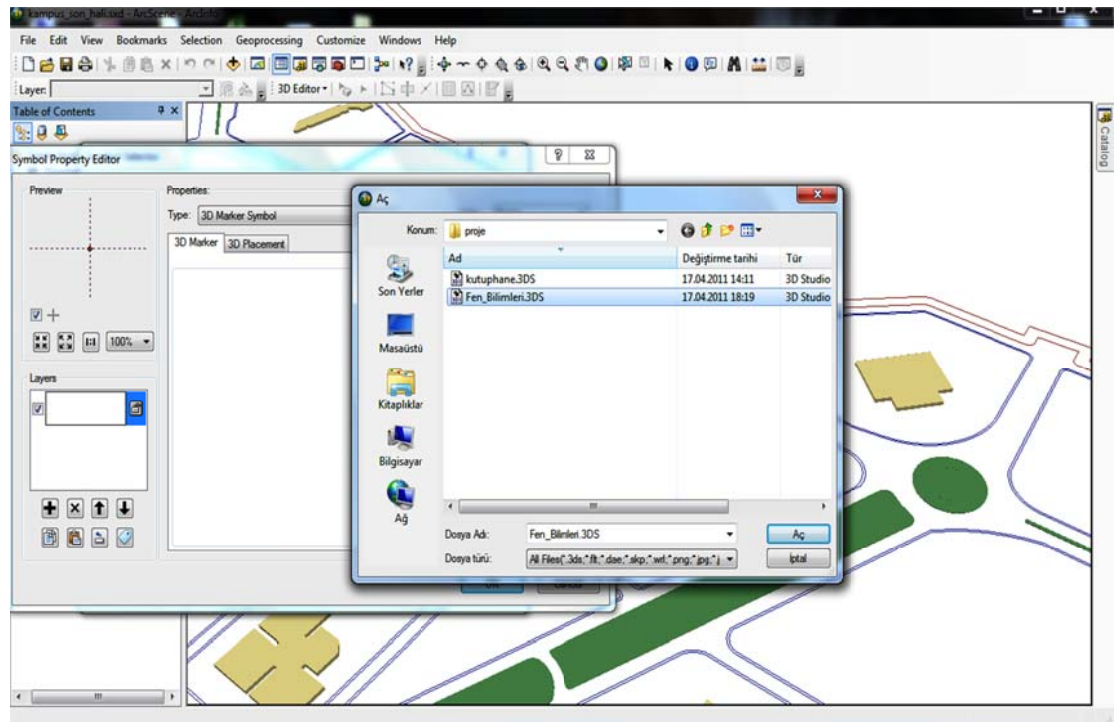


Figure 4.25 Transferring of buildings modeled in 3ds Max to ArcScene environment.

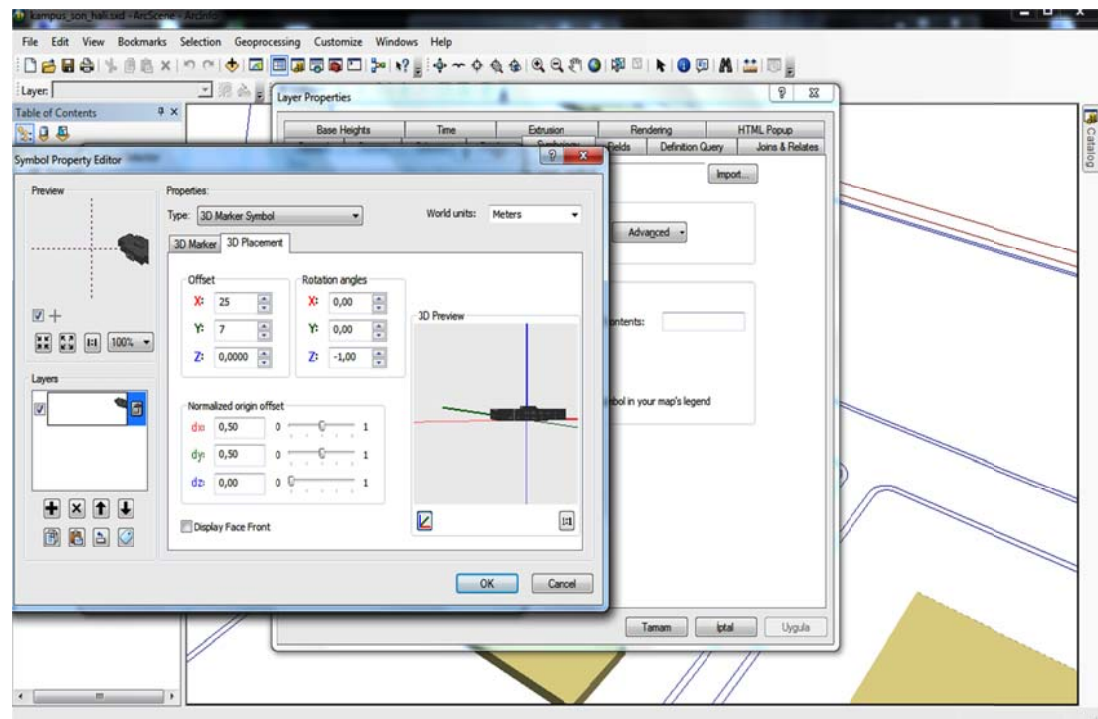


Figure 4.26 Addition of 3D model to symbol catalogue.

After 3D model prepared in 3D Studio Max was added to ArcGIS symbol catalogue, the new view of feature class whose geometry is point is as follows. Thus, 3D model was imported to ArcScene environment correspondingly.

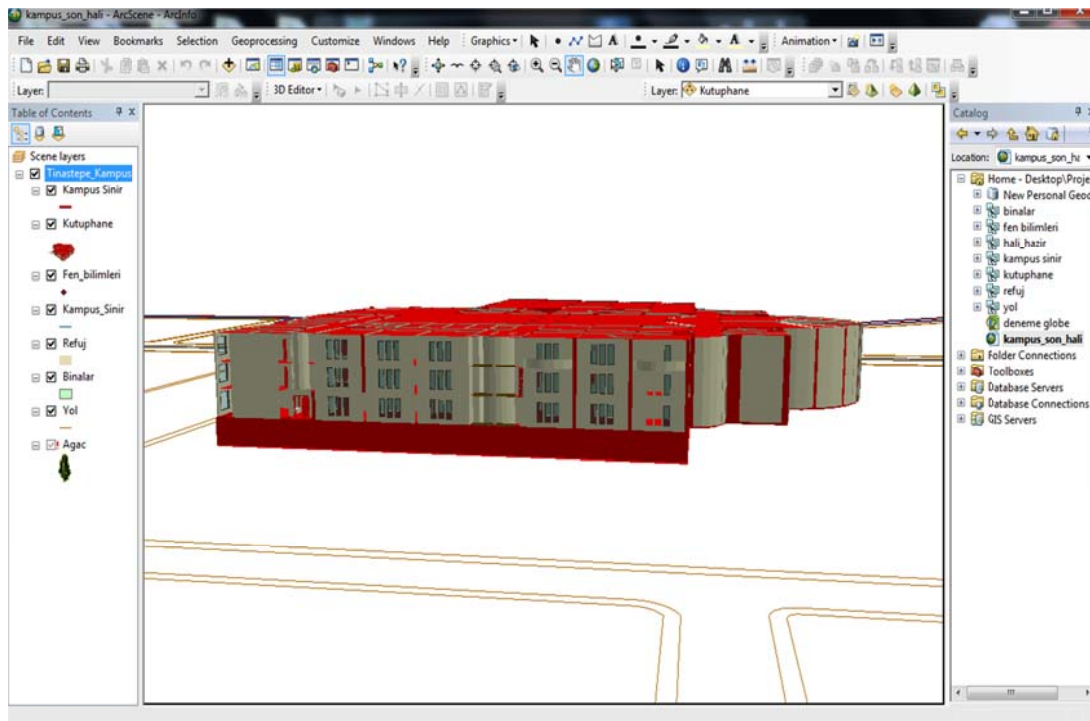


Figure 4.27 View of the model whose geometry is point and which was added to symbol catalogue in ArcScene

4.2.4 Usage of 3D Model

Dokuz Eylul University Tinaztepe Campus map was designed in AutoCAD environment and this map was operationalized. Buildings and some objects whose names are Fen_Bilimleri, Kutuphane, Kampus_Sinir, Refuj, Yol, Agac and their geometries are point, polyline and polygon were created at different layers. Hence, objects whose geometries are the same but they are different from each other in ArcGIS environment was showed with different symbols.

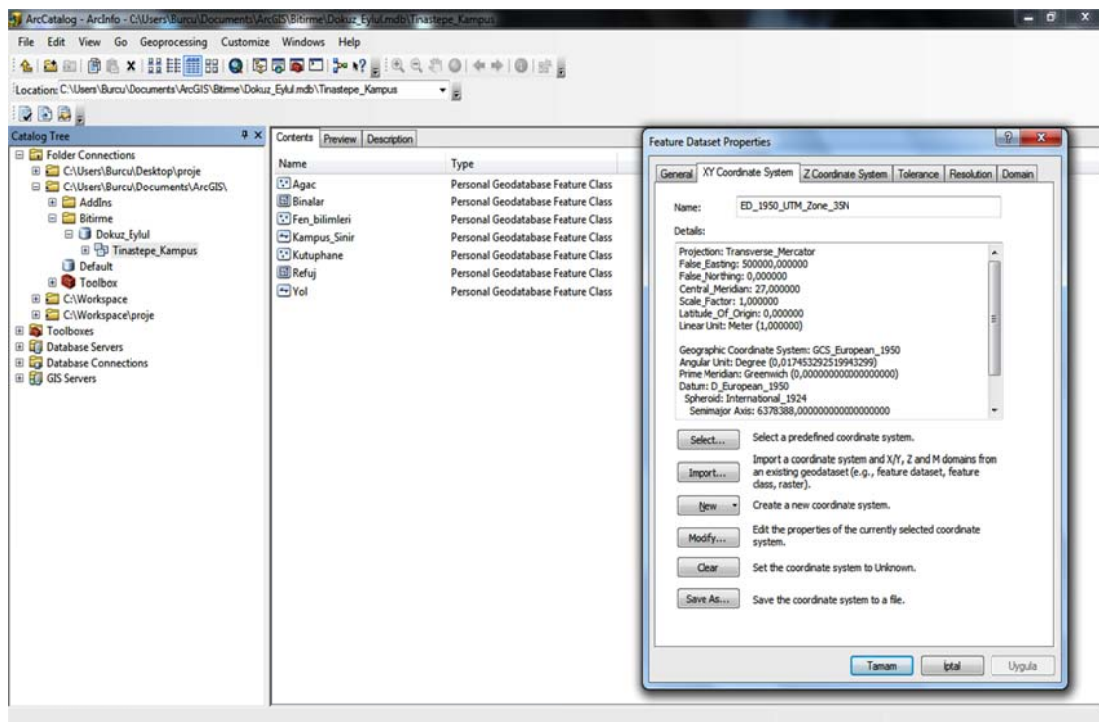


Figure 4.28 Formation of data layers.

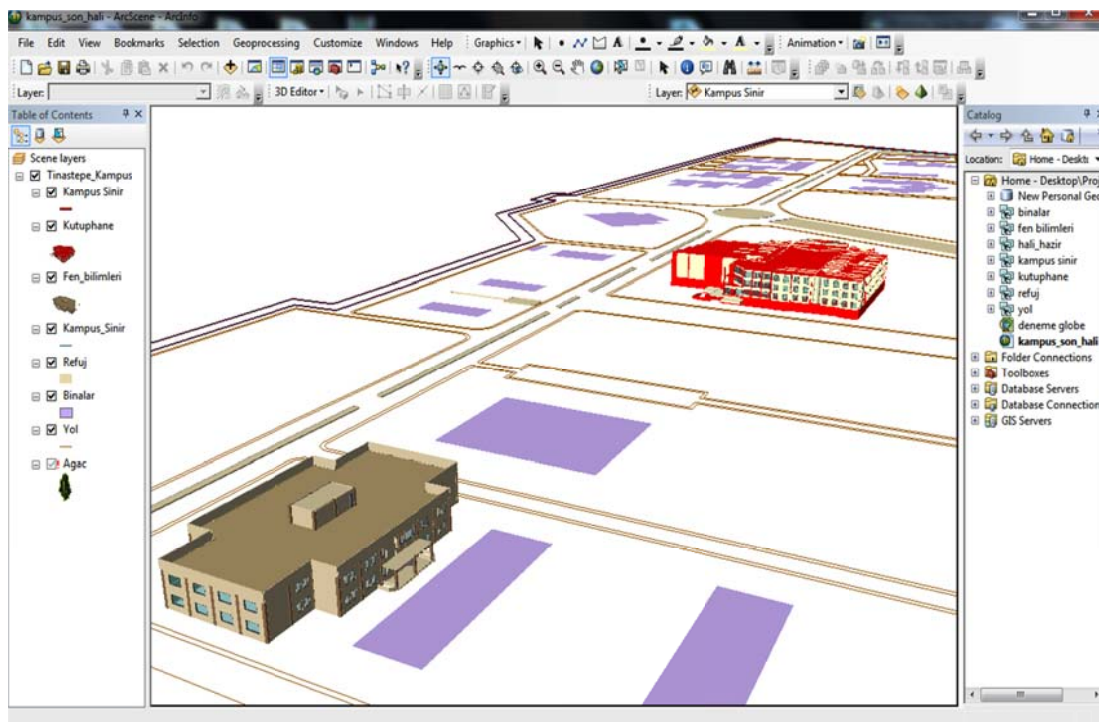


Figure 4.29 Transferred state of 3D models of Sciences and Library buildings

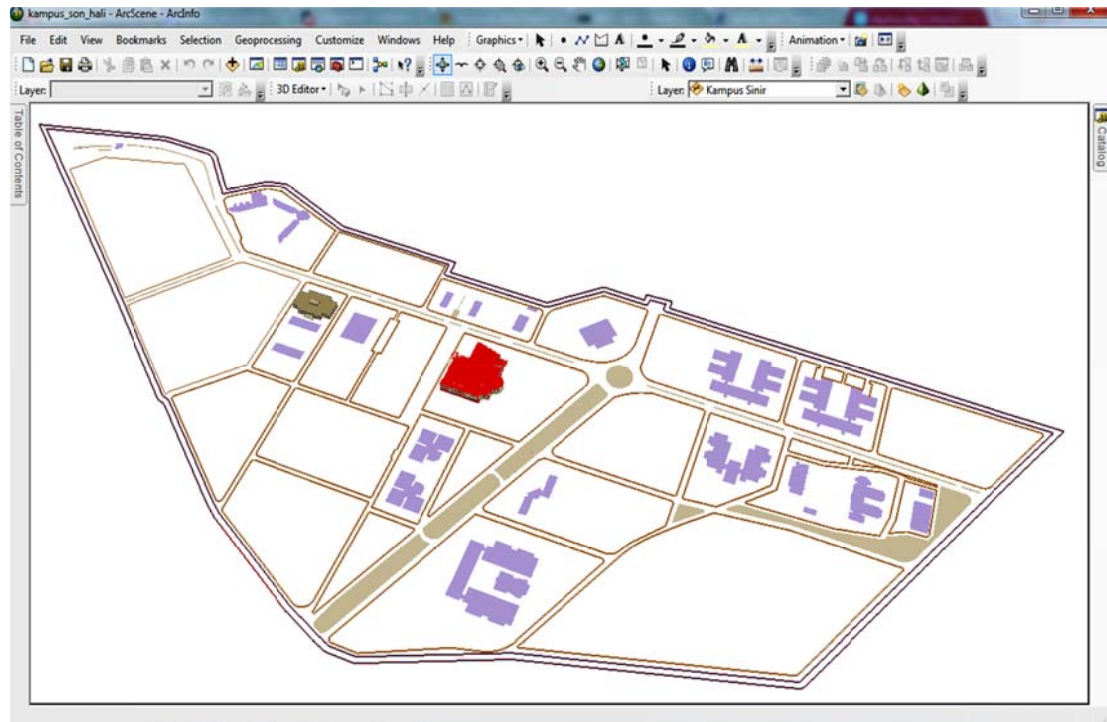


Figure 4.30 Top View of the Land.

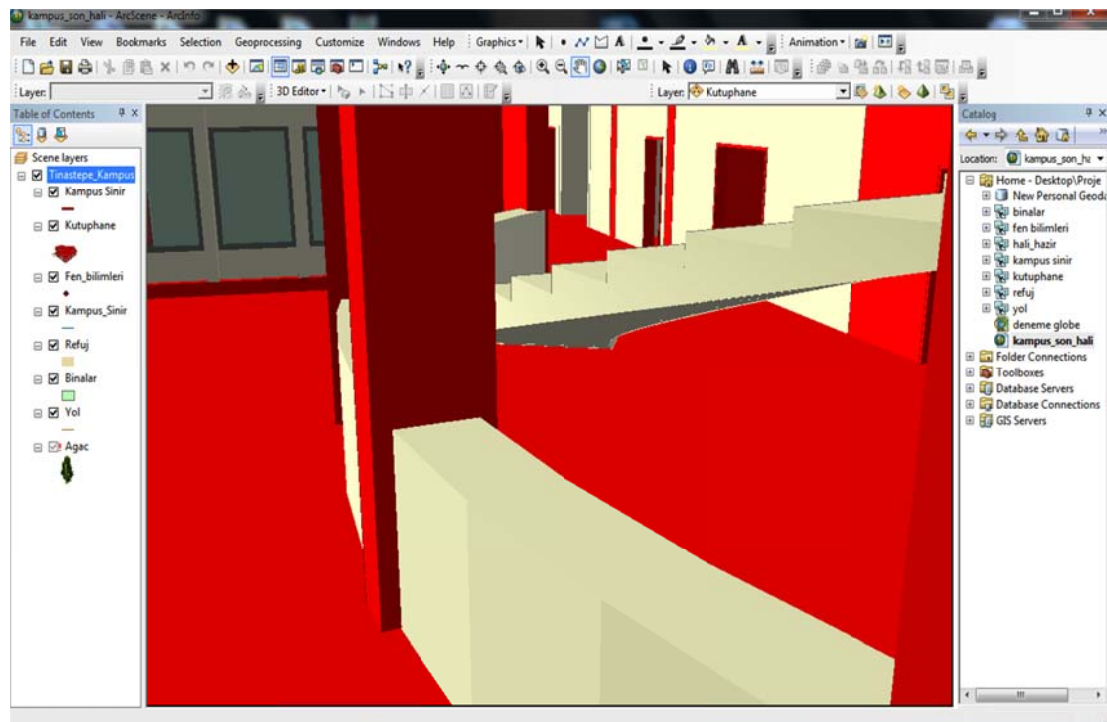


Figure 4.31 Detailed view of 3D interior of Library.

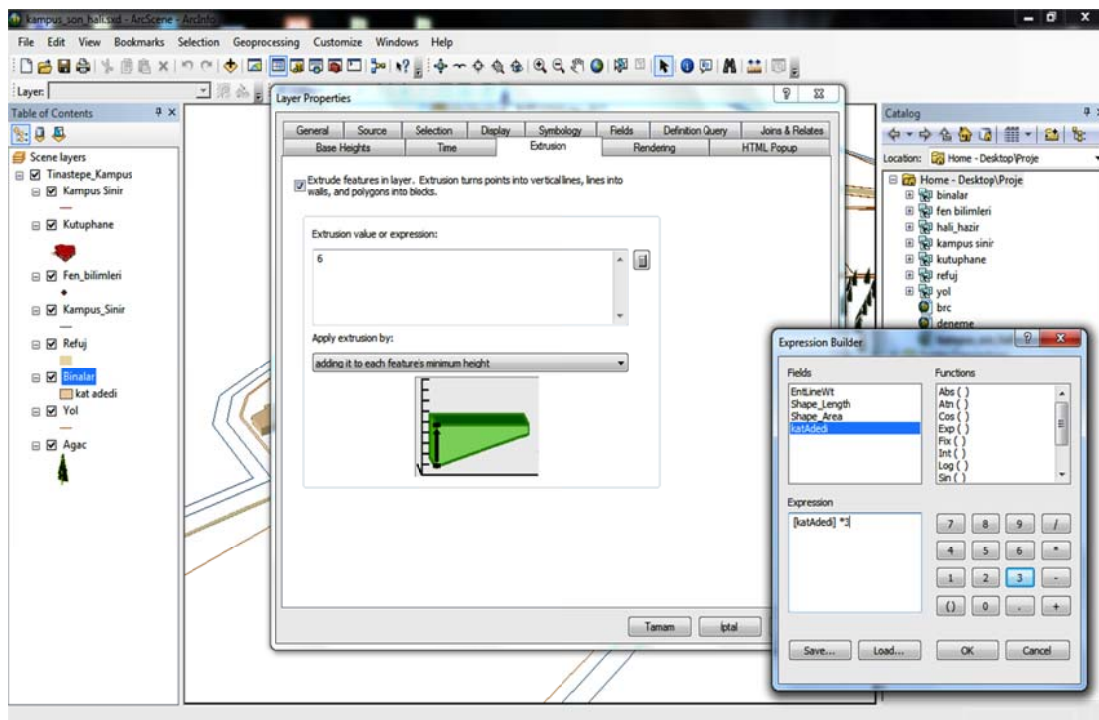


Figure 4.32 Uplifting of other buildings not modeled as 3D based on number of floors.

Also, GIS service named as ESRI Imagery World 2D presented to service via internet was added to the system by entering <http://services.arcgisonline.com/v92> by Add ArcGIS Server commands in ArcCatalog environment.

ArcGIS Server program which is web-enabling GIS server of ESRI does not recognize .sxd spanned file of ArcScene program as a 3D map document. Instead of this, it recognizes .3ds spanned ArcGlobe file. For this, applications done in ArcScene program were carried into ArcGlobe program and a 3ds spanned file of campus map was saved in workspace folder. The file named as “kampus.3ds” was served to ArcGIS server by using Publish to ArcGIS Server commands and right clicking this file in ArcCatalog environment.

4.2.5 Conclusion of ArcScene Study

However, 9.3.1 version and 10 version of ArcGIS program supports 2D map and analytic services as Web Mapping Application, it does not support 3D mapping services. So, Web Mapping Application could not be created for Globe Service

served to ArcGIS server and 3D campus map of DEU Tinaztepe campus could not be presented on the web. ESRI announced that ArcGIS 11 version will have this feature and enable 3D mapping service soon.

4.3 Web Application Developed with Adobe Flash Professional CS5

User interface is designed for Web based Interactive campus map navigation and spatial-non spatial querying. There are some basic tools used at fundamental maps at the toolbar part. These basic tools are Actual Size, ZoomIn, ZoomOut and also campus buildings and enstitutes' names lists. When user clicked on radio button so info window is displayed related buildings' name and fotograph information on the map via this list.

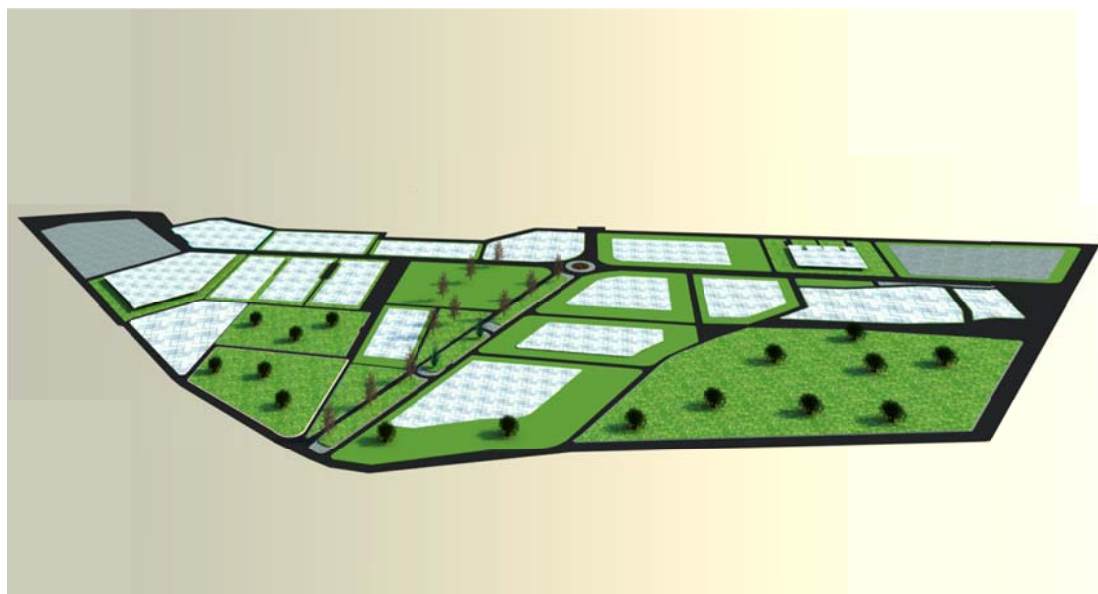


Figure 4.33 View of campus terrain which modeled with 3D Studio Max software.



Figure 4.34 After buildings ,which were modelled by 3D Studio Max software, were placed in campus terrain; Adobe Photoshop CS5 software was used for getting higher quality view.

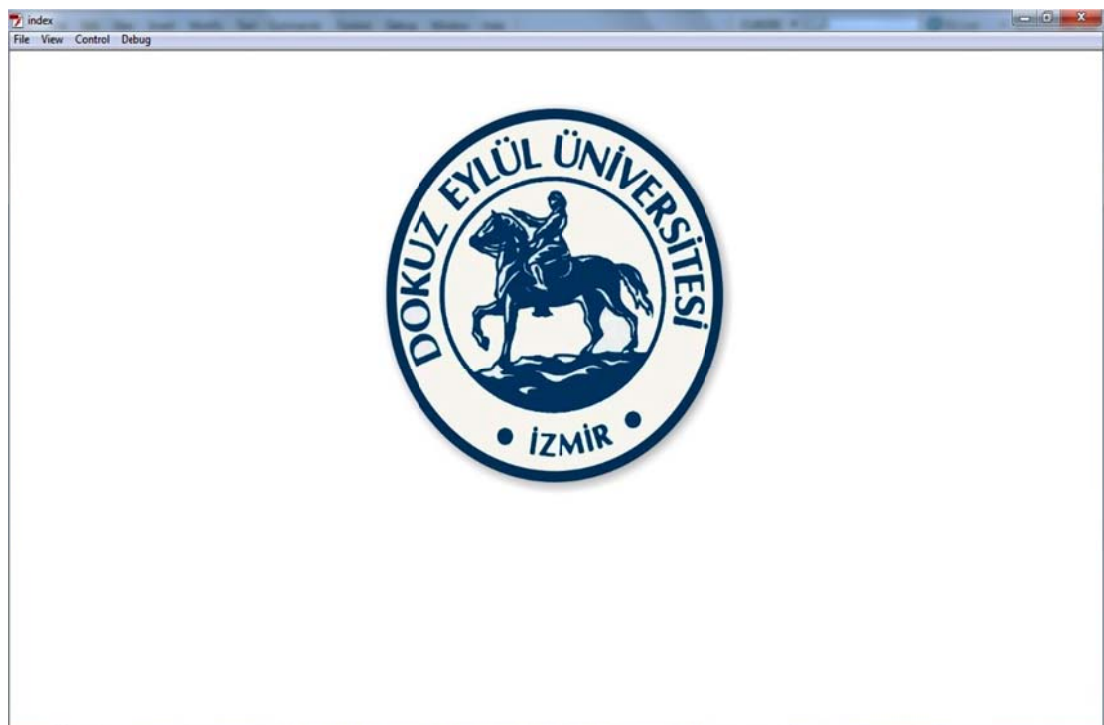


Figure 4.35 View of “Loading” of web home page application which was developed by Adobe Flash Professional CS5.

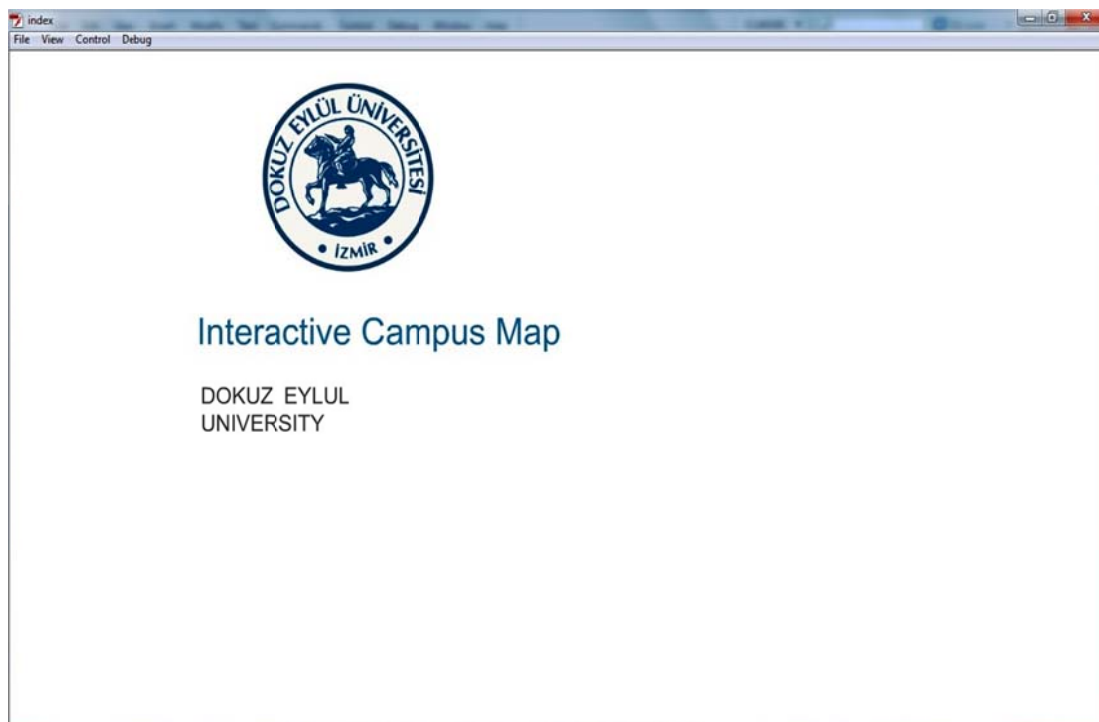


Figure 4.36 View of “end of Loading” of web home page application which was developed by Adobe Flash Professional CS5.



Figure 4.37. View of screen which gives information and picture view about Dokuz Eylül University Institute of Science and Technology.



Figure 4.38 View of screen which gives information and picture view about Dokuz Eylul University Civil Engineering laboratory.

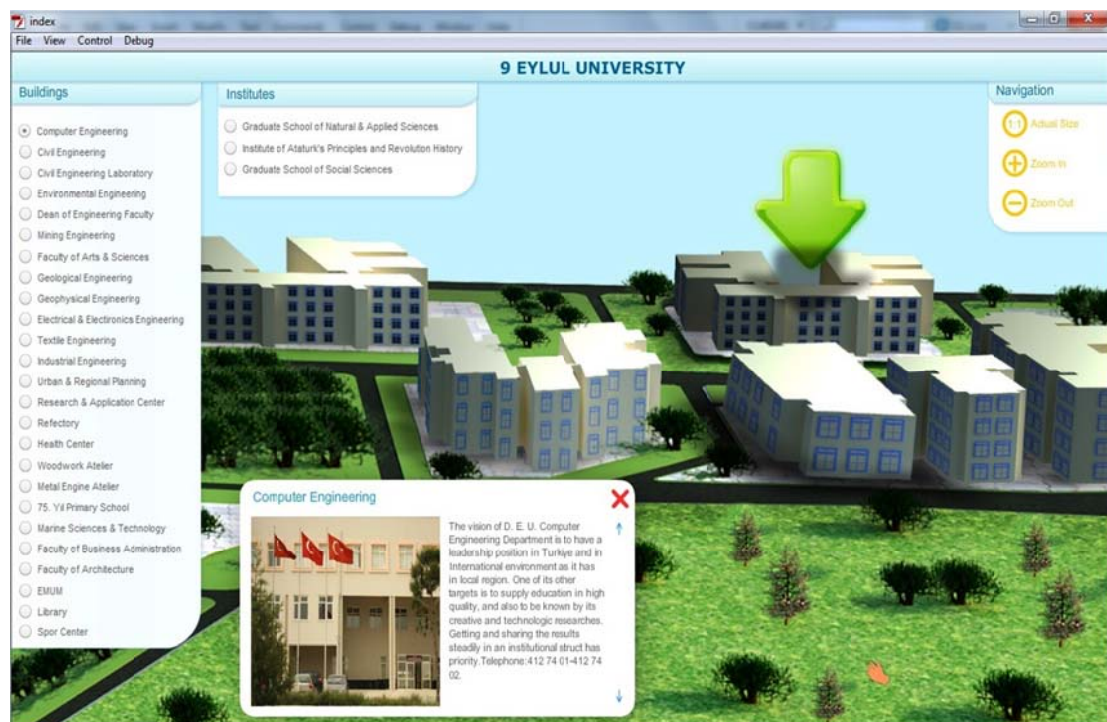


Figure 4.39 View of screen which gives information and picture view about Dokuz Eylul University Computer Engineering Faculty.

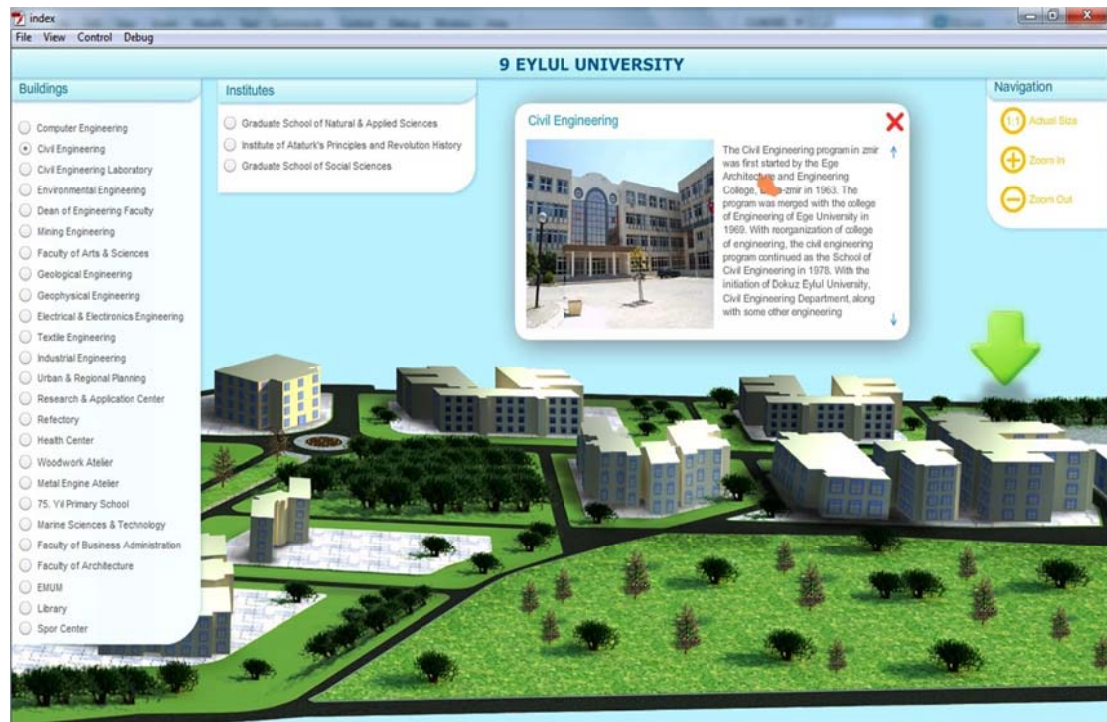


Figure 4.40 View of screen which gives information and picture view about Dokuz Eylul University Civil Engineering.



Figure 4.41 View of screen which gives information and picture view about Dokuz Eylul University library.



Figure 4.42 View of screen which gives information and picture view about Dokuz Eylul University sports hall.



Figure 4.43 View of screen which gives information and picture view about Dokuz Eylul university Textile Engineering.

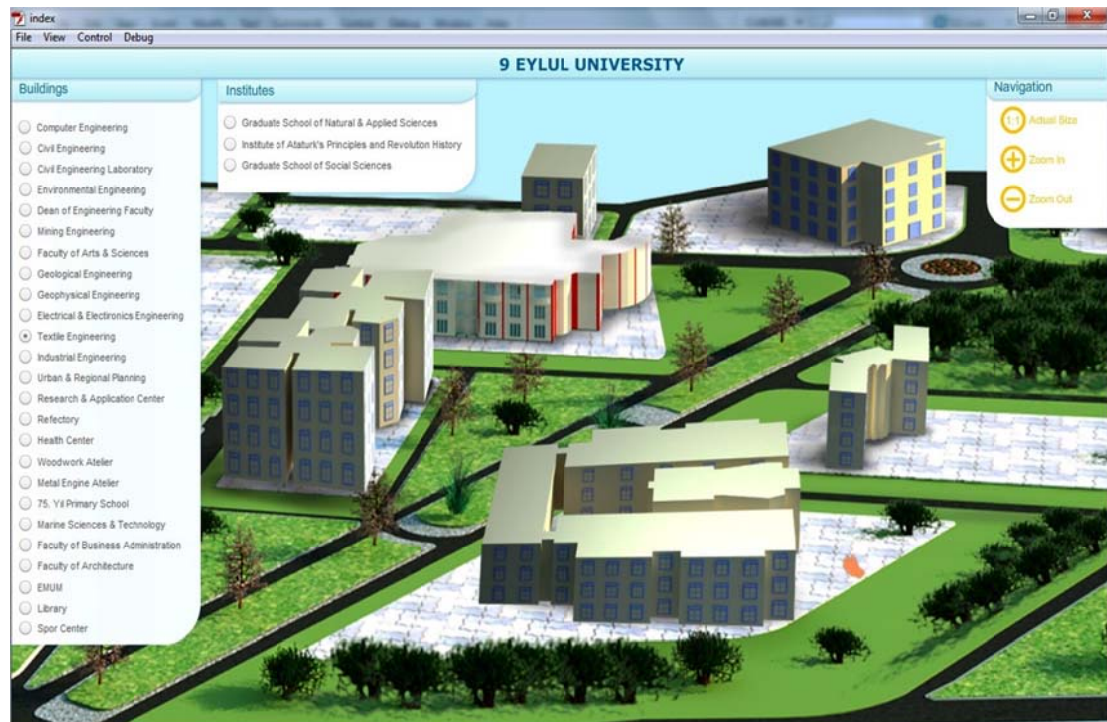


Figure 4.44 Screen view of dokuz Eylul University in maximum sizes.

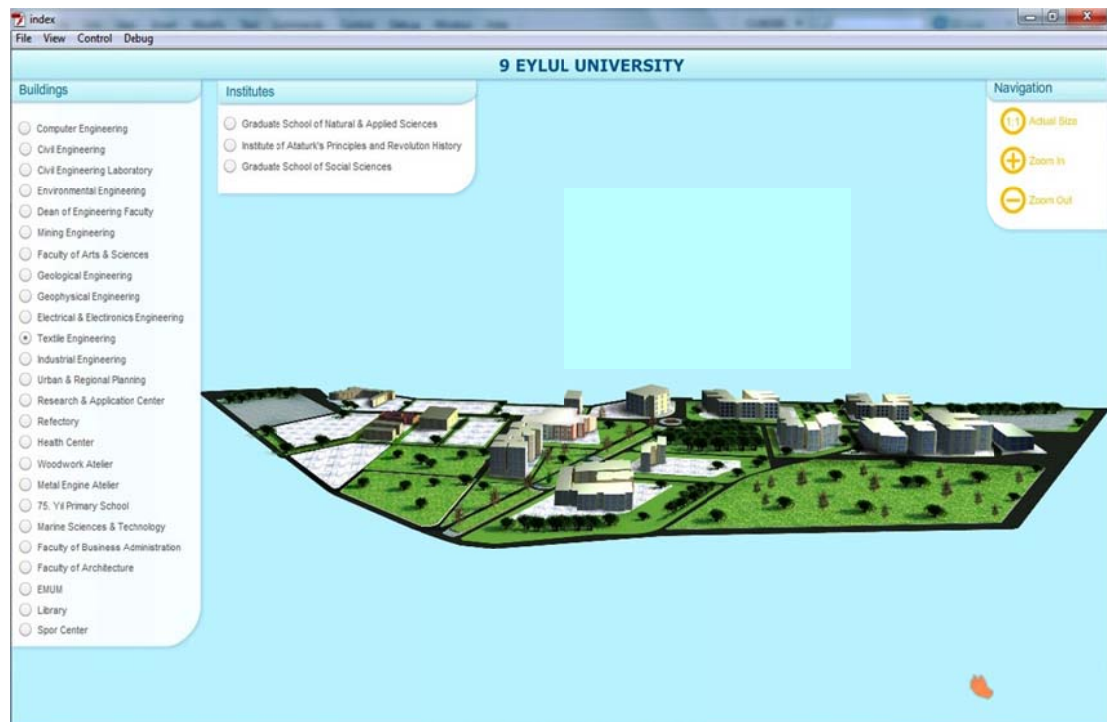


Figure 4.45 General overview of Dokuz Eylul University Tinaztepe Campus.

CHAPTER FIVE

CONCLUSION AND FUTURE WORK

Geographical Information Systems have been used for many disciplines nowadays. Gathering of different information under a single system, analyzing, examining and reaching of the information are the most important reasons which make Geographical Information Systems attractive.

Universities should create information technology based Campus Information System in order that they give better service toward modern management perception. Even if the purposes of universities in campus are pretty different from each other, these universities fulfill functions of small towns. In order to education and research, the existence of necessary places, student and staff services are the main functions for universities. It is obvious that all these activities around campus are held in an organized way. However, obtaining necessary information about campus is the only way for rapid growth of campus. Information Systems regarding location of campus are required particularly in the current information age. The studies done on this subject in many universities around the world show that there is a rapid improvement in this consideration.

From this point of view, an information system design was made and applied for the study “Dokuz Eylul University Interactive Campus Map”. This Project was developed in parallel with the main philosophy of the Geographical Information Systems. At first, necessary digitization was made, graphical information was obtained also, they were associated with data bases consisting of verbal information. After than, the layers whose topologic structures were formed in AutoCAD environment were transferred to ArcScene environment and analysis regarding location were created. After this analysis, 3D Studio Max software and 3D campus modeling were made. The examinations done beforehand show that thanks to system, inventories like planning, green field, way, building and etc could be obtained also, decisions regarding education, student, staff management and future could be made more rapidly.

It was aimed with study “Interactive Campus Map” that student, lecturers and administrative staff also some people (who do not know campus life) benefitted from the system. For example, the candidates to be gotten into the Dokuz Eylul University Tınaztepe Campus can reach the information about university, buildings and campus in easier way.

In conclusion, a 3D web-based pilot project in which spatial possibilities and verbal and graphical data about campus are used together was realized. The system in which we obtain only building based information will provide indoor query through advancing technology.

Finally, Spatial Information Systems, is expected to create the basic functions of spatial information, store, analyze, and share them. That perform these operations on a long-time 2D data Spatial Information System technology, today it is expected to perform transactions via the 3D data for 3D applications. However, all the analysis performed on the 2D data and perform operations on data in a 3D Spatial Information System technology is not readily available. For this reason, today's Spatial Information System research focused largely on the realization of the 3D analysis functions.(XYZ journal).

5.1 The Problems Which We Faced During This Study

Some problems were confronted during design and application phases in order to create project “Interactive Campus Map”. Particularly in design phase, obtaining data bases and associating with them are rather complex issues. As an example, during data was added to Oracle 11g database and 3D query, license problem was faced. In 3D spatial query which is wished to be done on building basis, the problem of recognition because of z coordinate added to x and t coordinates was confronted. The similar problems were emerged in “Interactive Campus Map” studies done in Turkey and abroad. Therefore, 3D studies are unable to go beyond simple applications or internet broadcast could be done with 2D studies. For example, the study named as

“3D Spatial Query Language for Building Information” by Andre Borrmann is one of the effective studies done on this field; however, it can be examined on floor basis. It has not provided indoor query yet. Although, the problems confronted in this issue will be solved owing to the advancing technology and R&D studies with Geographical Information Systems software.

Although, 3D campus model can be broadcasted with KML via Google-Earth, an additional study was done in order that it could not provide 3D query with current technology. Internet broadcast was realized by creating a 2.5D (isometric) campus model with Adobe Professional CS5 software and users could reach the information regarding building.

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APPENDICES

List of Codes

Loading

```

import flash.events.Event;
stage.scaleMode = StageScaleMode.NO_SCALE;

stage.align=StageAlign.TOP_LEFT;

stage.addEventListener(Event.RESIZE, ortalala);

function ortalala(olay:Event):void
{
    ani_mc.x= stage.stageWidth / 2;
    ani_mc.y=stage.stageHeight / 2 - 100;

    bg_mc.width = stage.stageWidth;
    bg_mc.height=stage.stageHeight;
    bg_mc.x=0;
    bg_mc.y=0;
}

import flash.events.MouseEvent;
import flash.events.Event;
import fl.transitions.Tween;
import fl.transitions.easing.*;

navigation_mc.x= stage.stageWidth;

stage.scaleMode = StageScaleMode.NO_SCALE;

stage.align=StageAlign.TOP_LEFT;

    header_mc.width = stage.stageWidth;

stage.addEventListener(Event.RESIZE, boyutlandir);

function boyutlandir(olay:Event):void
{

```

```

        header_mc.width = stage.stageWidth;
        var baslikTween:Tween= new Tween(baslik_mc, "x", Back.easeOut,
baslik_mc.x ,(stage.stageWidth- baslik_mc.width)/2, 0.5, true);
        navigation_mc.x= stage.stageWidth;

        var gelisX:Tween=new Tween(bilgi_mc, "x", Back.easeOut, bilgi_mc.x,
stage.stageWidth/2, 0.6,true);
        var gelisY:Tween=new Tween(bilgi_mc, "y", Back.easeOut, bilgi_mc.y,
stage.stageHeight/2, 0.6,true);

    }

area_mc.scaleX= 0.4;
area_mc.scaleY=0.4;

stage.addEventListener(MouseEvent.MOUSE_WHEEL,dene);

function dene(olay:MouseEvent):void
{
    if (olay.delta > 0)
    {
        if (areaW < 0.9)
        {
            areaW += 0.05;
            areaH += 0.05;

            var buyu:Tween=new Tween(area_mc,"scaleX",Back.easeOut,areaW,(areaW + 0.05),0.5,true);
            var kucul:Tween=new Tween(area_mc,"scaleY",Back.easeOut,areaH,(areaH + 0.05),0.5,true);
        }
    }

    if (olay.delta < 0)
    {
        if (areaW > 0.2)
        {
            areaW -= 0.05;
            areaH -= 0.05;

```

```

        var buyu2:Tween=new
Tween(area_mc,"scaleX",Back.easeOut,areaW,(areaW - 0.05),0.5,true);
        var kucul2:Tween=new
Tween(area_mc,"scaleY",Back.easeOut,areaH,(areaH - 0.05),0.5,true);
    }
}
}

```

```

var areaW:Number = 0.4;
var areaH:Number = 0.4;

```

```

stage.addEventListener(Event.ENTER_FRAME, imlecSurekli);

```

```

function imlecSurekli(olay:Event):void
{
    Mouse.hide();
    handOpen_mc.x= mouseX ;
    handOpen_mc.y = mouseY;
    hand_mc.x= mouseX ;
    hand_mc.y = mouseY;
}

```

```

area_mc.addEventListener(MouseEvent.MOUSE_DOWN, surukle);
area_mc.addEventListener(MouseEvent.MOUSE_UP, birak);

```

```

hand_mc.visible = false;
function surukle(olay:MouseEvent):void
{
    area_mc.startDrag();
    addEventListener(Event.ENTER_FRAME, surekli);
}

```

```

function birak(olay:MouseEvent):void
{
    area_mc.stopDrag();
    hand_mc.visible = false;
    handOpen_mc.visible=true;
}

```

```

        removeEventListener(Event.ENTER_FRAME,surekli);
    }

    navigation_mc.buyut_btn.addEventListener(MouseEvent.MOUSE_DOWN, buyut);
    // işte burada;
    navigation_mc.kucult_btn.addEventListener(MouseEvent.MOUSE_DOWN, kucult);
    // işte burada;

    function buyut(olay:MouseEvent):void
    {
        if (areaW < 0.9)
        {
            areaW += 0.05;
            areaH += 0.05;

            var buyu:Tween=new Tween(area_mc,"scaleX",Back.easeOut,areaW,(areaW + 0.05),0.5,true);
            var kucul:Tween=new Tween(area_mc,"scaleY",Back.easeOut,areaH,(areaH + 0.05),0.5,true);

        }
    }

    function kucult(olay:MouseEvent):void
    {
        if (areaW > 0.2)
        {
            areaW -= 0.05;
            areaH -= 0.05;

            var buyu:Tween=new Tween(area_mc,"scaleX",Back.easeOut,areaW,(areaW - 0.05),0.5,true);
            var kucul:Tween=new Tween(area_mc,"scaleY",Back.easeOut,areaH,(areaH - 0.05),0.5,true);

        }
    }
}

```

```

function surekli(olay:Event):void
{
    hand_mc.visible = true;
    handOpen_mc.visible=false;
    hand_mc.x = mouseX;
    hand_mc.y = mouseY;
    Mouse.hide();
}

/*
kutuphane_btn.addEventListener(MouseEvent.CLICK, kutuphane_goster);

function kutuphane_goster(olay:MouseEvent):void
{
    if (kutuphaneDurum == false)
    {
        kutuphane_isaret_mc.visible = true;

        area_mc.kutuphane1hover_mc.visible = true;
        area_mc.kutuphane2hover_mc.visible = true;
        area_mc.kutuphane1hover_mc.play();
        area_mc.kutuphane2hover_mc.play();
        kutuphaneDurum = true;
    }
    else if (kutuphaneDurum == true)
    {
        kutuphane_isaret_mc.visible = false;

        area_mc.kutuphane1hover_mc.visible = false;
        area_mc.kutuphane2hover_mc.visible = false;
        area_mc.kutuphane1hover_mc.play();
        area_mc.kutuphane2hover_mc.play();
        kutuphaneDurum = false;
    }
}
*/

navigation_mc.birebir_btn.addEventListener(MouseEvent.CLICK, birebir_yap);

function birebir_yap(olay:MouseEvent):void

```

```

{
    if (areaW != 1)
    {
        var buyu2:Tween = new Tween(area_mc,"scaleX",Back.easeOut,areaW,1,0.5,true);
        var kucul2:Tween = new Tween(area_mc,"scaleY",Back.easeOut,areaH,1,0.5,true);
        area_mc.scaleX = 0.4;
        area_mc.scaleY = 0.4;
        areaW=0.4;
        areaH=0.4;
    }
}

```

XML

```

import flash.net.URLRequest;
import flash.net.URLLoader;
import flash.events.Event;
import fl.transitions.Tween;
import fl.transitions.easing.*;
import flash.events.MouseEvent;
import flash.display.MovieClip;
stop();
var xmlDosyasi:XML= new XML();
var xmlListesi:XMLList= new XMLList();
//bilgi_mc.visible=false;
var xmlAdres:URLRequest= new URLRequest("data/datasource.xml");
var xmlYukleyici:URLLoader= new URLLoader();
bilgi_mc.visible=false;
area_mc.ok_mc.visible=false;
xmlYukleyici.load(xmlAdres);

xmlYukleyici.addEventListener(Event.COMPLETE, xmlYuklendi);

function xmlYuklendi(e:Event):void
{
    xmlDosyasi= XML(e.target.data);
    xmlListesi= xmlDosyasi.children();
}

```

```
menu1_mc.addEventListener(MouseEvent.CLICK, Goster);
```

```
function Goster(olay:MouseEvent):void
{
```

```
    //bilgi_mc.visible=true;
```

```
    //trace(olay.target.value);
```

```
    bilgi_mc.heading_txt.text=xmlListesi[olay.target.value].@heading;
```

```
    bilgi_mc.information_txt.text= xmlListesi[olay.target.value].@information;
```

```
    bilgi_mc.pic_mc.source=xmlListesi[olay.target.value].@image;
```

```
    bilgi_mc.visible=true;
```

```
    bilgi_mc.pic_mc.addEventListener(Event.COMPLETE, resimYuklendi);
```

```
    area_mc.ok_mc.visible=true;
```

```
    area_mc.ok_mc.x= xmlListesi[olay.target.value].@xKoor;
```

```
    area_mc.ok_mc.y= xmlListesi[olay.target.value].@yKoor;
```

```
    ///
```

```
    //    trace(area_mc.x -520);
```

```
    //    trace(area_mc.y + 120);
```

```
    //
```

```
}
```

```
function resimYuklendi(olay:Event):void
```

```
{
```

```
    //var gelisA:Tween=new Tween(bilgi_mc, "alpha", Regular.easeIn, 0, 1, 1,true);
```

```
    var gelisX:Tween=new Tween(bilgi_mc, "x", Back.easeOut, bilgi_mc.x, stage.stageWidth/2, 0.6,true);
```

```
    var gelisY:Tween=new Tween(bilgi_mc, "y", Back.easeOut, -300, stage.stageHeight/2, 0.6,true);
```

```
}
```

```
bilgi_mc.kapat_btn.addEventListener(MouseEvent.CLICK, bilgiKapat);
```

```
function bilgiKapat(olay:MouseEvent):void
```

```
{
    var gelisX:Tween=new Tween(bilgi_mc, "x", Back.easeOut, bilgi_mc.x,
stage.stageWidth/2, 0.6,true);
    var gelisY:Tween=new Tween(bilgi_mc, "y", Back.easeOut, bilgi_mc.y, -
300, 0.6,true);
    area_mc.ok_mc.visible=false;
}
```

```
bilgi_mc.addEventListener(MouseEvent.CLICK, bilgiSurukle);
bilgi_mc.addEventListener(MouseEvent.CLICK, bilgiBirak);
```

```
function bilgiSurukle(olay:MouseEvent):void
{
    bilgi_mc.startDrag();
    hand_mc.visible=true;
    handOpen_mc.visible=false;
    hand_mc.x= mouseX;
    hand_mc.y=mouseY;
}
```

```
function bilgiBirak(olay:MouseEvent):void
{
    bilgi_mc.stopDrag();
    hand_mc.visible=false;
    handOpen_mc.visible=true;
    handOpen_mc.x= mouseX;
    handOpen_mc.y=mouseY;
}
```