AN APPLICATION OF A GIS-BASED CAMPUS INFORMATION SYSTEM: KIRKUK UNIVERSITY AS AN EXAMPLE

MAAEDA MOHSIN

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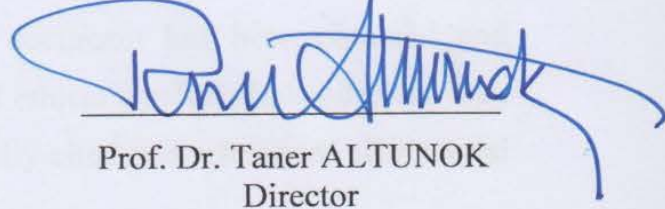**SCIENCES OF**

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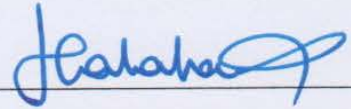
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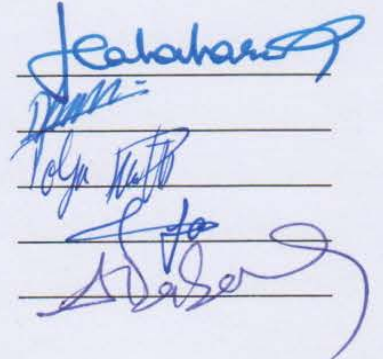Prof. Dr. Billur KAYMAKÇALAN
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ABSTRACT

AN APPLICATION OF A GIS-BASED CAMPUS INFORMATION SYSTEM:
KIRKUK UNIVERSITY AS AN EXAMPLE

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In today's world, developing information technology (IT) plays an important role in our lives. One of the advantages of developing technology is obtaining, creating, saving, collecting, analyzing and using data and information formed by data easily in the computer environment. Like all areas in our lives, in academic life too, information technologies should be used effectively in order to benefit from them. Computer-supported studies are providing an academic environment will enable information to be used effectively. An information system that is map-based and contains an academic structure is easy to use. It supports the people and the associations that are at the stage of decision-making. Geographic information systems (GIS) are one of the most active technologies available for a spatial data management or handling system. An easy way to have access to an area is to digitally represent it in a computer environment. The GIS started with the purpose of creating digital maps, and it quickly became a valuable tool in the decision-making process for various areas. GIS is a system that uses spatial (geographically referenced) data and non-spatial database of descriptive information (attributes) and includes operations that support spatial analysis. Therefore, GIS and the programs

supporting the system can be seen as advantageous while creating a map-based campus information system (CIS).

In this study, a map-based CIS was designed after preparing a digital map of the campus area in desired formats containing spatial and non-spatial data, integrating different types of data that include: images, text, video, and graphics in a 3D (three-dimensional) model of the University's structure shown by appropriate programs in a computer environment. The system is known as a Geographical Information System-Based CIS and users who are going to use this system should be identified. In this study, the map-based CIS users are academic and administrative personnel in the University's structure, present students, and visitors that are seeking information about the University. After considering all users and identifying their needs, the system was designed. Kirkuk University campus was chosen for the application of the study. A sample model of a campus information system was designed for this area.

The programs that were used while designing the CIS were MapInfo version 12.0 together with C#.NET, which was utilized to develop the GIS application-based CIS for Kirkuk University. In conclusion, users will integrate more easily into the Kirkuk University environment by using this application in text, images, a 3D model drawing of the campus (using the Google SketchUp program version 2013) and videos (using the Lumion program version 3.0). The multimedia database demonstrated in this study that GIS is a very important tool in the management of university facilities. This study is highly significant for Iraq and many other third world countries where the management of university facilities is conducted manually and is therefore slow and inaccurate. Advanced countries of the world where GIS is yet to be adopted as a powerful tool for the management of university facilities will find this study highly relevant.

Keywords: GIS, CIS, Kirkuk University, MapInfo, Multimedia Database, 3D Model, Decision-Making.

ÖZ

CBS TABANLI BİR KAMPÜS BİLGİ SİSTEMİ UYGULAMASI: KERKÜK ÜNİVERSİTESİ ÖRNEĞİ

MOHSIN, Maaeda

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Günümüz dünyasında, gelişen bilgi teknolojileri (BT) yaşamımızda önemli rol oynamaktadır. Gelişen teknolojinin avantajlarından biri bilgisayar ortamında bilgiye dönüştürülmüş verinin elde edilmesi, oluşturulması, saklanması, toplanması, analiz edilmesi ve kullanılması olanağının kazanılmasıdır. Yaşamımızdaki tüm alanlarda ve akademik alanda bilgi teknolojileri kendilerinden fayda sağlamak için etkin bir şekilde kullanılmalıdır. Bilgisayar destekli çalışmalar bilginin etkin kullanılabilmesini sağlayan akademik bir ortam sunmaktadır. Harita tabanlı olan ve akademik yapı içeren bir bilgi sisteminin kullanımı da kolay olmaktadır. Bu tür sistemler, karar verme aşamasındaki insanları ve kuruluşları desteklemektedirler. Coğrafi Bilgi Sistemleri (CBS) kurumsal veri yönetimi ve işlenmesi amacıyla hizmete sunulmuş en etkin teknolojilerden bir tanesidir. Bir bölge hakkında bilgiye erişebilmenin en kolay yöntemi, onu bilgisayar ortamında sayısal olarak temsil etmektir. CBS ilk başta sayısal haritaların oluşturulması için kullanılmış, kısa sürede, birçok alanda karar verme süreci için değerli bir araç olmuştur. CBS, konumsal (coğrafi olarak tanımlanmış) ve konumsal olmayan veri tabanı verilerini kullanan ve konumsal analizleri destekleyen işlemleri içeren bir sistemdir. Bu nedenle, CBS ve

bu sistemi destekleyen yazılımlar, harita tabanlı bir Kampüs Bilgi Sistemi (KBS) oluştururken avantaj sağlamaktadırlar.

Bu çalışmada, konumsal ve konumsal olmayan bilgileri içinde bulunduran ve Üniversitenin bilgisayar ortamında, uygun yazılımlarla görüntülenebilen üç boyutlu modelinde kampüs alanının değişik tipteki görüntüleri, metinleri, video ve grafikleri içeren, belli bir formatta sayısal haritası elde edilerek harita tabanlı bir KBS sisteminin tasarımı yapılmıştır. Bu sistem, Coğrafi Bilgi Sistemi tabanlı bir KBS olup kullanıcılarının tanımlanması gerekmektedir. Bu çalışmada, harita tabanlı KBS kullanıcıları, Üniversite teşkilatındaki akademik ve idari personel, mevcut öğrenciler ve Üniversite hakkında bilgi almak isteyen ziyaretçilerden oluşmaktadır. Sistem, tüm bu kullanıcılar ve onların gereksinimleri dikkate alınarak tasarlanmıştır. Sistemin uygulaması için Kerkük Üniversitesi Kampüsü seçilmiştir. Söz konusu alan için kampüs bilgi sisteminin örnek bir modeli oluşturulmuştur.

KBS tasarımında, Kerkük Üniversitesi için CBS uygulaması tabanlı KBS geliştirilmesinde faydalanılan MapInfo 12.0 sürümü ve C#.NET yazılımları kullanılmıştır. Sonuç olarak, kullanıcılar metin ve görüntü içeren, (Google SketchUp yazılımı 2013 sürümü kullanılarak hazırlanmış) 3B kampüs çizimlerini ve (Lumion yazılımı 3.0 sürümü ile hazırlanmış) videoları barındıran bu uygulamayı kullanarak Kerkük Üniversitesi ortamına çok kolay bir şekilde aşina olacaklardır. Bu çalışmada, çoklu ortam veri tabanı, üniversite hizmetlerinin yönetiminde CBS'nin önemli bir araç olduğu göstermiştir. Bu çalışma, üniversite hizmetlerinin klasik yöntemlerle hem yavaş hem de kusurlu bir şekilde yönetildiği Irak ve diğer üçüncü dünya ülkeleri için yüksek öneme sahiptir. Üniversite hizmetlerinde, CBS'yi güçlü bir araç olarak şimdiye kadar kullanmamış olan gelişmiş ülkeler ise bu çalışmayı dikkate alabilirler.

Keywords: CBS, KBS, Kerkük Üniversitesi, MapInfo, Çoklu ortam veri tabanı, 3B Model, Karar-verme.

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LIST OF ABBREVIATIONS

CIS   Campus Information System

CAD   Computer Aided Design

DBMS   Database Management System

ESRI   Environmental Systems Research Institute

GIS   Geographic Information System

3D   Three-Dimensional

CHAPTER 1

INTRODUCTION

1.1 Introduction

In the past, multiple software tools were required for viewing land, streets, addresses, sewers, street lights and other elements of a work site [1]. Nowadays, the GIS is the most widely used technology in geographic science and earth science. With the development of computer technology, GIS allows users to manage, analyze and visualize spatial data that is geographically referenced through one GIS application. One of the powerful features of GIS is the ability to overlay spatial data sets such as infrastructure locations, routes and buildings, allowing users to visualize and understand the relationship between data. The ability to see geographic features on the map gives a better understanding to the users of a particular location, enabling analysts, planners and others to make informed decisions about their communities. GIS touches every aspect of our daily lives, and it is widely used in diverse disciplines all around the world to solve problems. The majority of GIS applications are found in areas of natural resources, socio-economic demographics, transportation and urban planning. However, increasingly applications are found in almost all disciplines, including: agriculture, engineering, business, environmental sciences, law, health care and real estate [2].

As figuratively "living" entities, educational institutions change and grow and, thus, require stewardship, management, maintenance and planning. In this context, presenting to the user information on institutions that are able to access information constitutes one of the most significant steps. If we take universities as the most important institutions for informing societies, it becomes clear that universities should also be the platform where information should be utilized most efficiently

today. Computers stand out as important components in terms of making information available. The computer environment is employed so as to ensure a faster flow of information in the rapidly developing world.

In general terms, GIS is a computer system and includes hardware, software, data, users, organizations and institutional arrangements capable of assembling, storing, and analyzing, manipulating, managing and displaying geographically referenced information about districts of the earth [3]. The abbreviation GIS is occasionally used to mean geographical information science or geospatial information studies, which refers to the academic discipline or career of working with geographic information systems and is a wide field within the academic discipline of Geoinformatics [4].

GIS is an information system that captures, stores, edits, analyses and manages data and presents spatially referenced information for informing decision-makers. A GIS application in the strictest sense is a tool that allows users to create interactive queries (user-created searches), edit data on maps and analyze space information, and present the results of all these processes. Geographic information science is a science that has concepts underlying geographical perspectives, applications and systems. In the simplest sense, GIS is the merging of mapping, statistical analysis and computer science technology [4].

Maps in a 3D model are central in enabling presentation and exploration in many interactive computer graphic applications. GIS specialists use 3D maps as tools for presenting spatial data to non-experts. Lately, GIS and 3D graphics modeling have been merged with reality. The 3D model is considered to be a tool for expressing 3D objects in reality, using advanced graphics libraries such as SketchUp to enable effective modeling by rendering the third dimension. Videos are made with the help of the 3D visualization software Lumion, which enables visualization of campus structure designs quickly and easily through impressive video presentations that can get the user can implement flythrough over the complex 3D models, with a more complete understanding of the location of different objects.

As geographers know, the purpose of maps is to model reality. As cited in [5], the nature of maps is defined as a "graphic representation of the milieu". The term

"milieu" used in this definition is interesting because it refers to much more than the flat, stationary maps we are familiar with. For modelling reality more clearly, it most certainly makes sense that we strive to map what we actually experience.

An application introduced in this paper tries to represent the map of an area by storing geographical information of the area, and combining it with multiple attribute data (3D structure, animation, text and picture). In this way, the user of the system can use the multiple information available in one query to answer many questions relating to facilities at the University. So, the user can easily locate any part of the area without any assistance from the map or another person, leading to a basic change in the status of management. The inclusion of images, video, and a 3D model can improve the system's performance, turning it into a more realistic tool for spatial analysis.

1.2 Problem Statement

This thesis intends to search some solutions or methods of implementing of a GIS for CIS. The most common problems that are encountered in the University campus include: not having access to information as needed and/or storing the existing data without a regular structure. Traditional methods require the re-collection of the existing data from differences sources and analysis done with manual process, this require a large number of human power. Also includes Challenges in time consuming, resource intensive, data inconsistency. In addition, Increasing need for analysis and decision support for facility management in the large enterprise, and analysis becoming multi-dimensional; needing both geographical and attribute data. Finally, difficult to student, visitors and other inexperienced people to find their way around complex structure for University campus.

1.3 Objectives

The main objective of this study is to build an application of a GIS-based CIS that displays campus information that pertains to Kirkuk University. The secondary objectives are as follows: first, to make digital maps which connecting to attribute data for improving data management (e.g. maps, plans, usage of facilities). Second, use the system as a tool in order to create interactive queries, analyze spatial information, and present the results. Third, to visualize 3D information on the map

and to help students, visitors and other inexperienced people easily find their way around campus. In addition, to develop methods using a multimedia GIS that integrate different types of data such as text data, pictures data (still and moving Pictures), graphical data (maps, graphs), visualization of data through media (image, graphics, video).

1.4 User Characteristics

The essential users of the information system created are intended to be visitors, University students and University personnel with different levels of technical experience that may find it interesting to obtain or explore information about Kirkuk University. It is important to note that the "The System" or "Information System" or application or the "CIS" are all referred to as the campus information system. Also "Display Information" refers to the text, pictures and video that the application will display to those persons using the system. Our intention is that this study will be easily understood by non-technical personnel. So this decision was made based on the nature of the variety of personnel who will be using and managing the application.

1.5 Organization of the Thesis

This thesis contains seven chapters and is organized as follows:

Chapter one gives a general introduction to the study and the objectives of the study to enable the reader to understand the research target.

Chapter two contains a literature review of those that have performed significant previous work related to this study.

In Chapter three, we present the theoretical framework which contains a brief overview of GIS and GIS applications in various fields.

Chapter four explains in detail the CIS, problems that are solved with CIS and the benefits of CIS for universities. Also described are certain applications of GIS-based CIS that are applied in many universities around the world, to illustrate how some of the university information systems work.

Chapter five gives a brief description of the study area, and discusses the methodology used in the research to build a campus information system for Kirkuk University that deals with data availability and data processing, data analysis, the generation of a 3D model, and visualization of this model.

Chapter six explains the use of the programmable interfaces of a GIS application-based CIS for Kirkuk University. It provides users with interactive information such as pictures, text, video, a 3D model drawing and a useful measurement tool etc.

Chapter seven ends with the conclusion and future work for this study.

CHAPTER 2

RELATED WORKS

Currently, many universities around the world raise funds in various ways to start building a campus information system project [6–7]. So far different projects have been created related to geographic information systems and campus information systems. Several projects have proposed the use of GIS for easier accessibility to information in a similar way to this project, to move away from the problems of paper works and maps that can be converted into computer-based works. The maturity of GIS and the dramatic improvement of the geodatabase have led to the proposal to store spatial information of an area for easy accessibility.

One of these projects started in the middle of the 1990s at the University of Jiaotong in China. Currently, they have established several information systems such as a mail system, an office automation system, an education management system, an e-card management system, a library management system and other information application systems at this University [8].

The earliest concept of a digital campus was the campus computing project, headed by Professor Kenneth Green from Claremont University in America, started in 1990. In American higher education, this research project is the largest continuing study of the role of information technology. The national studies of this study have gathered lots of quantitative and qualitative data to help campus administrators, faculty members and others interested in the use of information technology in American universities [8].

The University of Calgary in Canada has smart campus projects. To help visitors and students easily find their way around the campus, the University of Calgary developed an interactive room-finder application using institutional spatial data. The user can input the building name and room number they wish to find, and the

application generates a detailed map showing the floor plan with the desired room highlighted. From a risk management perspective, the University has also used the ArcGIS program to enhance public safety. By using a current model of the campus and incorporating up-to-date floor plans, evacuation plans and emergency preparedness were developed.

The University of Calgary in Canada has smart campus projects, used to help visitors and students find their way easily around the Calgary campus. An interactive room-finder application using institutional spatial data was developed by Calgary University. The user can input the building name and room number to search for the building they wish to find. A detailed map showing a floor plan with the desired room highlighted is generated by the application. From the perspective of risk management, Calgary University has also used the ArcGIS program in order to enhance public safety. By using a current model of the campus and incorporating floor plans, emergency preparedness and evacuation plans were developed [9].

A virtual campus based on 3D modelling, image processing and a database was studied by Hunan City University and Ningde Normal University in China. In this study, 3D MAX was used to create a 3D model and to insert the texture images, ArcGIS special analysis and C# are used to redevelop specific functions, so as to make the system functioning perfectly [10].

Also, headed by Dr. Hugh Buchanan, such a study was conducted by a group of students at Newcastle-upon-Tyne University (England). But due to the difficulties suffered with the management of related data, it wasn't successful [11]. At Georgia University (USA), a similar study continued between 1995 and 1997, headed by Dr. Lynn Usery. Funding and organization of this study were provided by the American Geography Administration. In this study, professionals were employed [11]. At Texas A&M University (USA), a GIS application study was started aimed at campus management and mapping by James Culver in 1996 [12].

At UC Berkeley University (USA), a "coordinating council" was established in campus management and university library usage. This council was asked to provide preliminary studies and needs analysis with making decisions for the team [11]. Also, at the Vienna University of Technology in Austria, the most comprehensive

study was obtained in 1993. This study was created by taking into consideration the University administrators and decision-makers. This study, called HIPS, offers a query and analysis environment to decision-makers [11].

In a study conducted at Patras University between 1972 and 1973 the University elaborated its own master plan. After a few years, construction of the University of Patras began according to this plan. As academic and social activity expanded significantly, the need arose to construct new buildings on campus. Therefore it was necessary to revise the master plan. GIS works started during the revision phase of the master plan. The planned goals were to solve the problems listed below [13]:

- Developing a tool for academic and management purposes,
- Finding the best places to place the buildings needed in the new planning,
- Regulating the traffic circulation, transportation routes, the parking system and the pedestrian circulation,
- Better organization of green spaces.

In line with these goals, a GIS was created for the campus. Thus, the system is used in campus traffic planning, park and open space planning, pedestrian planning and surrounding landscaping planning [13]. In [14] have also worked on the usage of GIS in digital cartography.

Dr. Scott Mason, of Cape Town University in South Africa, carried out a similar study, but later a GIS that provided basic support for the campus turned out to be inadequate [11]. At Yildiz Technical University (Istanbul), in 2001, a study was conducted aimed at creating a campus information system in the environment of a geographical information system. Automation systems that already existed at the University were added to the system by relating them to the geographic objects. Determined to be used by Internet-based systems in order to make it accessible to everyone else [12].

Istanbul Technical University (Istanbul) designed a campus information system taking into account the topography of the campus [11]. At Middle East Technical University (Ankara) [15], the entire infrastructure mapping information of the University, which are completely on map sheets or in CAD format, and paper map, converted to the GIS environment.

Gebze High Technology Institute Turkey (Gebze) established an interactive Web-based campus information system [17]. Also, Afyon Kocatepe University (Afyon) created a campus information system that consisted of the topography of the area near the University, land use, land arrangements and personnel information [16].

Ege University (Izmir) also established a campus geographic information system and made building information system as a part of campus geographic information systems by choosing a literature faculty, which is designed as a pilot study [18].

For Karadeniz Technical University (Trabzon) [11], an information system design was created and applied in the name of KTUBIS.

In summary, due to restrictions of technology and history, and the defects and internal deficiencies of management systems, present information systems could not adapt to the requirements of management and services, restrict to develop the University [8].

CHAPTER 3

THEORETICAL FRAMEWORK

3.1 Brief History of GIS Development

Since the inception of the GIS in its automated form in the early 1960s, the GIS industry has been growing by leaps and bounds. Traditionally, maps have long been used as a method of storing and disseminating spatial data as well as exploring the earth and locating cultural and natural resources.

Canada was the pioneer in the development of the world's first GIS computer system: the Canada Geographic Information System (CGIS) was developed in 1962. And a large digital land resource database was built and developed as a mainframe-based system in support of federal and regional resource management plans. The system's strength was the analysis of complex data sets at the continent level. The CGIS was never available commercially.

In 1970, at the Graduate School of Design (GSD) at Harvard University, the Laboratory for Computer Graphics and Spatial Analysis (LCGSA) began to develop a general-purpose GIS, which is a seminal software code and systems, such as ODYSSEY GIS, GRID, and SYMAP that served as inspirational sources for commercial development to corporations, universities and research centers worldwide [19].

In 1969, the Environmental Systems Research Institute (ESRI) was founded, inspired by Harvard's software. The first GIS software came from the lab of the ESRI. In 1982, the ESRI released the ARC/INFO system, the first commercial GIS. The ESRI's ability to make its ARC/INFO system function across computer platforms ranging from personal computers, through workstations and minicomputers up to the largest mainframes, has clearly been beneficial to the company. In this way, GIS

began to take off in the early 1980s, when the price of computer hardware had fallen to a level that could sustain significant software and cost-effective applications [19–20]. Also, in 1992, the ESRI released the ArcView desktop GIS. In addition, the first desktop GIS product for the DOS operating system was brought out in 1986 by the Mapping Display and Analysis System (MIDAS), and when it was ported to the Microsoft Windows platform in 1990, the product was renamed to MapInfo. The process of transferring GIS from the research department into the business environment had begun [19].

By the end of the 20th century, the fast growth in different systems and standardization on relatively few platforms and the concept of viewing GIS data had begun to be exported over the Internet (Internet-based GIS services) along with the proliferation of GIS applications. More recently, the number of free and open-source GIS packages has grown and run on a range of operating systems. Increasingly, geographic data and mapping applications are being made available via the Internet [21]. As we can see today and as indicated by a variety of information, the GIS field has expanded rapidly in recent years. GIS has become a powerful tool and useful to all, without exception, who handle spatial data.

Modern GIS is a computer-based information system used to represent data digitally and analyze geographic phenomena that exist and events that take place on the earth's surface and linked the non-spatial data to the spatial data. In this way, GIS has proved itself as a strong and reliable technology for managing geographic data and as a tool for decision support.

3.2 The Concept of GIS

Understanding what a GIS represents can be helped by considering the constituent parts of the term separately:

Geographic: This word can be defined with respect to its constituent parts: geo and graphic. Geo refers to the earth and graphic refers to something concerned with written signs. This term is used because GIS deals with "geographic", which implies that information about location is known, or in terms of geographic coordinates (latitude, longitude) can be calculated [22].

Information: This is derived from the interpretation of data, which means that data in a GIS are organized and processed to produce useful knowledge. This is often in the form of colored maps and images, but also tables and statistical graphics, and various on-screen responses to interactive queries. Computer technology has enabled much more efficient processing and management of information [22].

System: This means that a GIS is made up of several interrelated components with many different functions. Therefore, GIS has functional capabilities for data collection, input, transformation, manipulation, combination, visualization, analysis, query, modeling and output [22].

3.3 Definition of GIS

There have been many attempts to define GIS, thereby making it difficult to select a particular definition. The suggestion as given in [23] is that the definition of GIS will depend upon who is giving it, their disciplines and viewpoint. Also, we should bear in mind that definitions of GIS are likely to change rapidly as technology and applications develop further. Some of the shorter definitions of GIS give an idea of what a GIS is, albeit in a superficial way [23].

For example, in [24] GIS is defined generally as a computer system that can hold and use data describing spaces on the earth's surface. A convenient way to define a geographical information system that gives more idea of what GIS can do is to say that it is a set of computer tools capable of capturing, storing, manipulating, analyzing and displaying geographic information for a particular set of purposes [25].

Various definitions of GIS offered by different references are presented below; each definition is made for a different type and for different decision-making purposes.

GIS defined as a computer-based system that provides four sets of abilities to deal with geographically referenced data: input data, management data (storage and retrieval), manipulation and analysis data, and output data [26].

GIS defined as an information system that is designed to work with data defined by the coordinates (spatial referencing). In another sense, a GIS is both a database system with specific capabilities for geographically referenced data and a set of

operations for working with (analyzing) the data. In a sense, a GIS may be thought of as a higher-order map [27].

Geographic analysis is the primary purpose of a traditional GIS. Therefore, it may have limited capabilities in terms of data collection and cartographic output. Decision-making is typically supported by capabilities of analysis for limited geographic areas. The characteristics of a map database (accuracy, continuity, completeness, etc.) are typically suitable for small-scale map output. Raster and vector data interfaces may be available. Nevertheless, topology is usually the sole underlying data structure for geographic analysis [28].

Furthermore, GIS is defined as an organized system comprising hardware, software and spatial data, and is user designed to collect, store, manipulate, update, analyze and present all forms of spatially referenced information [29]. A list of further definitions of GIS may be found in [30].

All the definitions of GIS mentioned above can be summarized as "GIS is basically a computer-based system for gathering computer hardware, software, data referenced by spatial coordinates, people and procedures logically arranged to store, manipulate, retrieve, analyze, update and output data as information, to make decisions. This way, a GIS system is useful as a powerful spatial Decision Support System (DSS). It may also be considered as a higher-order computer-coded map."

3.4 The Applications of GIS Technology

GIS is designed as a general system for managing large spatial data volumes. The power of a GIS lies in the ability to collect data from the real world then integrate database operations with analysis and transform this into usable information, offered by a digital map interface. Based on this information, decisions are taken and plans are implemented in the real world. It should be noted here that any task starts and ends with the real world. So, in most areas, GIS acts as a standard tool to support decision-making in planning activities, based on spatial information characteristics and the types of data they use. The following categories of GIS applications are identified in [31–33]:

- Emergency response planning:
  - Planning emergency evacuation routes
  - Fire prevention systems
  - Natural hazard monitoring
- Natural resource-based application:
  - Wildlife habitat
  - Wild and scenic rivers, flood plains
  - Desert encroachment control
- Transportation:
  - Street network analysis
  - Traffic congestion analysis and control
- Agriculture:
  - Mapping of crop patterns
  - Mapping soil characteristics
- Health:
  - Mapping of disease locations and spread
  - Location of health facilities
- Business management:
  - Managing mailing lists (addresses of customers)
  - Advertising, customer services
- Research and education:
  - Teaching and learning
  - Mapping and management of school facilities
- Tourism:
  - Park and recreation planning/management
  - Mapping tourism facilities
- Facilities mapping and management:
  - Mapping the locations and distribution of facilities
  - Locating underground cables and pipes for maintenance
- Street network-based application:
  - Vehicle routing and scheduling
  - Location analysis or site selection
- Urban and regional planning

Shown in Fig.5 are some samples of GIS applications and what GIS can help to do in various fields.

An engineering department monitors the condition of roads and bridges and produces planning maps for natural disasters.	A tax assessor's office produces land use maps for appraisers and planners.	A wastewater department prioritizes areas for repairs after an earthquake.
A pipeline company finds the least-cost path for a new pipeline.	An electricity utility models its circuits to minimize power loss and to plan the placement of new devices.	An emergency management agency plans relief facilities by modelling demand and accessibility.
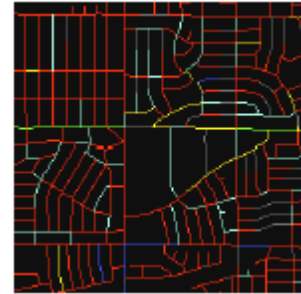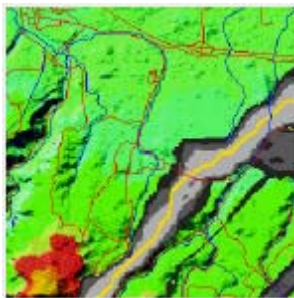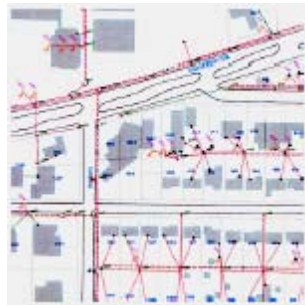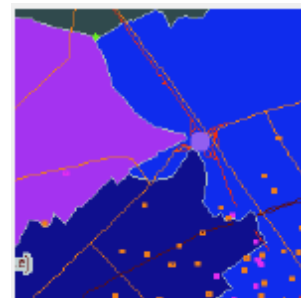
Figure 1 Samples of GIS applications in various fields [34].

3.5 Components of GIS

Many people think of GIS as simply a software program for making maps. However, GIS software systems are a specialized type of information system integrating five key components that are critical to a successful GIS.

These five key components, when working together harmoniously, enable people to collect, analyze, manage and present the spatial information needed to support decisions and solve problems. Below is a list of the basic components in any GIS:

3.5.1 Hardware

These components include physical components of the system such as computers, printers, servers, the network, scanners, cameras, digitizing tablets, satellites, GPS receivers, etc. They are used for spatial data input (acquisition, collection, capture), computing (storage, processing, retrieval) and output (display, communicate, print). GIS has been greatly aided by the technological transformation of the computing industry such as inexpensive mass storage for large databases and faster computational power. The ability to access more information in a timely and accurate manner has increased the overall productivity in the private sector.

3.5.2 Software

In general, software is a digital language that consists of a set of commands, rules, programs or algorithms, written in a logical and systematic way to perform certain tasks. The elements of software allow users to input data and store, transform, manage, analyze and output it [35].

In the main, GIS software is a computer program specially designed to provide or produce the tools and functions needed to store, analyse and display geographically referenced information.

The typical software of a GIS has four distinct but interrelated main functional subsystems, as follows:

- Subsystem of data input. This allows the user to transform both spatial and non-spatial data into digital form after capturing and collecting it. It is used, for example, for digitizing or scanning, editing and etc.

- Subsystem of data storage and retrieval. This organizes the spatial and non-spatial data into a form that allows it to be quickly retrieved by the user for analysis. This component usually includes the use of a database management system (DBMS).

- Subsystem of data manipulation and analysis. This allows spatial and non-spatial procedures to be defined and executed by the user to generate derived information. It is used, for example, for querying, buffer creation, overlay operations etc., and it is generally believed that this subsystem is the heart of a GIS, and usually distinguishes it from other computer-aided drafting (CAD) systems and database information systems.

- Subsystem of data output. This allows the user to generate graphic displays (maps) and tabular reports representing products of derived information, e.g. for screen display etc.

Some of the more popular GIS software packages include: ArcGIS, ArcView, ArcIMS and ArcGIS Server from ESRI Products; GeoMedia and GeoMedia WebMap from Intergraph Products; MapInfo Professional and MapXtreme from MapInfo by Pitney Bowes Products; Maptitude from Caliper Products. Clark Labs at Clark University developed IDRISI GIS and Image Processing Product.

(For more details on GIS software and their manufacturers, see [20].)

3.5.3 Data

Without question one of the most important components of GIS is data. Spatial data and other existing data resources can be integrated by GIS and can even be stored in a DBMS. The key functionality afforded by GIS is the integration of spatial data (often proprietary to the GIS software) and tabular data stored in a DBMS.

A GIS stores information on real-world features as a collection of thematic layers to be interlinked together by geography. This concept is simple but extremely powerful and versatile, and it has proven invaluable for solving many real-world problems. The thematic layer method enables the organization of a simple representation from the complexity of the real world to help facilitate understanding of natural relationships. A layer can contain anything including similar features such as streets, buildings etc. Typically, this data includes either an explicit geographic reference, for

instance the coordinates (longitude and latitude) of a place, or an implicit reference, for instance an address, road name or postal code etc.

Accordingly, there are two basic types of data that are utilized in GIS technology: spatial (geographic) data that show where the feature is and non-spatial (attribute) data that provide information about the feature.

Spatial data is any data that has a geographic location. This type of data is used to graphically represent some real-world features. In other words, spatial data is presented in the form of a map that displays the real-world features on a computer screen. In a GIS, all spatial data models are usually stored digitally in a database called a geodatabase, which is referenced to relative locations in the real world. Basically, there are two basic types of spatial data models used for storing georeferenced data: vector and raster.

A Vector data model is commonly used to represent geographic feature as points, lines and polygons. Information about geographic features is encoded and stored by the use of sequential vertices; each vertex consists of x,y coordinates as shown in Figure 2. Point feature location can be stored by a vertex, with one x,y coordinate pair. Arcs are line segments forming polygon borders or individual linear features. The location of linear features such as roads is defined by a string of vertices. A linear feature has the advantage that it provides the ability to determine the length of the line. Polygon features are areas enclosed by arcs, such as buildings, and can be defined as a set of closed coordinate pairs. Polygon features are essential when considering area calculations. Vector data models are very useful for handling discrete features such as data represented by an area, but less useful for handling continuously varying features such as soil type.
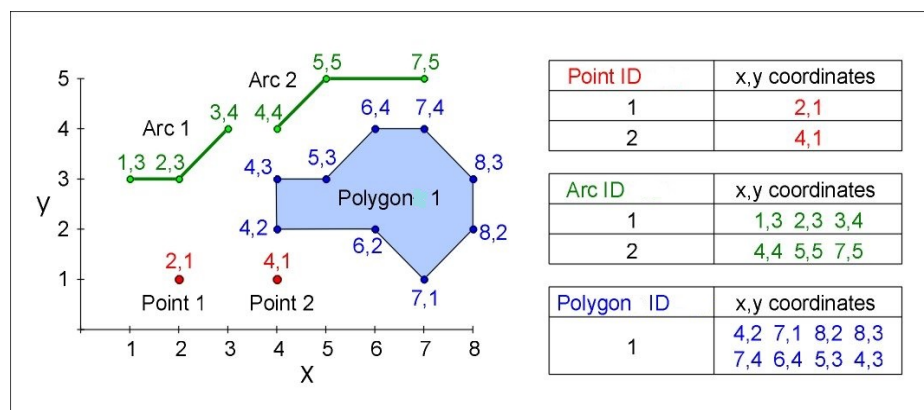
Figure 2 Vector data model [38].

The raster data model in its simplest form is more like a photograph than a map. A raster consists of a grid-cell data structure identified by row and column where the spatial area is divided into cells and each cell includes a value that represents information, as shown in Figure 3. Most often, raster data is associated with some type of remotely sensed imagery, such as satellite scenes or orthophotos. It can even be a scanned map that has been rectified and geographically referenced to its real-world location. A GIS may use raster data, that has simple data structure and is compatible with remote sensing software and are considered the most appropriate choice for modeling continuous geographic phenomena such as landscape and depth as well as simple spatial analysis procedures.
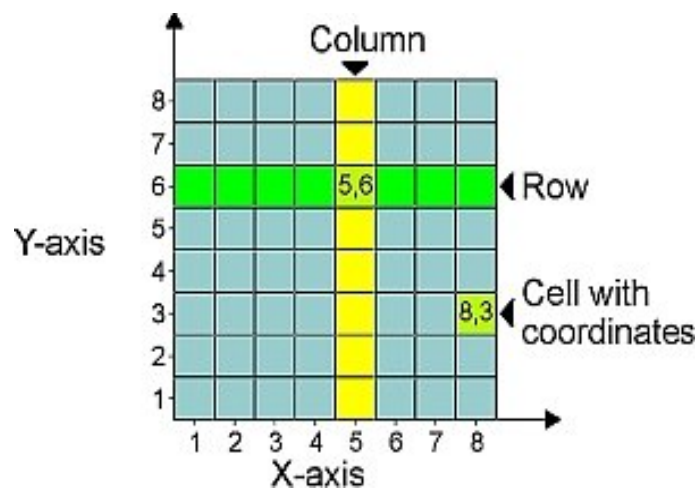
Figure 3 Raster data model [38].

Non-spatial (attribute) data is generally defined as additional information about each geographic feature. Attribute data in a GIS environment are usually presented in tabular format; such data can be of text, boolean, date or numeric type, where each column of the table describes one attribute and each row of the table corresponds to a separate spatial feature. The tabular database related to the map feature can also be linked to the digital spatial database.

3.5.4 People

A GIS is useless without people that understand how to use and manage it, so in any GIS program the most valuable asset required is people – well-trained people who understand how to use hardware, software and data, manage the system and develop plans for applying it to solve real-world problems. GIS has a wide range of users across the globe from technical specialists who design and maintain it to the end-users who use the system to perform their day-by-day activities [32].

3.5.5 Methods

Methods include how the data will be retrieved, input into the system, stored, transformed, managed, analyzed and finally displayed in a final output. An organization that operates successful GIS has a well-designed plan, executive direction, business rules, considering these as operating practices, and a model that is unique to each organization. Methods depend on the goals in addition to modus operandi of each organization separately, and accordingly, methods may vary from one organization to another [20].

3.6. GIS Tasks

Spatial data must be converted into a suitable digital format before it can be used in a GIS. The source of spatial data often comes from paper maps, manual digitization and scanning of aerial photographs, and existing digital data sets. Through the use of a CAD program a hard-copy map can be converted into a digital medium. The process of converting paper maps into digital format is called "digitization". The map data are simplified by digitizing into sets of points, lines or cells that can be stored in the GIS computer [78]. Modern GIS technology is capable of automating this process fully, but small jobs may require some manual digitizing via a digitizing table, and larger projects via scanning technology. Today, several types of spatial data can be obtained in digital format from their source and loaded directly into a GIS. The process of digitizing makes maps have a special place in GIS. It begins with the creation of a database.

The data type required for a certain GIS project will be likely to need transforming or manipulating in some way to be compatible with the system utilized. For example,

spatial information is available on different scales (less detailed census boundaries, detailed street center line files, and postal codes at a regional level). Before integrating this information, it must be transformed on the same scale (degree of accuracy or detail). This transformation could be a temporary requirement for display purposes or a permanent requirement for analysis. After the conversion stage, the user deal with the compilation stage, by relating respective attributes to spatial features. After the compilation stage, the files of the converted digital map are stored on digital or magnetic tapes. With regard to the management of geographic information, for small projects, it may be sufficient to store as simple files. But it is often best to use a DBMS to help store, regulate and manage when data volumes become large and the number of data users becomes greater. DBMS is computer software for managing a database. After these stages, query and analysis processes might be performed. GIS must provide tools for finding specific objects based on their location or attribute; queries that are often created as a logical statement or expression such as SQL are used to select features on the map and their records in the database. Simple questions include; "Where is land zoned for industrial use?", "How far is it between two places?" and "Who owns the land parcel on the corner?", and analytical and more advanced questions include "Where are suitable sites for building new houses?" and "If I build a motorway here, how will traffic be affected?" Consequently, the geographic analysis usually involves more than one spatial database and requires working through a series of steps based on spatial relationships from one database to another to answer the above questions. Both simple click query capabilities and advanced analysis provide timely information to analysts and managers alike. Many powerful analytical tools are owned by modern GIS, but the two most important are proximity analysis and overlay analysis.

3.7. Visualization

In a GIS the end result for many types of spatial operation is best visualized as a graph or map. Maps are very effective for storing and communicating spatial information. While cartographers have created maps for millennia to explore the earth, GIS technology provides advanced tools to enhance the science and art of cartography.   Map displays can be integrated with some other means of communication, known as "multimedia cartography". This means that the map is

hotlinked with text, images, animations, three-dimensional views and other output such as multimedia. These hotlinked items permit researchers to present their subjects in several ways and in ways they never could be before [36].

3.8. GIS and Related Technologies

There are many types of information system technologies that are closely related to GIS. Nevertheless, such systems do not share GIS's ability to provide a larger range of analytical capabilities to analyze geographic data, which sets GIS technology apart. Although no hard and fast rules exist about how to distinguish systems, the discussion below should help differentiate GIS from some associated technologies such as CAD and DBMS technologies.

3.8.1 CAD

CAD mapping software is sometimes confused with GIS software. CAD systems are used by the architectural community to create designs and plans of buildings and infrastructure. The main difference between CAD and GIS is the provision of capabilities for transforming original geographic data in order to be able to answer certain queries. Both GIS and CAD systems have some common transformation capabilities, but GIS still offers a richer array of analytical capabilities. Moreover, as stated in [20], the analysis functions of GIS software that will be able to operate on a topological data structure permitting the spatial analysis of the data based on the spatial relationships among map elements, but a topological data structure is not required by the CAD application. GIS usually provides limited means of drawing map objects as well, however, digital outputs of popular CAD programs are strongly expected to be imported into GIS software. CAD systems have been extended to support maps but have typically limited use for analyzing and managing large spatial databases.

3.8.2 DBMS

DBMS is a specialized system in the storage and management of all data types including spatial data. The purpose of DBMSs is to provide a way to store and retrieve data, and GIS relies on them for this purpose, so DBMS is an important component of any GIS.

CHAPTER 4

CAMPUS INFORMATION SYSTEM

Computer technologies have been developing all the time. It is not possible to see an end to this development. The best thing to do is to participate actively in the development process. Therefore, it is necessary to follow the innovation of computers and informatics. For the changes in the existing systems, one should benefit from information technologies.

Today, with the advances in information technology achieved in all areas of our lives, the information is stored and used efficiently in information systems. Information systems are interested in the application of information technology. The design and implementation of information systems in order to support information processing, and updating the acquired information that is stored are becoming easier and more efficient. As a consequence, it is possible to develop information systems at every stage of life as long as such an opportunity exists. Also, different forms of GIS are found in today's ever-expanding range of information technology tools [39].

A CIS should be able to answer all the questions that potential users might ask. It should also make locational and statistical analysis when they are required. In addition, it should be available to multiple users and provide current and detailed information. Information systems are expected to be fast and to include interfaces that can even be used by people who are inexperienced computer users, and these interfaces should be provided in some languages that are internationally used and open to updates. These expectations are also the general expectations for geographical information systems [11].

The most common problems that are encountered in institutions are not having access to information as needed and saving or storing the existing data without a regular structure, which has led to a number of problems. Therefore, generating databases on existing data and retrieving information in a fast and reliable way when

it is needed are the most significant managerial demands of all institutions. As a result, it can be claimed that it is inevitable for educational institutions that have an important role in the development process of the society to benefit from information systems.

A university can be defined as "a high-level educational institution that has academic autonomy and public corporate entity and consists of faculties, institutes and colleges or units that are similar to them and provide a high level of education and training and opportunities to conduct scientific research and produce publications. The term 'academy' is also used for institutions that are similar to universities. The word 'academy' has Greek origins and the word means 'board of scholars, writers and artists'" [18].

Today, the campus information system is a GIS-based system, and has been used by many universities for different goals and become an effective tool. It is an integrity that is formed by hardware, software, data and users that are brought together in order to collect spatial and non-spatial data related to the campus and then transform this data to a computer environment for storing, analyzing, querying and presenting the results of this data to the user in multiple formats including maps, charts and reports [41].

University campuses are generally dwelling units that have a number of buildings. A dense population lives on the campus. The fundamental duties of universities are education and research, which are not easy to manage and plan with limited resources. A geographical information system, which is an important decision support system, provides an opportunity to analyze both spatial data and non-spatial data at the same time so that it helps managers make fast and accurate decisions. Using geographical information systems will lead to important developments in the near future for physical planning, and will provide benefits from limited resources [42].

4.1 Problems that are Solved with the Campus Information System

4.1.1 Standards in software, data and applications

In order to establish a system that can be used by the whole campus, there should be some basic standards in terms of the software, accuracy of the maps, providing the contents and integration of the applications [12].

4.1.2 Data in computer environment

Most of the maps on campuses are not digitized. In order to operate a geographical information system the existing maps and other information on paper should be digitized. A system that needs data sharing on the network needs digital data at the same time [41].

4.1.3 Introducing the technology

There are several procedures that have been used for years. In some situations, people may resist using the new technology as they can have insecure attitudes towards the new technology. That's why introducing the system and telling them the benefits of the system are important factors. In addition, they must perceive the maps as visual presentations of the data instead of just graphics or pictures [39].

4.1.4 Common database

The key point of such a system is to have a common base map that can be used by all the units. Maps that are prepared in the same projection and coordination system can be used by all the units. Therefore, a thematic map that is created by a unit can be overlaid with the thematic maps that are generated by other units [34].

4.1.5 Reducing the complexity of the system and realizing it

A campus-wide system has great complexity in terms of managerial and technical aspects. In addition to this complexity, dealing also with the bureaucratic complexity will delay the establishment and development of the system. It is important that managers should make the necessary regulations to provide facilities such as changes in the procedures or the required permissions for the system concerning the complexity of the system [12].

4.1.6 Qualified human resource

Giving the necessary regular training to personnel, while the system is being established and after it has been established, plays an important role in the use of developing technology and improving the system.

4.1.7 Personnel

Trained personnel who can respond and meet the needs when they are necessary should be found for the ordination inside the campus and management of the system [12].

4.1.8 Coordination inside the whole campus

The main reason for most of the problems that are listed above is a lack of coordination inside the whole campus. If coordination cannot be provided, there will be some problematic situations such as repeated efforts, inconsistent standards, different software and hardware and different scales [12].

4.1.9 Distance analysis

A distance tool used to produce distance on maps is commonly available in GIS, which allows users to add points of interest. In addition, by using Google Maps to design the user interface for a campus map, as it provides more detailed maps and higher-resolution satellite pictures, in this case the distance tool is used to determine the distance from the source to any locales. All of these easy-to-use tools strengthen the spatial information service for the digital campus.

4.1.10 Map change

It is hard to draw a map of the changes in an area to anticipate future conditions. By integrating spatial information within a GIS environment, the aim is to develop information systems for future and current planning of universities, decide on a course of action or to evaluate the results of an action.

4.1.11 Finding way around campus

How is it possible to help students, visitors and other inexperienced people easily find their way around campus? Therefore this system enhances visitors' experience and helps them save time, the user can easily locate any part of the area, just like walking on the campus, without any assistance from the map or other people.

4.2 Benefits of the CIS for Universities

The most significant benefit of the campus information system to a university is that it provides savings. Here, what is meant by savings is savings in time that people will spend on acquiring information about the university, efficient and productive use of both human resources and physical resources and reducing the expenditure thanks to better planning. Since most existing maps are on paper and old, they have some restrictions with respect to their use. As the technology develops, people should make use of the benefits of the technology. The need for maps in traditional methods requires the re-collection of the existing data of the same location for different units. At the same time there are not any specific standards for them, so different base maps emerge. This situation both makes the existing data inconsistent and raises doubts about the accuracy of the data. In addition, the costs increase because of the repeated data collection process.

The university campus is an area in a space containing the spatial information of features. GIS operates as a management tool for spatial information; it can combine the spatial and non-spatial information on the campus, which provides further information channels, leads to essential changes in management concepts, saves a lot of manpower and material resources and provides photos, video, design and other information for the management. Therefore, GIS plays important roles in the digital campus information system framework [40].

An accurate and fast analysis can be made through highly qualified information that is available whenever needed, and more appropriate decisions can be made accordingly. Better cost/benefit analysis and more qualified documentations can be made and developments can be monitored. There are a number of applications that can change the decisions in physical planning at a high rate. For example, decisions about a new building or about a building that is to be relocated can be made through the CIS.

One of the main roles of the geographical information system is that it can visualize the data that was previously presented in the tables and make it easier to understand by providing the data on maps. Making use of such maps will bring good results when they are used in public relations. In addition, there are also many applications

that can be used in emergency situation management and risk management. The data on paper can be stored more effectively in the computer environment. Therefore, sharing the information and accessing it will become easier. Updating of information will be facilitated. Moreover, better and more accurate analysis for the construction of new buildings or similar processes can be carried out as the system makes it impossible to bring different plans to a reality in the same coordinate system [12].

All of the benefits and advantages that are stated above will both simplify the lives of stakeholders at the University and enable the managers to carry out their tasks more accurately, so that the relations of the managers with the other institutions or people may be changed.

As stated in [40], compared with traditional management information systems (MIS), a campus GIS includes the following characteristics:

1. During the processing and analyzing of problems, a campus GIS uses both spatial and non-spatial data, which are analyzed, managed and applied by the DBMS, providing a new way to understand spatial information. However, only attribute data can be managed by an MIS, and the graphics are often stored in files. So the operation of spatial data such as spatial query, retrieval and more complex spatial analysis cannot be supported by an MIS.

2. Through the reasonable spatial index and the use of the spatial analysis functions, campus GIS emphasizes spatial analysis and information analysis. Research and design of the spatial analysis model are necessary for successful application of a campus GIS.

3. The characteristics of a campus GIS are having information carrier diversity and large processing data. That provides the model of campus management and a robust database for the building of the digital campus.

According to the above characteristics, the campus GIS is not only used to manage the campus information, but also, because of the integration of the spatial and non-spatial data, it becomes a harmonious whole.

Currently, most CIS GISs are 2D, because 2D is the planar projection of various objects in the real world, so much of the 3D information cannot be fully used. The

3D GISs have a more vivid effect than 2D GISs, and they are more cognitive and more expressive.

In this thesis, the design and implementation of the campus GIS is based on the components of MapInfo. The system has the basic results including the campus status information and thematic map information. The attribute data is attached to the corresponding spatial data, such as the attribute data of various buildings, roads and some infrastructure networks etc. In accordance with the general principles for constructing a system, and the actual campus situation, the system methodology will be clarified in the following chapter.

4.3. Examples of Campus Information Systems around the World

Many examples of campus information systems can be found all around the world. There may be different kinds of information systems related to the universities that can be reached in the Internet environment. One of them is in the form of campus maps. Most universities perceive a campus information system that is map based as creating a campus map. Along with creating a campus map, other structures that can be seen in these information systems may not be available to users outside of the campus. Information systems that are not available outside of the campus are used through passwords given to the administrative or academic personnel and students on the campus. In addition, information systems are established only within the University database so that no kind of information sharing can be provided.

What the universities do within the scope of the campus information systems is explained below by giving examples. However, before giving these examples the term "interactive map" needs to be defined. An interactive map is a map that provides information about an object in another window when the object is selected.

As a result of the conducted research, the universities that are analyzed are shown in tables. Some of them are explained in detail. The CIS is applied in many universities both in Turkey and around the world. Here are some examples of university information system:

Youngstown University

As can be seen in Figure 4, the purpose of this map is to provide information about campus buildings. When a building is selected on the map or from the list, departments and units inside the building, the personnel working in that building and some other information are provided through a picture. When a department's tab on the picture is selected, websites that belong to the departments can be reached. Opening and closing times of the buildings can also be seen [43].

Figure 4 Youngstown University [43].

Berkeley University/University of California

The interactive map of the campus is shown in Figure 5 and the familiar Google Maps interface is used. Queries can be made in two ways. The first one is as follows: when a building is selected on the interactive map, both pictures of the building and information about the building can be acquired. As for the other one, any building, road or point of interest from the expandable alphabetized list that is on the left part of the Web page can be selected. The location of the building on the interactive map, information about it and pictures can be found [44].
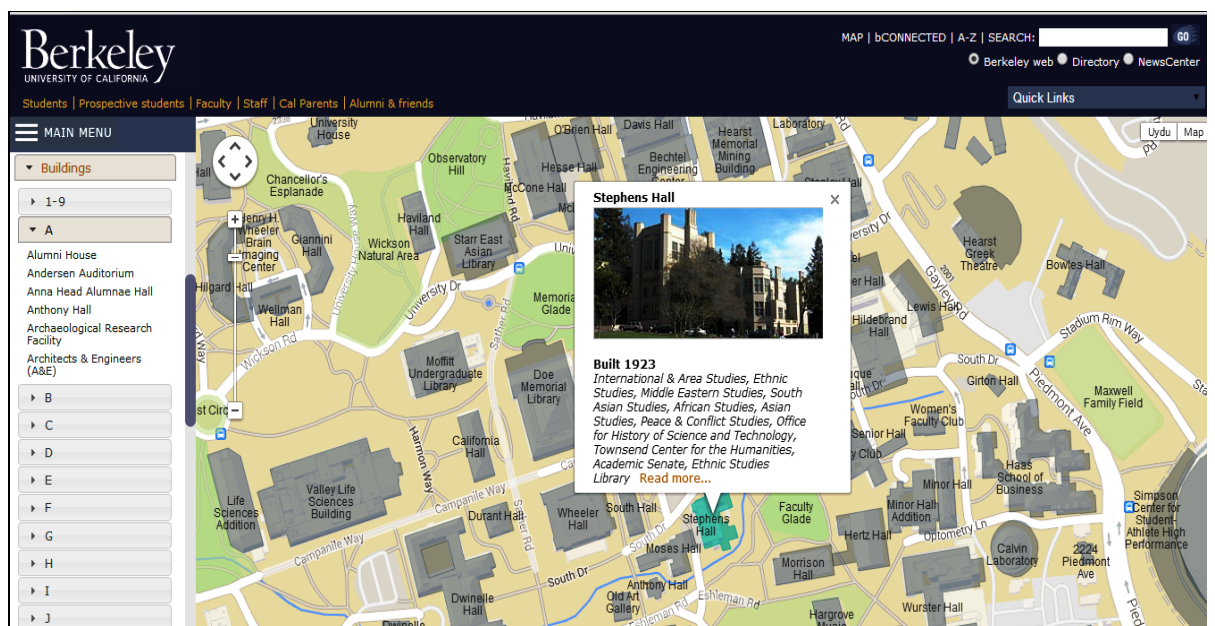
Figure 5 Berkeley University [44].

George Washington University

The existing map of the campus, as can be seen in Figure 6, is presented with two- and three-dimensional maps. When you zoom in on the map it is possible to see the details of the buildings, and you zoom out it provides the opportunity to view the whole campus. There are tabs on the left side of the page that allow the user to make inquiries. There is also an opportunity to make inquiries by typing the building names. Moreover, buildings can be categorized and seen on the map. Buildings can be marked on the map to find information about them. Street names that are on the

campus or nearby can also be queried through the system. It can also provide photos of some places that have an all-round view [45].
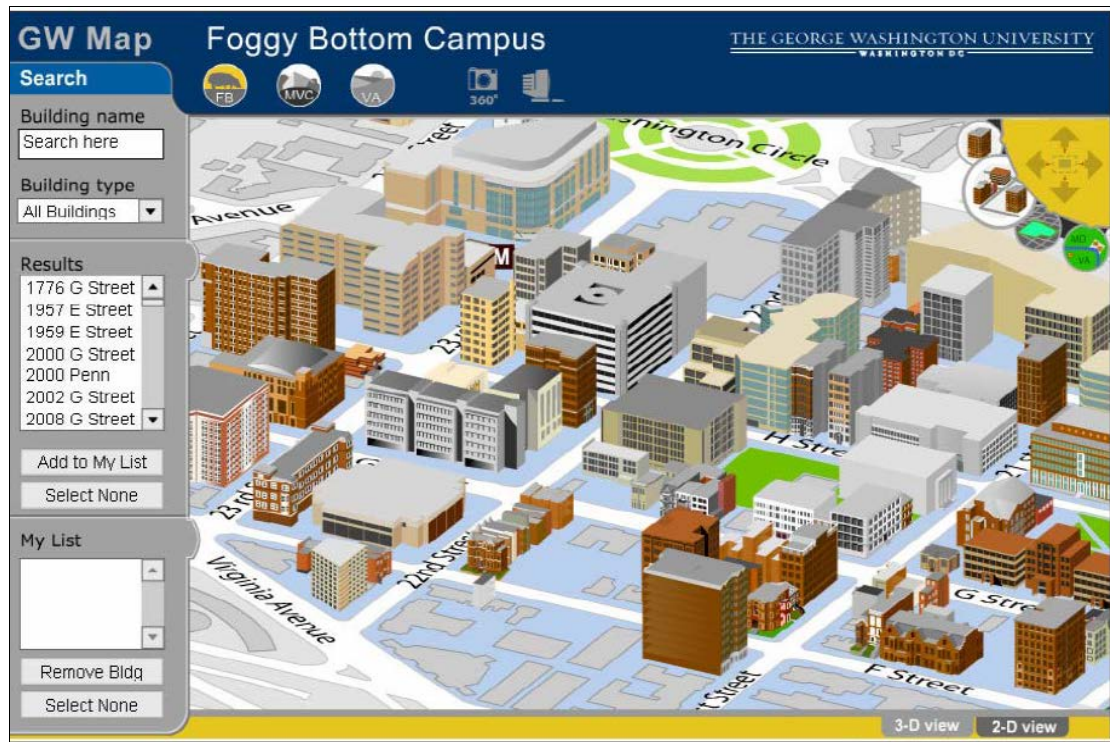
Figure 6 George Washington University [45].

Yale University

Although it is not easy to use, the interactive map of Yale University is used to quickly find buildings on the campus. The interactive map as shown in Figure 7 has three zoom levels, which can be accessed by using the zoom in/out (+/-) in the right upper corner of the interface or by clicking on the map, and also by using the pan arrows to move up and down or side to side on the inside edges of the map. The menu on the left can be used to find the location of a building on the campus, such as:

- search for buildings by name, address;
- select a category.

A list of relevant results will be generated by most queries. Locations on the map will be highlighted when the list rolls over. The user can click on any building on the map or on a particular result to display more information about the building, including a list of departments and offices. They can also click on the organization's

link to link to the website that belongs to it. Likewise, the interactive system serves as a geographically based portal to the campus.

Also, an accessibility map can be accessed by clicking on the disability access link on the left side. The campus access maps are grouped inside itself. The campus area is divided into five different areas and each group is named according to its features, and by clicking on a map or link you can view the related accessibility map. The entrance gates of the buildings and their locations, and elevators and their locations, are shown on the map. When the buildings are clicked on, detailed access information about the buildings is provided through a window [46].
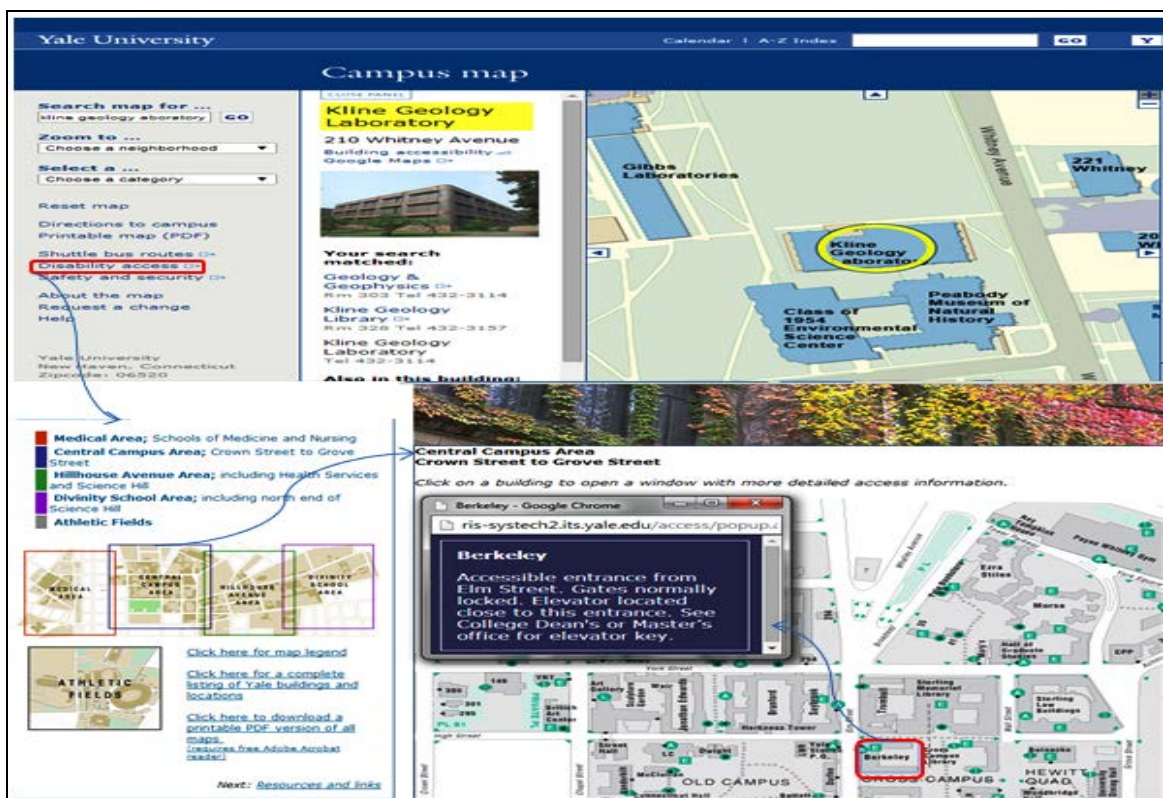
Figure 7 Yale University [46].

Abilene Christian University

As can be seen in Figure 8, there are two basic maps. While one of them shows the access to the campus, the other one includes the campus plan. This is an interactive map. Information about the buildings can be acquired from the map and the numbers located below contain the buildings' names. The relations are established through the numbers. The information provided includes the history of the buildings, opening-closing times of the buildings if they have them, the address and photographs of the buildings and the units that are inside the buildings [47].

Figure 8 Abilene Christian University [47].

Academy of Art University

On the map of San Francisco the buildings that belong to the University, relevant streets and campus housing are presented as shown in Figure 9. Selections cannot be made on the map. On the right side there are three main titles (view by address, view by department and campus housing). The street or building names that are under the titles can be selected and their locations on the map can be found. In addition, at the bottom of the page, pictures of the buildings and their full addresses are presented [48].
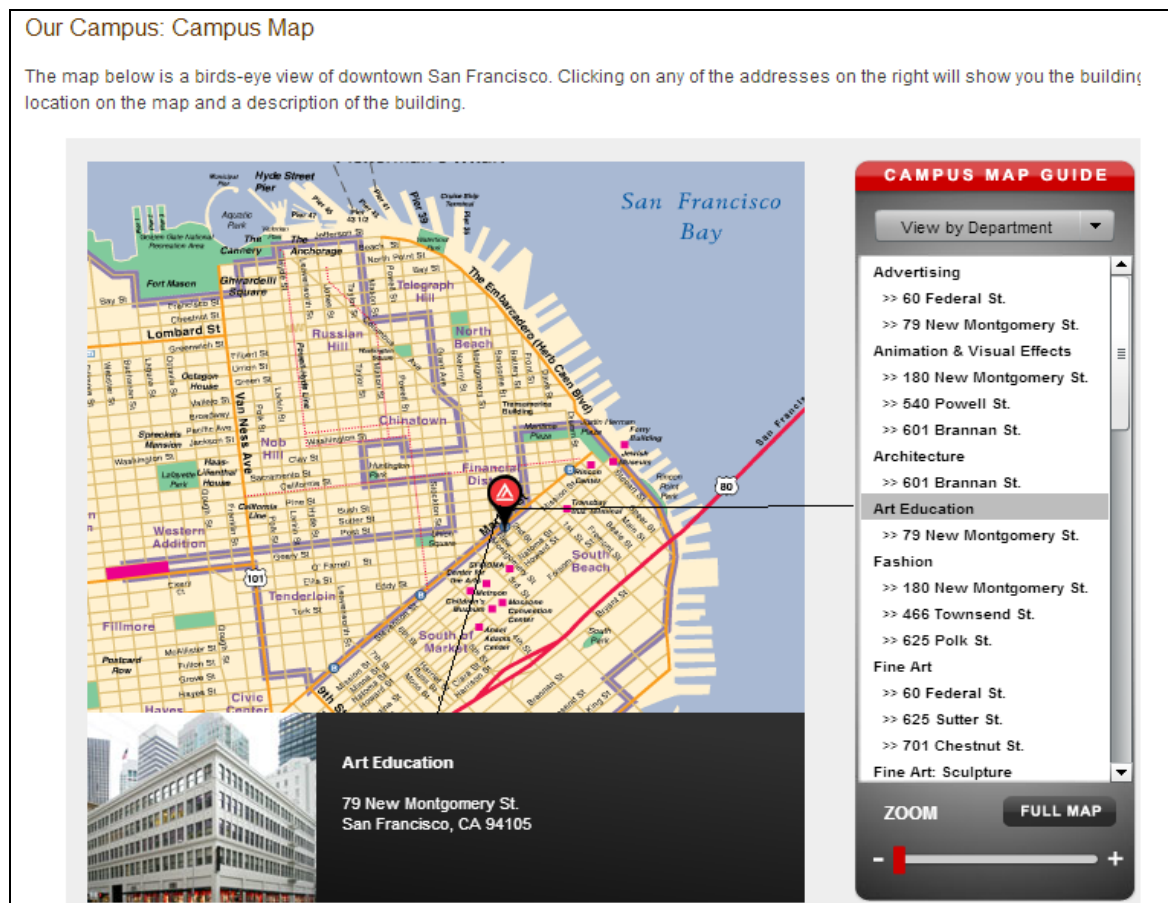
Figure 9 Academy of Art University [48].

Since there are different campuses in multiple locations of California State University, each of them is arranged separately. Each of the campuses has different campus map arrangements. Only two of the campuses are discussed below.

California State University, Bakersfield

The purpose of the campus map as shown in Figure 10 is to provide information about campus buildings. A number is assigned to each of the buildings. If one of the buildings on the list is selected, the buildings in that zone number and their maps can be found. Places that may be needed in the case of an emergency situation (such as telephones etc.) and car parks, along with accessible entrances, accessible paths and accessible toilets, are presented on the map. Also, the phone numbers of some important buildings are provided. Streets that are used to access the campus are also shown on the map [49].
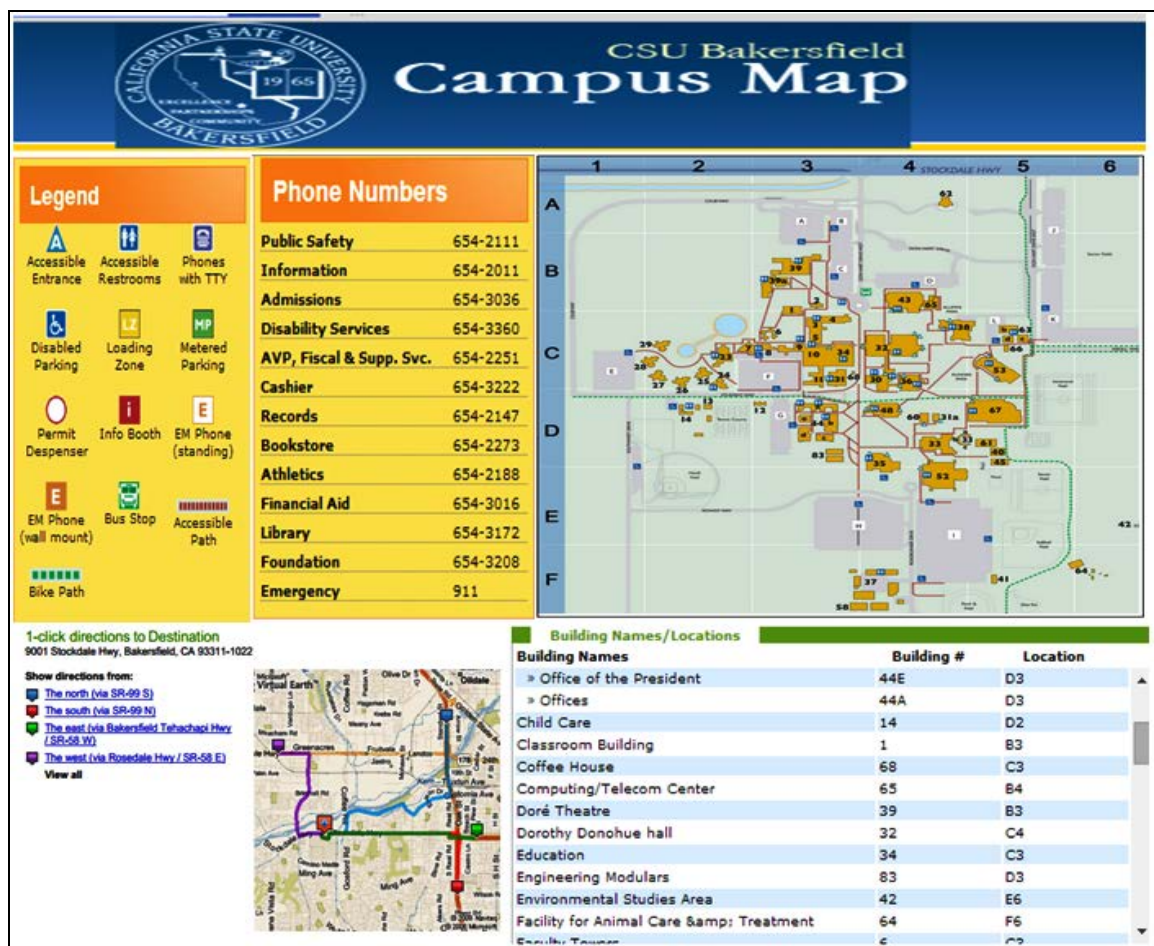
Figure 10 California State University, Bakersfield [49].

California State University, Chico

As shown in Figure 11, the 3D buildings that belong to the University with its names are presented on the map. When a building is selected on the map, the units inside the buildings can also be seen. When one of the units is selected, the associated website of that unit can be accessed, and information about relevant programs and announcements can be found [50].
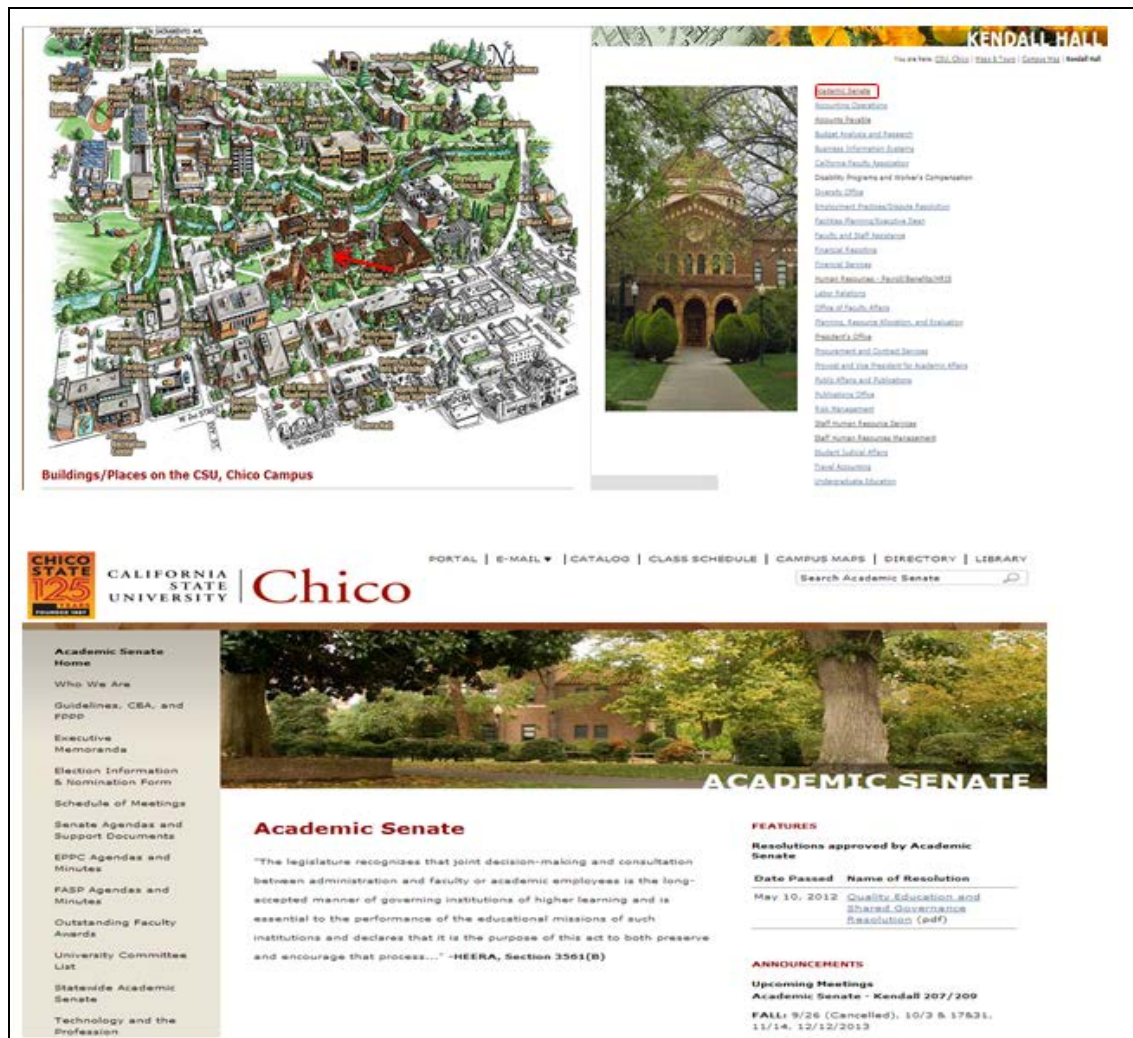
Figure 11 California State University, Chico [50].

Western Michigan University

The map of the campus, as shown in Figure 12, uses the familiar Google Maps interface, and provides access to multiple WMU layers of information. Users can zoom in and out of buildings to some extent on the map. Buildings can be found by searching or browsing the dropdowns above the map. After selecting a building the pop-up window appears, and from here more information about the building can be found, a photo can be viewed, or directions can be obtained to or from the building. In addition, there are overlays for car parks and mobility maps [51].
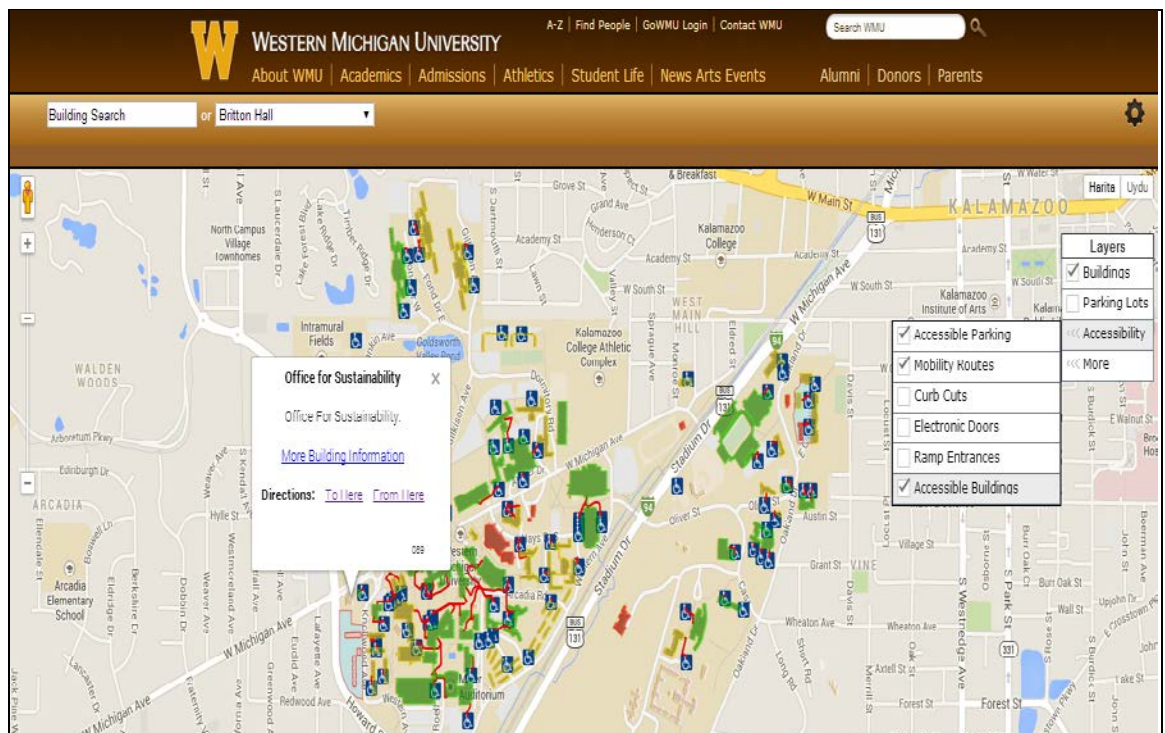
Figure 12 Western Michigan University [51].

University of Cambridge

There is an interactive map of the University as shown in Figure 13, When a building is selected on the map, a menu of icons is shown indicating operations at that point. The user can click on one of the numbered location spots from the full listing, and the location is shown by a pin. Also, the building name and the address and telephone information of that building can be found on the right side of the Web page. The building's related website can also be seen. Only information concerning the building that is numbered on the map can be acquired. One can go back to the

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map from the Web page on which the contact information is presented. There is also an opportunity to zoom in or zoom out. The campus map is displayed with the other important buildings and street information. Access to the campus, routes (suitable for foot, motor, cycle and service access) and building entrance for search results are also provided [52].
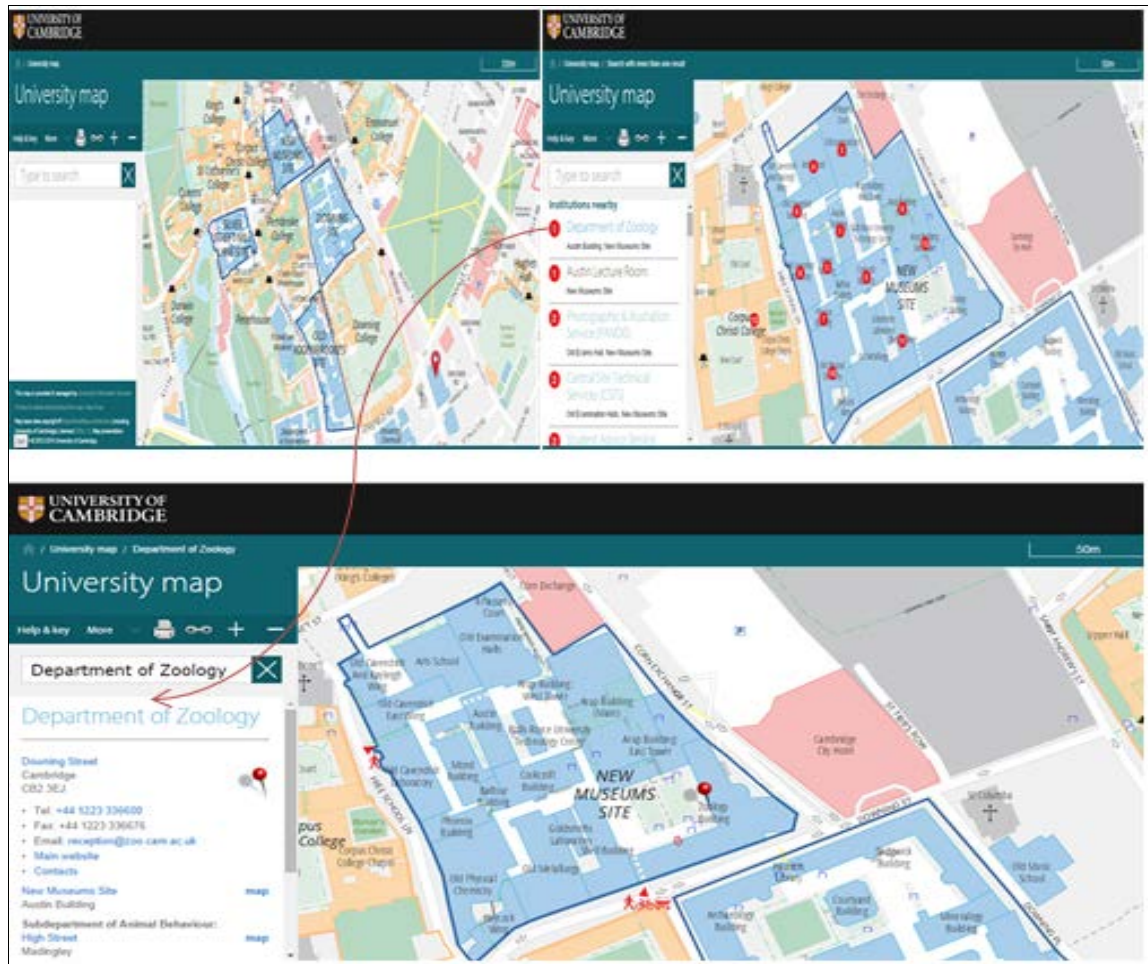
Figure 13 University of Cambridge [52].

Tsukuba University

As can be seen in Figure 14, the whole campus is divided into four sections here. For each of the sections, a normal map is presented. On a normal campus map the building names, campus bus stops, pedestrian roads and parking areas are always presented. Also, transportation alternatives and travel times are presented. There is also a list of facilities on the right side of the Web page. When a campus is selected a list of facilities appears. The facilities' names are divided into categories in the lower part of the Web page. When the button is clicked, the facility in question appears on the Google Map and its name and picture can be seen [53].
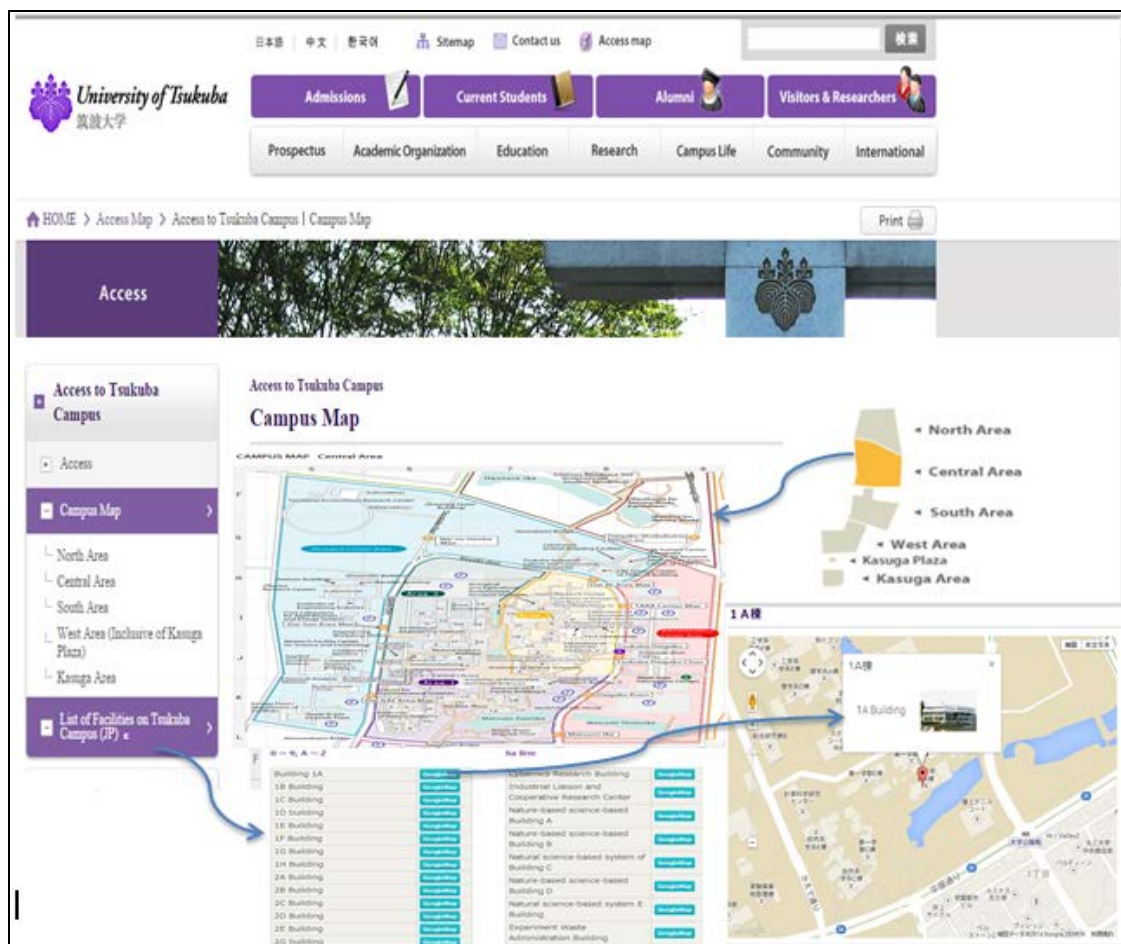
Figure 14 Tsukuba University [53].

Shandong Jianzhu University

In [54] the 3-D GIS developed to achieve an information inquiry function. When a feature is selected as targets on the map, the information about the target will be displayed in the GIS interface. Moreover, it can also be inquired when entering the destination information via a query window, and the results queried will become highlighted feature goals in the figure. The integrated layers of the zone include DEM, images and features (buildings, roads, meadows, vegetation, etc.). Figure 15 shows the search functions relating to the building attribute information, the buildings' attributes and photographs related to the 3D GIS models, therefore users can achieve bidirectional data queries.
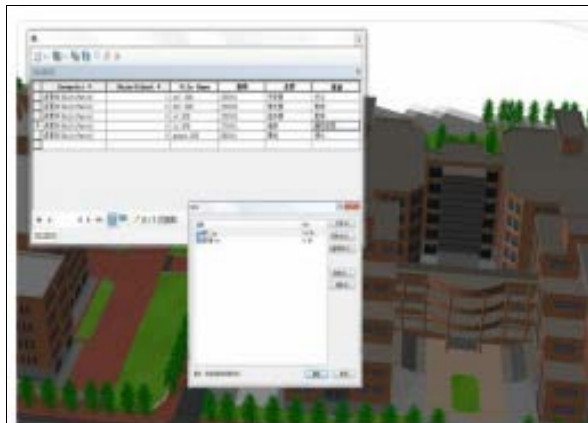
Figure 15 Shandong Jianzhu University in China [54].

Anadolu University

As can be seen in Figure 16, maps of the campuses, which are located in different places in the city, are presented. When clicking on a link (campus map) on the left side of the Web page, maps of the campuses can be accessed. The map has two zoom levels. When a building is selected on the map, the name of the building appears, and its pictures can be seen on the right side of the Web page. Additionally, a building can be selected from the list at the top of page and its location will be highlighted on the map. If the user zooms out of the map, the locations of the campuses in the city can easily be seen [55].
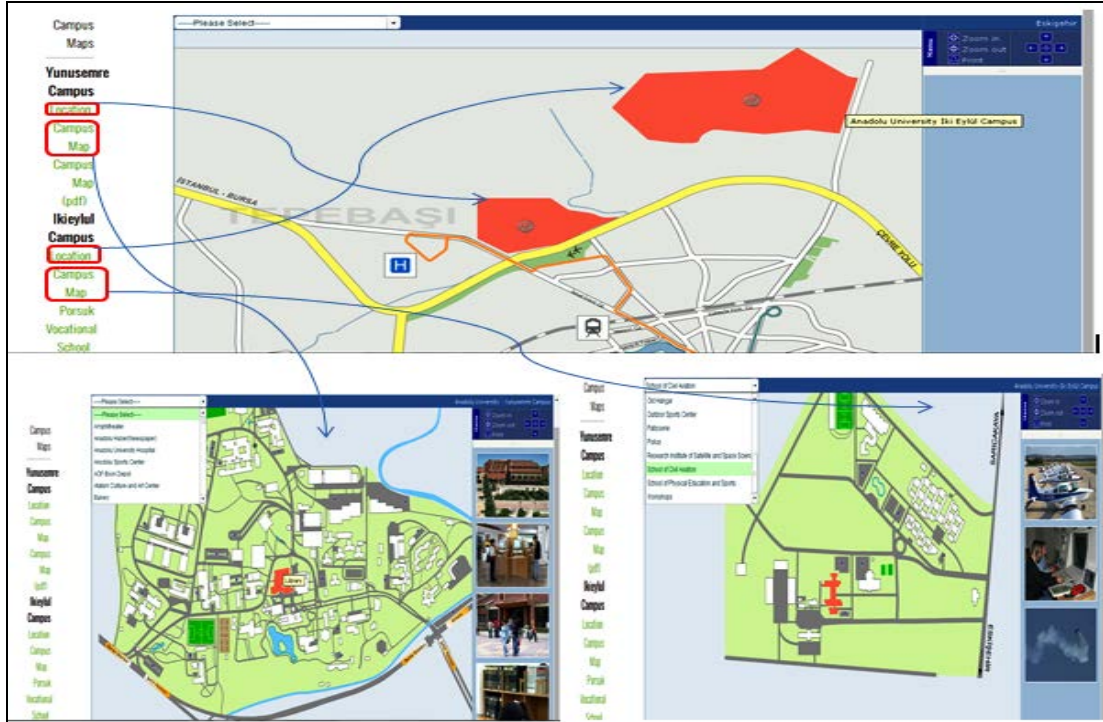
Figure 16 Anadolu University [55].

Istanbul Technical University (ITU)

On the map of the ITU campus, when roll over the buildings, only the building names can be seen, as shown in Figure 17. Additionally, when a building is selected from the list at the top of the page, its location can be seen on the map. No additional information is provided [56].

Figure 17 Istanbul Technical University (ITU) [56].

Boğaziçi University, Turkey

The map of the campus, which uses the familiar Google Maps interface, is shown in Figure 18. The map can be used to view Istanbul city plans along with the campus area. Separate maps are prepared for each campus. There are certain types of signs on the map. When a building sign is selected on the specific campus, information about the history of the building and related pictures are presented [57].
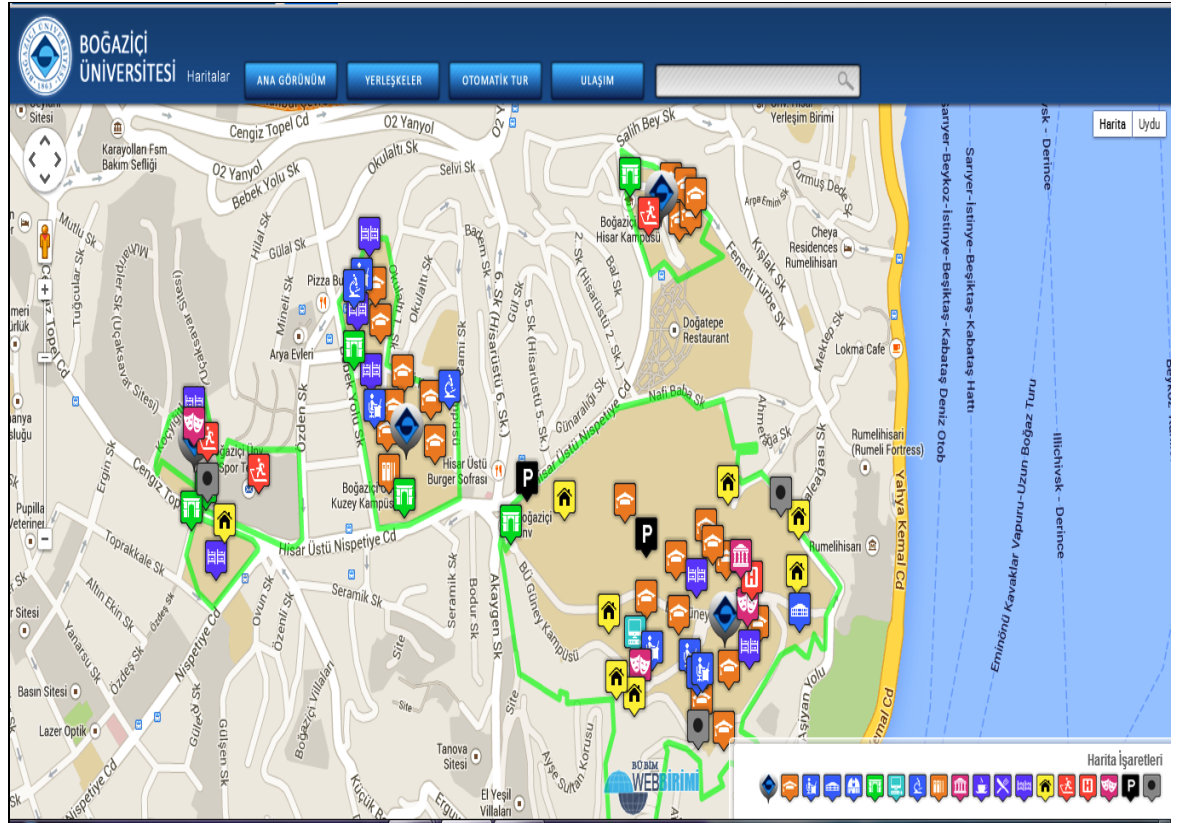
Figure 18 Boğaziçi University [57].

Yıldız Technical University

The map of the campus, which uses a satellite image interface, is shown in Figure 19. This system displays basic GIS functions (Zoom in/out and pan the map, Full-extent, Back-extent, Next-extent, and Magnifier tools, Identify and Measure tool) on the toolbar. The toolbar allows the user to interact with the map by clicking on the map with a tool. Information about the structures, buildings, roads, sports areas, green areas, trees and car parks at the University is collected. The Identify tool can be used to discover information about a feature on the map. Also, the Measure tool can be

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used to measure distances and areas. The Results panel on the right side of the Web page displays the output information from a search [58].
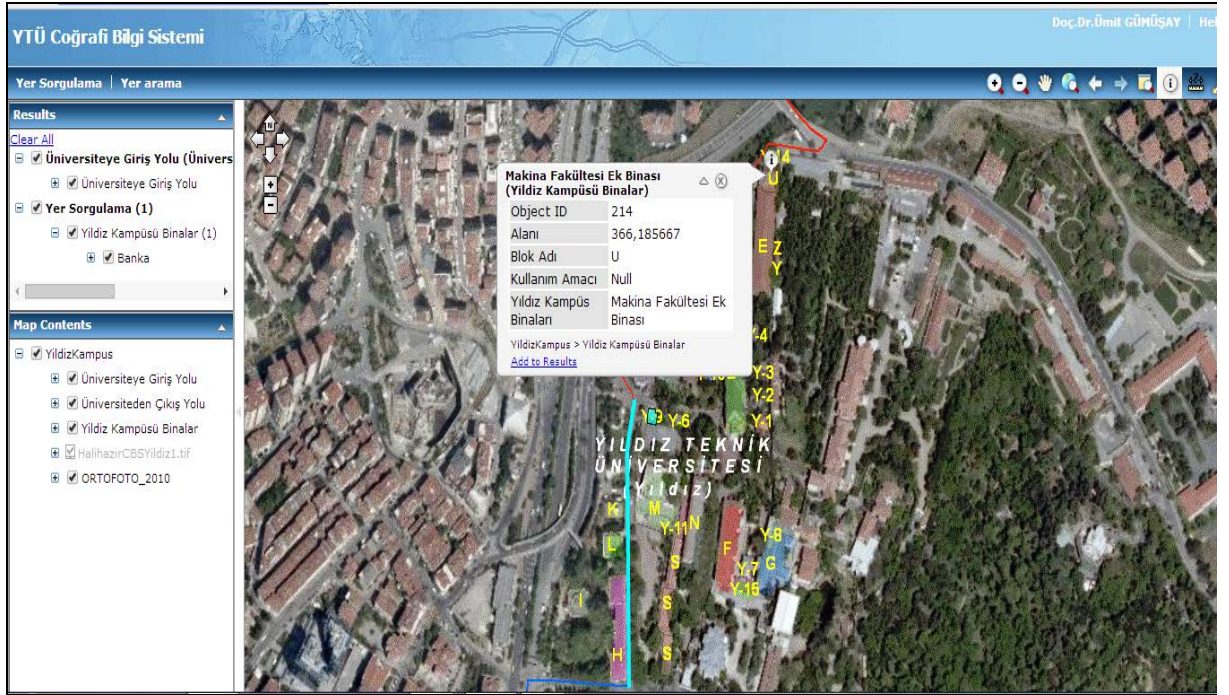
Figure 19 Yıldız Technical University [58].

Afyon Kocatepe University

Once the Afyon Kocatepe University Campus Information system (AKÜBİS) had entered into service, University managers would have been able to make fast and accurate decisions with respect to the following needs:

• Education

• Personnel training

• Facility management

• Future planning

In accordance with these purposes, the steps that are stated below to establish AKÜBİS are conducted.

• Information collecting

• Required literature is reviewed and terms related to the geographical information system are examined in order to establish the campus information system

• System is designed

• Database is prepared

• Map sheets required for the system are generated, and digitalized on ArcGIS

• The system is tested with positional queries and analyses

• The project is presented to the external users via Arc/IMS software after the system is made ready for use [16].

Sakarya University

The Campus Automation Web Information System (CAWİS) at Sakarya University is not available to users outside of the campus. It can only be used by administrative and academic personnel and students via the passwords that are given to them. It is not known whether or not this information system is map based. Sakarya University users access the services in various categories after login. The aim of using the CAWİS system is to create Web page authorization from only one point to provide security, avoid the recurrence of the same operations and increase the productivity of the infrastructure. Although it entered into service in 2004, the process of adding services to develop the system is still continuing. CAWIS is the biggest automation system of the University that is software based [59].

Middle East Technical University (METU) Campus Information System

The campus plan is presented on the map through the METU website. However, an interactive map cannot be found. There are names of buildings that are on the campus on this map, and there is the opportunity to zoom in or zoom out. Infrastructure maps for water, sewage, natural gas, heat, electricity and telephones that are in the campus area as different layers are planned to be presented via a geographical information system within the scope of the infrastructure information system of METU. In accordance with this plan, four different operations are conducted.

1. Ankara Metropolitan Municipality maps are taken as a basis and the existing maps on the country coordinate system are used exactly.

2. Digital CAD maps are located on the existing 1/1000 scaled maps. (Relocating and turning processes are conducted.)

3. Information that is on the paper maps is scanned and digitalized on the screen.

4. Information that is not provided on the map and that is not updated is collected through field works.

The information created is added to the existing attribute information so that there is an opportunity to make inquiries (search-find), report on and analyse the system. The system also has interfaces to enter new data (to make updates). In order to make efficient and accurate updates, it is planned to use GPS (Global Positioning System). One of the most significant advantages of the METU infrastructure system is the underground gallery system on the campus. Infrastructure services are easy to operate as they are in this gallery system. When it comes to the service lines that are outside of the gallery, some problems may be encountered in finding the actual location. Work on the system is still going on and the necessary additions and edits for operating are being made with respect to the system [60].

Erciyes University

In an interactive manner, campus maps can be queried both locally and via the Web. The graphical data sources used in this study are satellite image, various thematic maps, digital boundary maps, large-scale topographic maps, 1/5000 Campus Master Plan and Digital Elevation Model maps. The graphical and attribute data belonging to the University can be collected and transferred into the computer environment by using ArcGIS software.

Preparation of data for availability in the local environment:

- On the interactive maps, queries for each layer are enabled, and access to detailed information can be gained through viewpoints. A general idea about the campus can be inferred by examining the camera views of classrooms and rooms. When viewpoints are clicked on, realistic panoramic views of each characteristic campus point can be viewed and rotated 360°.

- Through the campus information system, the noise levels in the morning, at noon and in the evening can also be monitored at 50 metering stations established within the campus. The noise of the campus area is modelled by using the Inverse Distance Weight (IDW) method.

- The system has also provided information on transportation to the campus area by displaying bus stops and routes. Thus students are enabled to travel to the campus area easily from all districts, and departure times and bus routes can also be checked through the system.

The interactive campus map is presented on the Internet by using the ArcGIS Server software. The campus map is displayed in sports areas, car parks, the pool, green areas and other important buildings that were designed in 3D form using the SketchUp software, which maintains similarity to the actual structures. In addition, panoramic views can be viewed and photographs of buildings that exist within the University are linked to the project, through hyperlinks.

The objects can be selected with a mouse; the attribute data for graphic objects can be seen or an inquiry can be made by list. All analysis and query processes that can be performed in the ArcGIS software can be accessed in the Internet environment. Here, the user is able to choose components such as layer, distance, scale and site information that can be seen on the Web page [61].

Al al-Bayt University campus

3D maps are one of the main topics in the GIS. There are many research efforts in the area of developing 3D maps. In this thesis an application for the Al al-Bayt University campus, Jordan, was constructed to generate a real 3D GIS modeling that would include the campus buildings and infrastructure layers. Different GIS layers exist in this study; these layers are: the buildings layer, the utilities layer and the road networks layer. The 3D modeling of the University campus and its application for a campus information system comprised the following steps: data acquisition, generation and visualization of the 3D model. The application is composed of three components as described in the paper that provides illustrations of creating a 3D model of the main campus by steps:

• Input data: This refers to getting the CAD drawings and paper plan maps for the studied area. The 2D base model of the campus is created by using ArcGIS to convert the AutoCAD files to shape files.

• Data processing: After converting the AutoCAD files to shape files. The objects have building features that were transformed into polygons; road networks were transformed into polyline features and other utility layers. Then all spatial databases are joined to create layers in the GIS environment in order to build the relational database and the 3D model is built using the Arc Scene from the ArcGIS software.

• Output: For using the 3D model in ArcGIS. Similar to the 2D view, users can view different types of campus building planning information in the 3D view, and the 3D green space view.

An "Identify" tool shows in the 2D or 3D view. Users can select a building to view the query information, such as building height, land use zoning, the number of classrooms and capacity, site of faculty, staff offices and phone numbers, utilities attached to the building and so on. Also, it is possible to query information at any point on the campus map. The main objective of this research is to make geospatial information accessible to students, administration and visitors. The importance of campus planning and the effective use of 3D GIS modeling in the decision-making process are focused results in this work. 3D GIS capability for data analysis and visualization is considered a powerful tool for solving various issues that modern cities confront [62].

King Abdul-Aziz University

The main objective of the project is based on the establishment of GIS-integrated elements for King Abdul-Aziz University, Saudi Arabia, which overlooks the Red Sea coast. The main stages of the establishment of the project are divided into four phases as follows: data collecting stage, data entry stage, processing stage and analysis stage, and displaying the results.

So, this work has become a modern digital map containing many campus data for the King Abdul Aziz University.   Then, it was used to take advantage from its knowledge such as, knowing actual location for water network pipes and solve

problems faced in the case of cutting off water. Also, for the routes it will be easy to identify the places to be accessible easily, the shorter and easiest routes, and solve the problem of reaching the place by making another route. In addition, it facilitates the process of organizing traffic analyses that show places of congestion-density to the students. It also processes the query within the project, and constructs the three-dimensional buildings for some areas of the University using Google SketchUp.

One of the main outputs of the project is to raise the map of the University system from a desktop system to a networking (WEB) system by using ArcGIS Server, which contains an updated digital map of the University, showing the classroom buildings, colleges and some data that anyone can take advantage of. And the production of DTM (digital terrain model) for Mecca contains the location of the University according to Jeddah city and a risk analysis of torrents through the valleys to discover places that are a source of danger to Jeddah and displays the site of King Abdulaziz University in the valley through which the torrents flow, which lead to human and material losses [63].

A summary of the examples of the map-based information systems in the above universities is given in Table 1.

Table 1 A Comparison of Various University Campus Information Systems

University name	Satellite picture	Map	Interactive map	Building photography	Building names	Building information	3D map	Contact address	Enquiry	Zoom in/out of map
Youngstown University			●	●	●	●	●		●	
Berkeley University	●	●	●	●	●	●			●	●
George Washington University			●	●	●		●		●	●
Abilene Christian University		●	●	●	●	●		●	●	
Yale University		●	●	●	●	●			●	●
Academy of Art University		●		●	●					●
California State University, Bakersfield		●			●			●		
California State University, Chico		●	●	●	●		●	●	●	
Western Michigan University	●		●		●	●			●	●

University										
University of Cambridge			●		●	●		●	●	●
Tsukuba University	●	●	●	●	●			●	●	●
Shandong Jianzhu University			●	●	●	●	●		●	
Anadolu University			●	●	●				●	●
Istanbul Technical University		●			●					
Boğaziçi University	●		●	●	●	●			●	●
Yıldız Technical University	●				●				●	●
METU		●			●					●
Erciyes University			●	●	●	●	●		●	
Al al-Bayt University	●		●		●	●	●		●	

CHAPTER 5

RESEARCH AREA AND METHODOLOGY

5.1. About Kirkuk University

Kirkuk University, established in 2003 in Kirkuk, Iraq, is considered one of the modern universities. This university includes eight faculties: Law, Engineering, Science, Medicine, Management & Economics, Nursing, Education and Agriculture. All these faculties were scattered in different places and it has changed much since its inception, as shown by the academic research programs provided by the faculty professors and their participation in scientific conferences, both those that took place in Iraq's universities and universities of other countries, as well as the achievements of the mixed religious and ethnic students, in the different disciplines. Also, Kirkuk University aims to exercise its best efforts in the development of cooperation programs, promoting mutual academic research collaboration, establishing ties of friendship, and cultural and personnel training exchanges.

In 2012, the University sought to achieve its ambitions by gathering its scattered colleges in one place where there is a new University complex that includes modern classrooms comparable with the developed countries in terms of modern laboratories and equipped with sophisticated research equipment, and the establishment of a research center, an integrated multi-purpose center suitable for new University scientific research and the achievement of scientific achievements that reflect the capabilities of the Iraqi mind. The new main campus comprises academic buildings with various academic departments. These include the education college, which was established with eight departments: Qour'anic sciences, physical education, geography and history, as well as language departments (Arabic, English, Turkish and Kurdish). The science college was established with six departments: computer, mathematics, physics, biology, chemistry and earth sciences. The engineering collage was established with the following departments: civil, mechanical, petroleum and

electrical engineering. Also included are student hostels, roads, garden spaces, the mosque and gates as well as other infrastructure facilities.

Kirkuk University is one of the public universities in Iraq. It was established as one of the landmarks within the Al-Zayada district. The campus of Kirkuk University occupies an area of more than 0.6 km². It is located about 9 km north-west of the city center of Kirkuk, in Northern Iraq. The satellite image in Figure 20 shows the location of Kirkuk city and the main University campus. The coordinates of the system area in the projection of Universal Transverse Mercator (UTM), Zone 38N of the World Geodetic System 1984 (WGS 84) and the distance units are in meters. The population of Kirkuk University is approximately 7,900. The major part of the population is students. Nearly 7242 students were registered at Kirkuk University in 2012–2013 and the rest were academic staff [68].

A university campus is a complex infrastructure, especially to visitors and new students, because they have a hard time directing themselves and finding places. The campus has different buildings with up to three floors and some of these buildings are far from each other. So, how is it possible to help some inexperienced people and freshmen to orient themselves on the University campus and how can they be supported using modern tools? The Kirkuk campus is chosen for the application of the study. A sample model of a campus information system will be design for this area, which would include the campus buildings, roads, a 3D model, video and infrastructure layers.

Figure 20 Kirkuk University locations on Iraq map and photo of University campus.

5.2. Research Methodology

This chapter deals with the methodology involved in the execution of the application of the campus information system. The methodology used is subdivided into various steps: data acquisition, data processing, data analysis, generation of a 3D model and visualization of the 3D model. Also, in the course of this project, the following processes were carried out: georeferencing, digitizing, database creation, hyperlinking mechanism and presentation of the produced map. Detailed information about these works is presented in the following section.

5.2.1 Software selection and data acquisition

A number of software were required by this research project because of the multimedia nature of the data requirement. The software packages used were as follows:

1. MapInfo Professional v12.0.2 was used for exporting maps, images and all text data into the MapInfo environment and for editing, analyzing of cartographic and spatial information.

2. Google Earth program was used to take the satellite image for Kirkuk University as raster imagery.

3. SketchUp program (Version 2013) focuses on rapid 3D solid modeling of the campus.

4. Lumion 3.0 (rendering and video-making program)

5. Microsoft Windows Media Player was used to play the video, as well as the AutoCAD program.

Data acquisition, as stated in [64], is a process of acquiring, extracting, transforming and transporting data from external data sources and source systems to the data warehouse database objects. Data is a fundamental part of a research project. All the available maps and related data of the project area taken from the University were in paper format. As this paper map must be converted to digital format, an on-screen digitization method was used for this project. The paper maps were therefore scanned, digitized and edited using the AutoCAD program (CAD format data).

On the basis of this, we obtained the data sets in AutoCAD files in dwg and dxf format from digitization of the available paper maps, such as:

- Base map of the University campus showing main campus geographical features, buildings and road network.

- The infrastructure layers (sewage network, fiber-optic network, rainfall network) come from base map files. These drawings were abstracted and combined into a single file. The capacity and diameters of pipes were all written on a previously printed map. So those attribute values were entered into the GIS system.

The on-screen digitizing method was used in order to get a vectorised map of the campus. This map was imported from AutoCAD to MapInfo. While digitizing is a time-consuming process, it has some advantages over raster images, particularly if we want to use the map for geographic analysis. Each feature we digitize becomes a map object that we can modify, edit and attach data to.

A raster map, on the other hand, is simply a graphic image that is used for display purposes only. We cannot edit or attach data to it. It is used as a backdrop for other map layers. Its main advantage over digitizing is input speed. We get raster imagery

such as Google Earth images for the area of interest from the Google Earth program. Photographic images of some campus buildings were collected from the website.

5.2.2 Data conversion to MapInfo format and georeferencing

In our case, the Kirkuk campus spatial data are in the AutoCAD dwg format. Nevertheless, this spatial data must be imported and displayed as a map on the MapInfo professional platform. MapInfo Professional is a desktop GIS software, produced by the Pitney Bowes Software corporation, and its powerful mapping lets us create, analyze, manage and access geospatial assets. MapInfo is used to utilize all formats of vector, raster and database, to enhance presentations and create highly detailed maps, and it can help in decision-making. It also performs sophisticated and extensive data analysis and easily visualizes the relationships between data and geography.

So, the spatial data in the CAD dwg format must be converted to a format that MapInfo can accept. MapInfo reads spatial database with a tab format. Data conversion means converting the data from dwg format into tab format. There are two methods of conversion: by import/export in MapInfo software and by using the Universal Translator tool (FME Quick Translator), we choose "Tools > Universal Translator"; the Set Translation Parameters dialogue box appears in the Reader panel we select the AutoCAD dwg source format. In the Writer panel we select the MapInfo tab format, as shown in Figure 21.
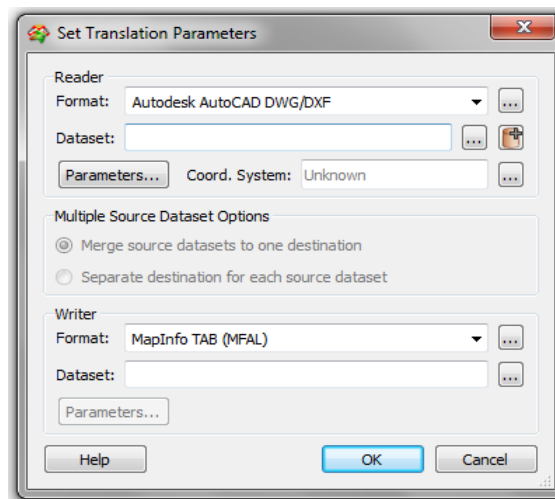

Figure 21 The Universal Translator tool (FME Quick Translator) is a bidirectional translator from MapInfo to popular file format and vice versa.

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The next step is converting the AutoCAD dwg file of the base map layer, which contains the campus roads, buildings and other features as shown in Figure 22, into a MapInfo tab file using the Universal Translator in MapInfo software.
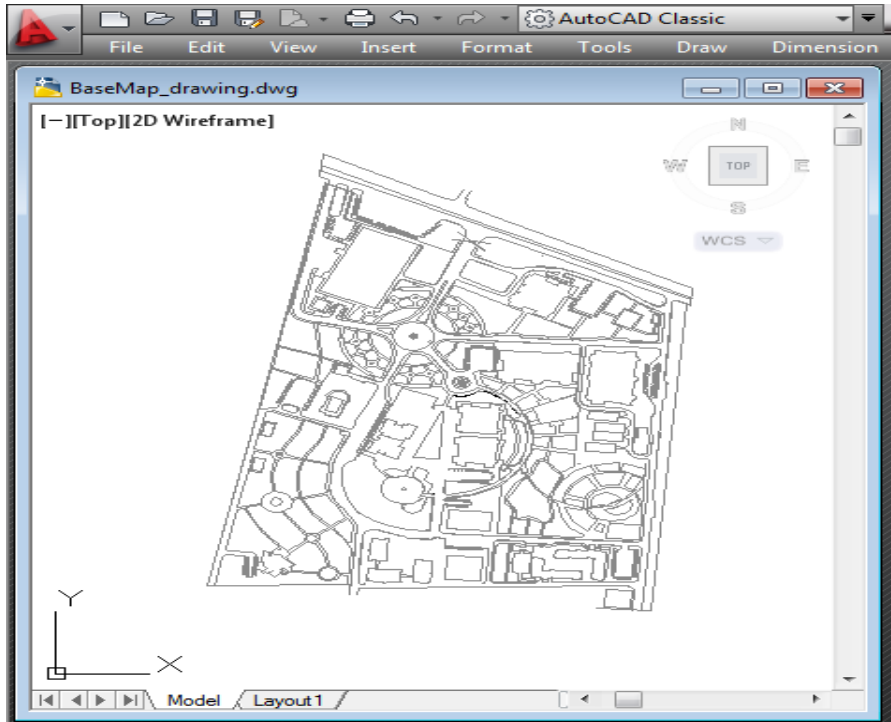

Figure 22 Campus files in AutoCAD.

The transformation produced one layer of a map includes campus roads, buildings and other features as shown in Figure 23.
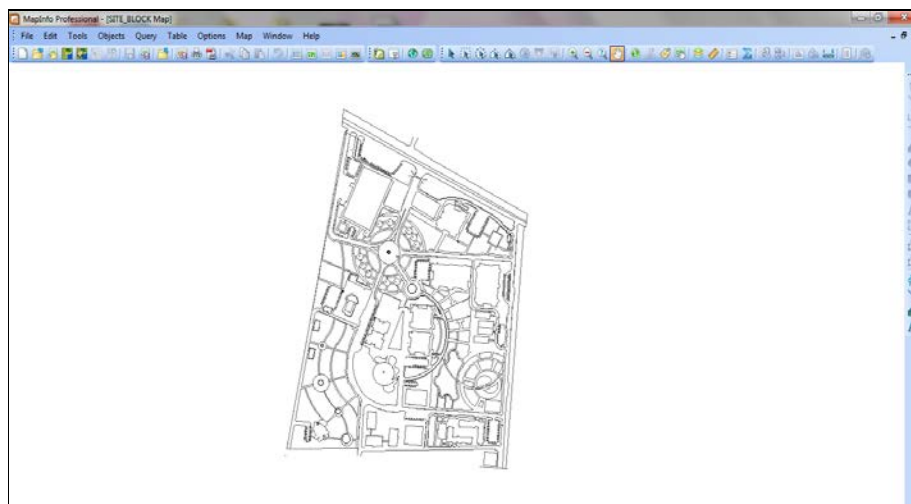

Figure 23 After converting AutoCAD files into MapInfo TAB format

After transformation we export the map by MapInfo to Google Earth Overlay as shown in Figure 24. We note that the drawing map was not in correct projection, because the AutoCAD file does not have earth projections associated with it, and if the projection is unknown, the Universal Translator will bring the files in as a non-earth coordinate system.
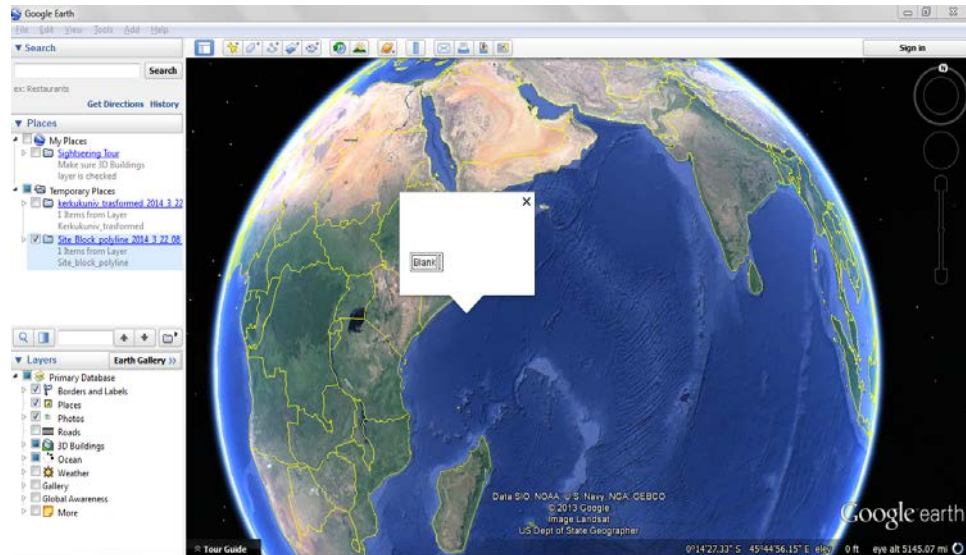
Figure 24   File locations in Google Earth.

The spatial data must be spatially adjusted in GIS. We must convert it from the current coordinates to the correct coordinates. But in this phase the spatial data still has no spatial reference. In this case, it requires specification of some correct control points to register a raster image to get a spatial reference.

The next step was importing the satellite map of Kirkuk University as shown in Figure 25, which was captured from Google Earth software.

Figure 25 Satellite map of Kirkuk University.

We open the satellite image for Kirkuk campus with "**File>Open**" and choose raster image from "Files of type" input box that can be seen in Figure 26. Then, Figure 27 shows the satellite image and main campus map in MapInfo.
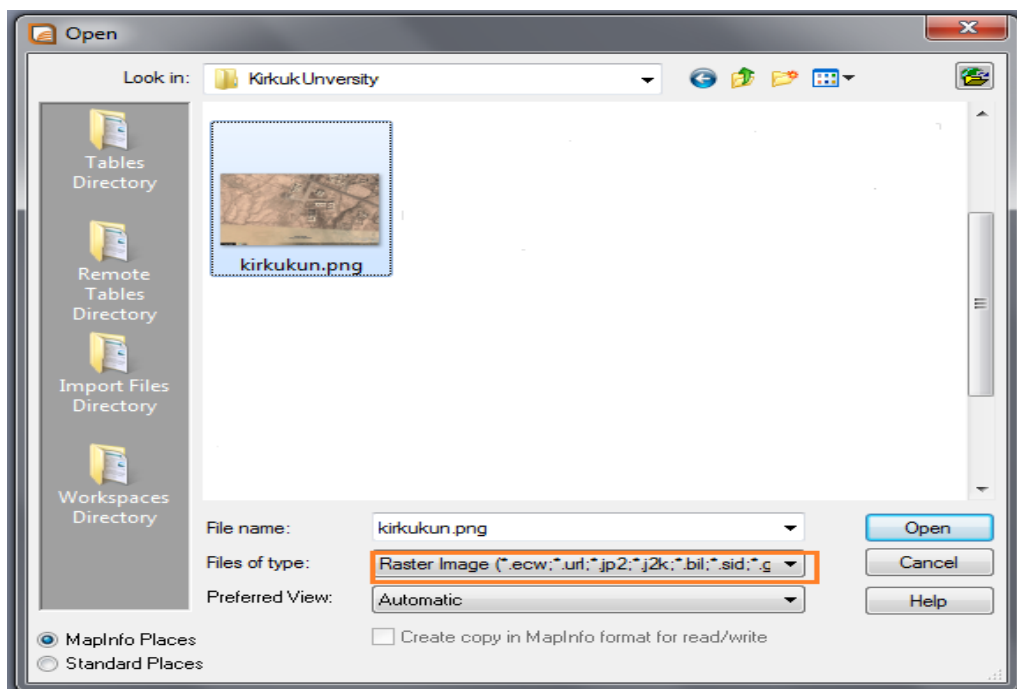
Figure 26 Importing satellite image of Kirkuk University.

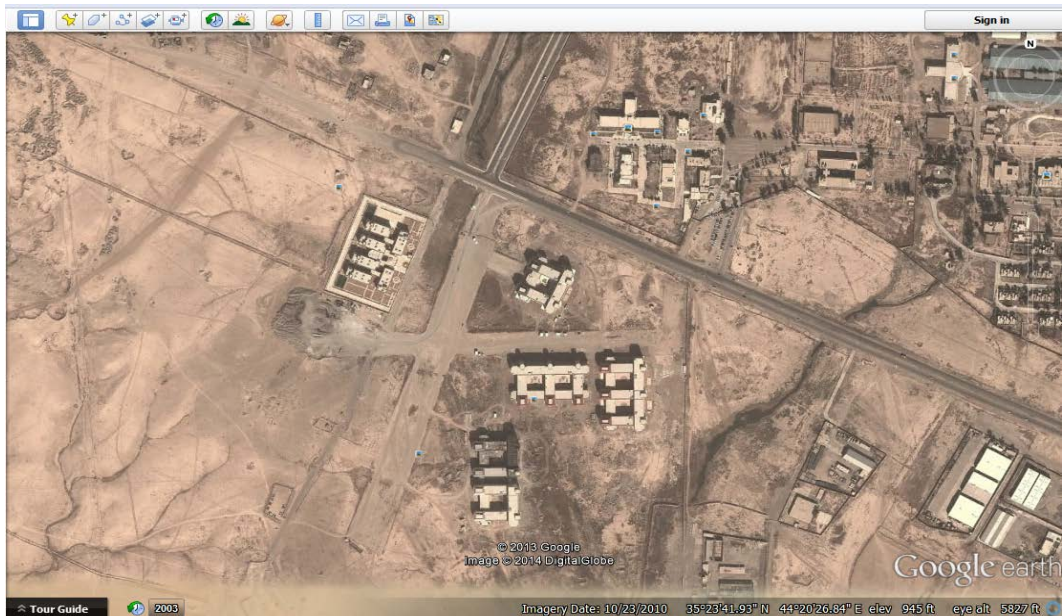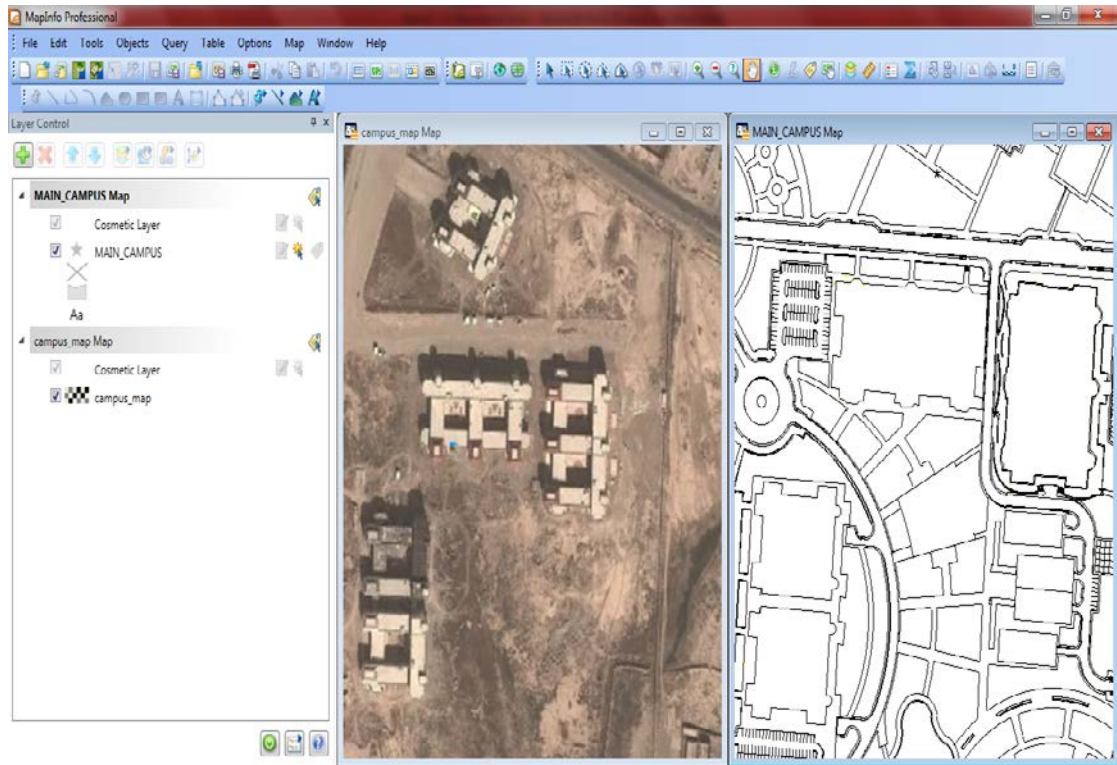**Figure 27** Satellite image and main campus layer.

The latter is a raster image of the same type as a jpeg, tiff, gif, etc.; it's just a digital picture at this point. Usually when opening a raster image for the first time in MapInfo, we must first register the raster image as an earth-related projection by choosing "**Table>Raster>Modify Image Registration**", to display the image registration dialogue box. We choose at least three distributed control points across the image and this should not be a line, then enter their precise longitude and latitude coordinates to be defined as x,y coordinates as shown in Figure 28.
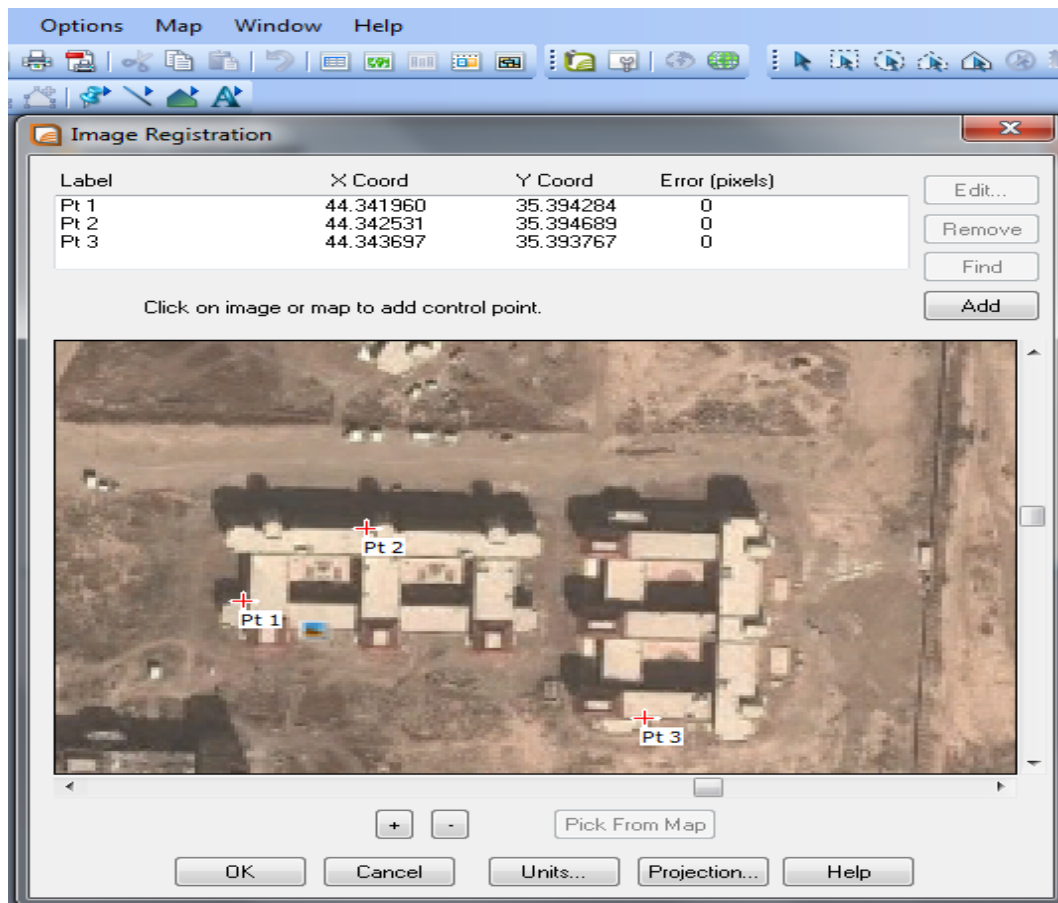
Figure 28 Image registration.

After we register the raster image (2D arrays of data values), MapInfo can associate any point on the raster image surface with longitude and latitude position; this allows MapInfo to perform distance and area calculations , and overlay multiple vector (lines and polygons) map layers, because they provide a much greater level of detail than vector maps.

In order to convert the entire vector map of the main campus into a real-world coordinate system, we choose "**Tools>Register Vector>Register Vector Map**" to run the tool, as can be seen in Figure 29. We use this tool to drop three control points into a vector map of the main campus, the corner of the existing building is in focus. And we do the same to drop three reference points into a map window that contains a raster image of the campus and then an affine transformation is performed to line them up. In this process the vector table is transformed, scaled, skewed and rotated to display properly [67].

Figure 29 Register vector tool.

We click the finish button to transform the coordinates. The projection of the main campus map registered table will match the earth projection of the map window used for reference. The vector map is now properly overlaid with the raster image as shown in Figure 30.

Figure 30 The whole main campus file transformed into a real-world coordinate.
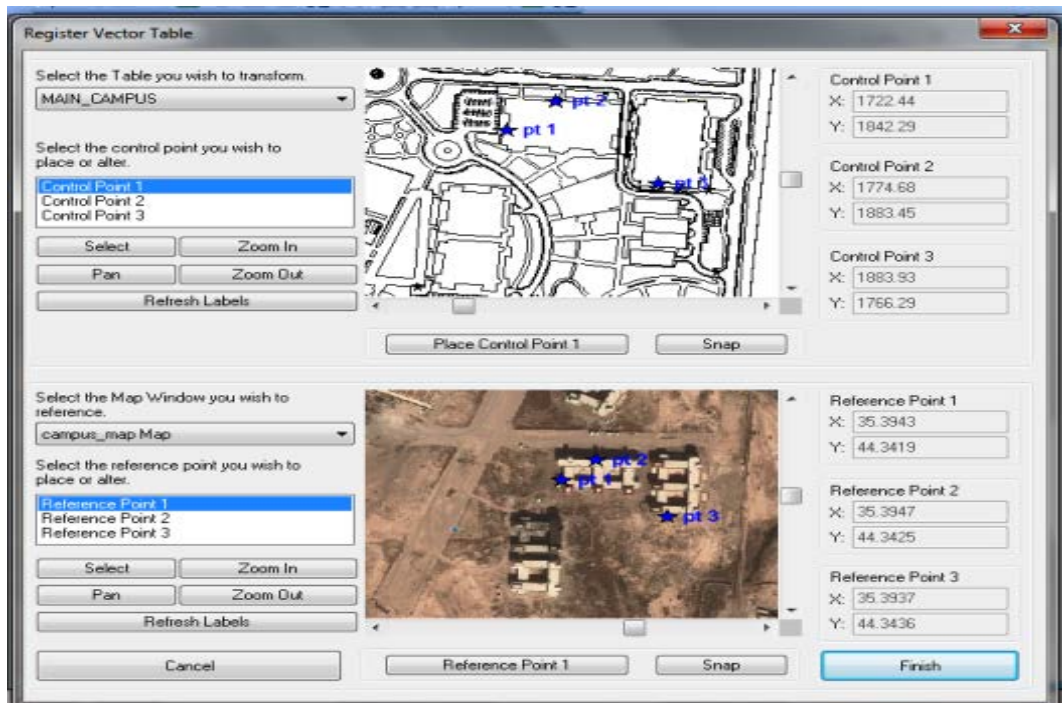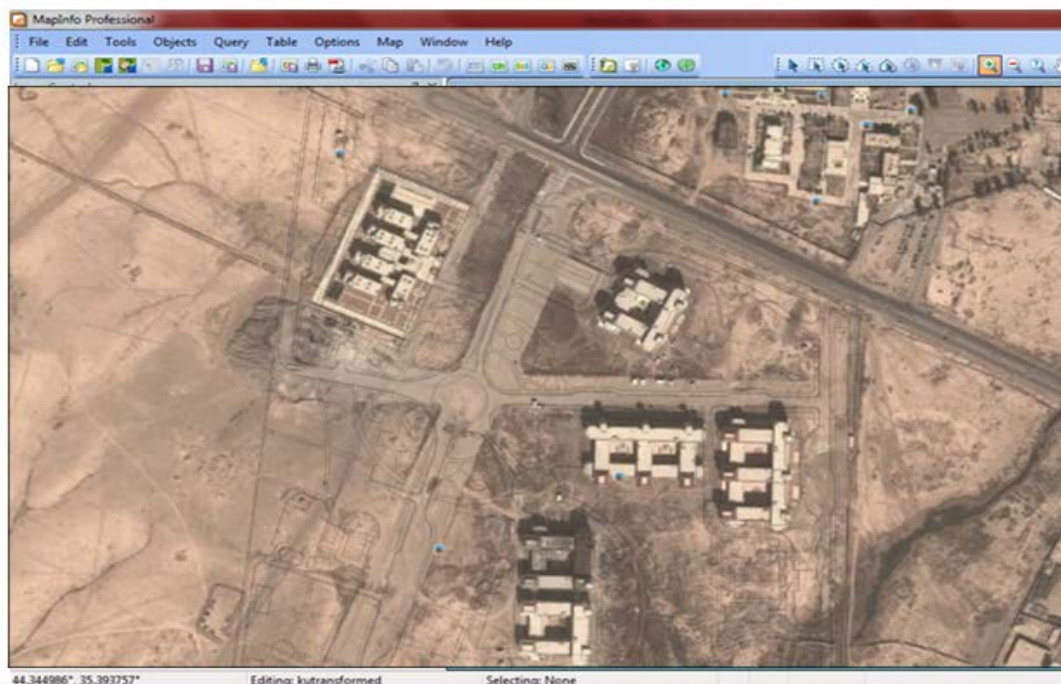
After completing the conversion of all features in the study area buildings and roads from AutoCAD drawings to GIS features and transforming them into real coordinates, we separate this layer depending on their spatial features. All closed polylines should be converted to polygon features, line features into polyline features, and it is necessary to create attributes for the transferred lines, polylines. The attribute data will be created as described below.

5.2.3 How files make up a table and arrangement of layers in MapInfo

All of the underlying information regarding MapInfo is organized in the form of tables; each table composed from a group of files is used to build a layer in a map. MapInfo manages the map with layers, thus each map layer will have the following basic files: the MapInfo (.TAB) format is the main file describing the structure of the MapInfo table. It is a small text file associated with the files containing the data, for describing the format of files; these files are an (.DAT) attribute data file, (.MAP) spatial data file and (.ID) crossing index file. The (.TAB) file describes the structure of the attribute data file, including name, type and length fields, and also specifies the index field. The .DAT format is generally a large file used to store complete attribute data; the header of the file is followed by a description of the table structure and the tabular data records one after another. The .ID file is actually a cross reference file used to link the attribute data with the objects. The .MAP file describes the map objects, and includes spatial coordinates, color and other spatial object information.

According to the above transformation, the whole file was transformed to produce one layer of the vector map including the campus buildings, roads and other features. But, according to application need and actual situation, this map layer would be divided depending on its geometric features into building layer and road layer.

For creating a building layer, we select "**File>New Table**" the new table Structure dialogue box appears as shown in Figure 31. More fields were added to the table according to the type of available data and necessary attributes of each layer. The attribute fields could be expanded with respect to new demands, or may be modified if necessary.
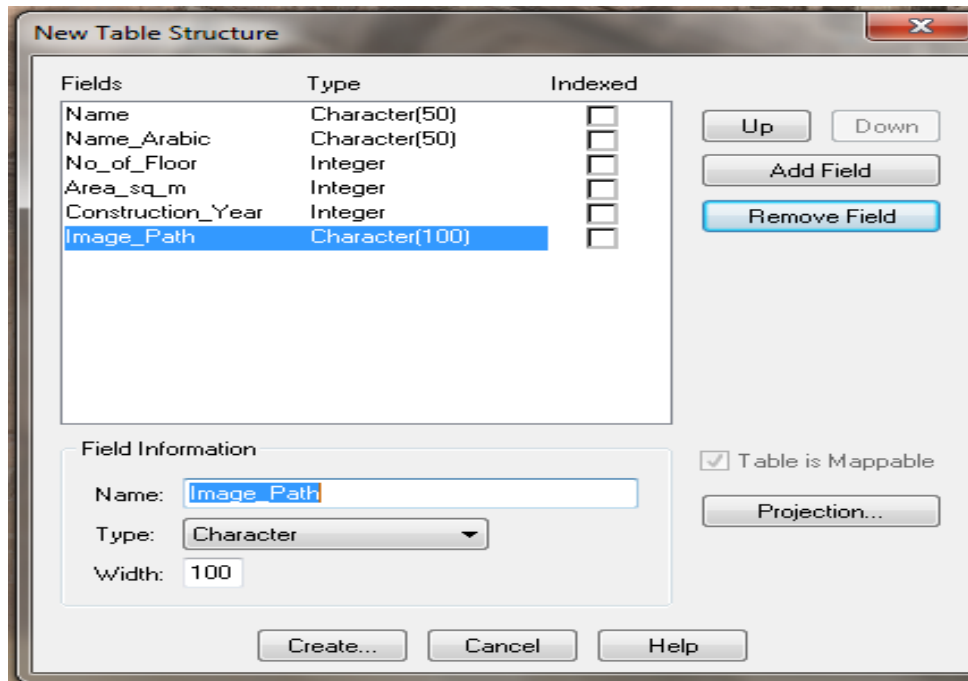
Figure 31 Creating a building layer by using "Table Structure" dialogue.

In order to make changes or modify the spatial objects in a layer, the layer must be editable; only one layer can be editable at a time, and then we can draw objects on that layer. By choosing "**Map > Layer Control**", as can be seen in Figure 32, to make the layer editable, we click the editable icon. We can also control through this window the appearance of the layers by ticking the check boxes.
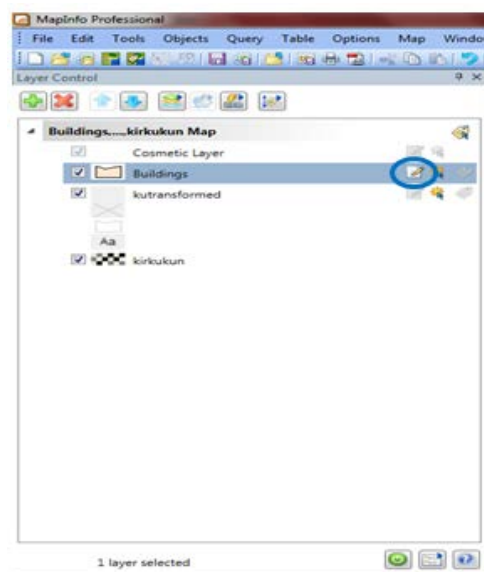
Figure 32 Layer control.

The next step is to convert the objects that have building features into polygon features, by clicking on the small green button in the drawing toolbar named Polygon. When we click on that button we will see the cursor become a plus symbol and we begin to draw as we want to represent the region. MapInfo fills the region with the default pattern. We can also change the color and pattern of the region by using the Region Style button, as can be seen in Figure 33.
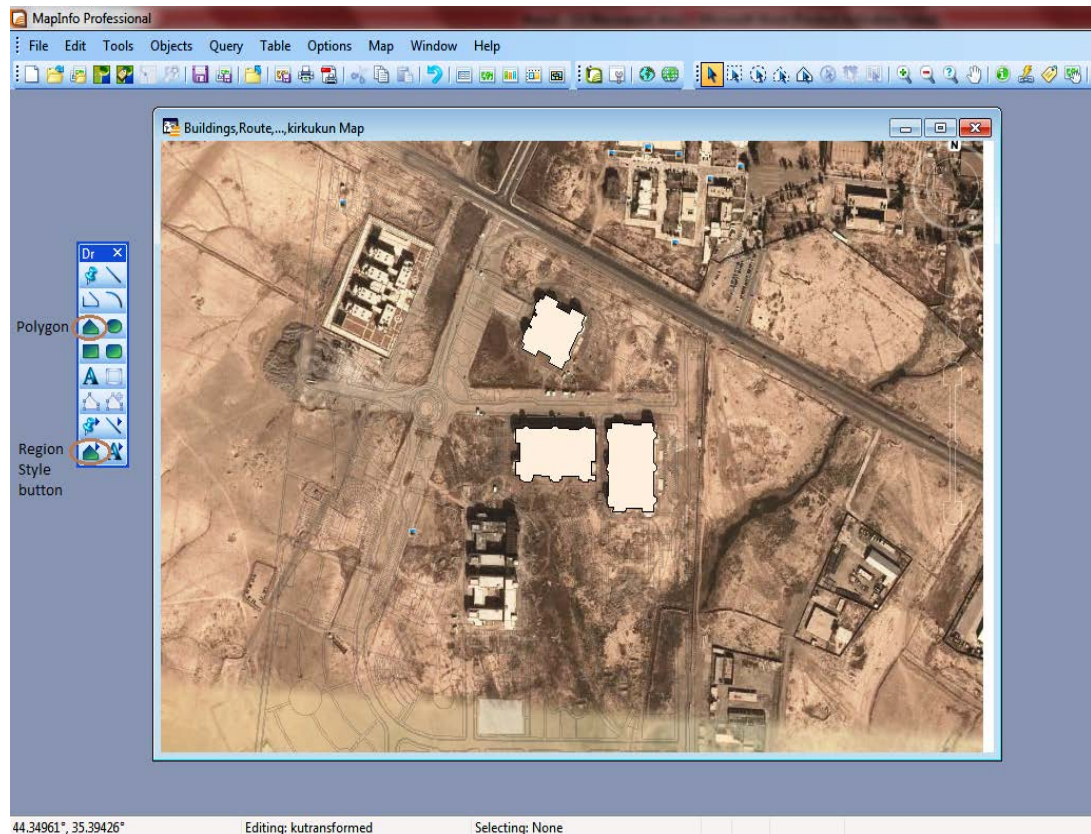
Figure 33 Drawing building layer.

After the required number of fields were added to table for attribute data entries for all the objects in their corresponding records, this template are stored for future use in GIS analysis. Attribute data that is connected with the corresponding spatial data can be entered in a number of ways. A browser window shows all of the objects' attribute data in a tabular form as shown in Figure 34a. The info window shows tabular data for one object as shown in Figure 34b.
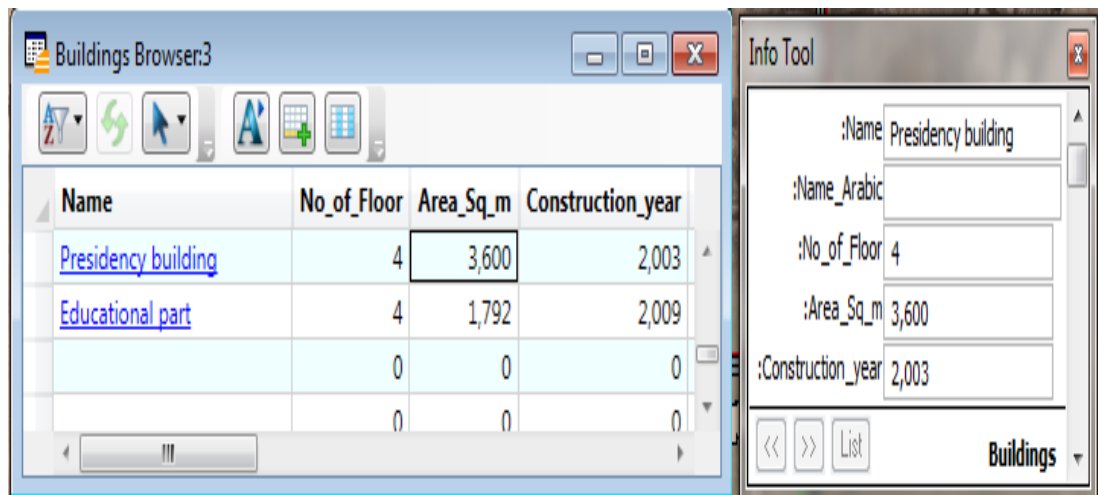
Figure 34 Entering attribute data to objects by using browser (a) and info (b) windows.

We continue to draw the building regions and enter the building names, number of floors, area square and construction year of buildings as attribute data until we finish. Finally, we get a new layer of polygons of buildings called the "Building layer".

In order to provide an enhanced digital map of Kirkuk University, the digital maps were further developed using MapInfo software. Labels were assigned to the various features for easy identification and visualization.

A geographic object from a map layer has a short description called a "label"; the text of this label comes from the table that the layer is based on, and is attributed to the map layer. In this thesis we can choose the building name in English or in Arabic from the list and the building objects in that layer will be labeled with the selected name, as can be seen in Figure 35.
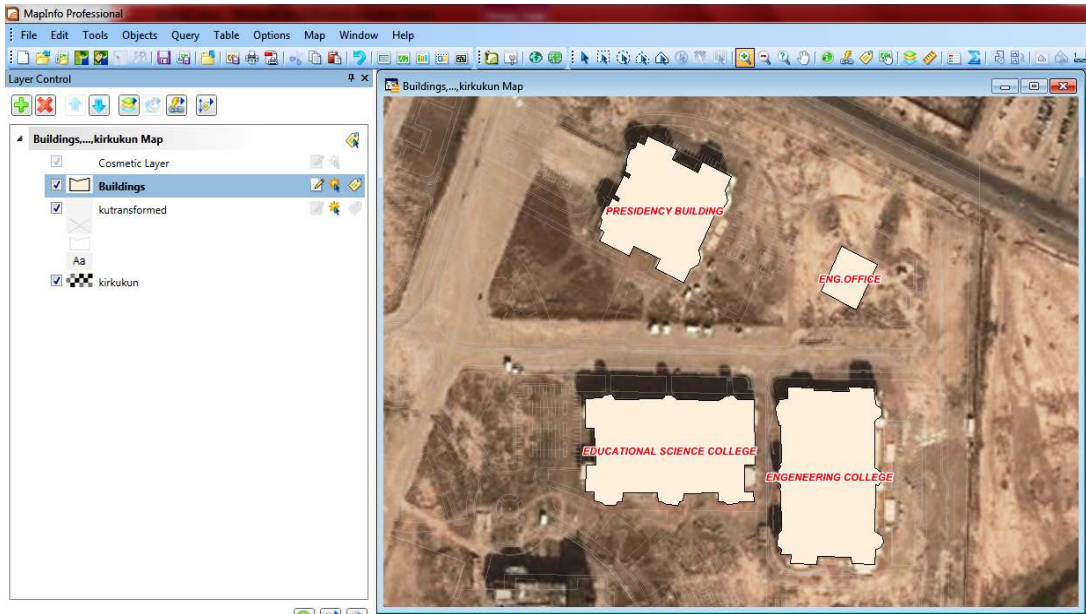
Figure 35 Labelling of the building region

The previous step was creating the building polygons layer. In this step we create a road layer. We convert the objects that have line features (roads network) into polyline features. First we choose the line style, color and width by clicking on the line style button in the drawing toolbar. Then, we click on the polyline button in the drawing toolbar. When we click on that button we will see the cursor become a plus symbol and we begin to draw the first line segment as shown in Figure 36.
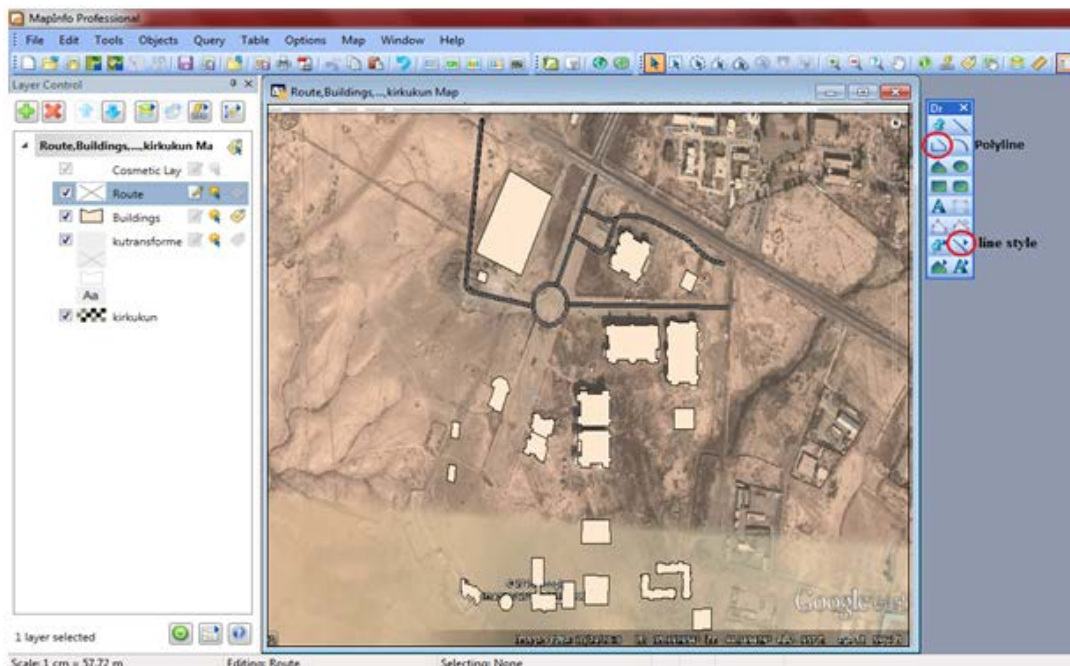
Figure 36 Drawing the roads layer.

The name, length, direction and width of roads were entered as attributes into the roads layer. To enter the route width we used the Ruler tool, which measures the distance between two points, as can be seen in Figure 37.
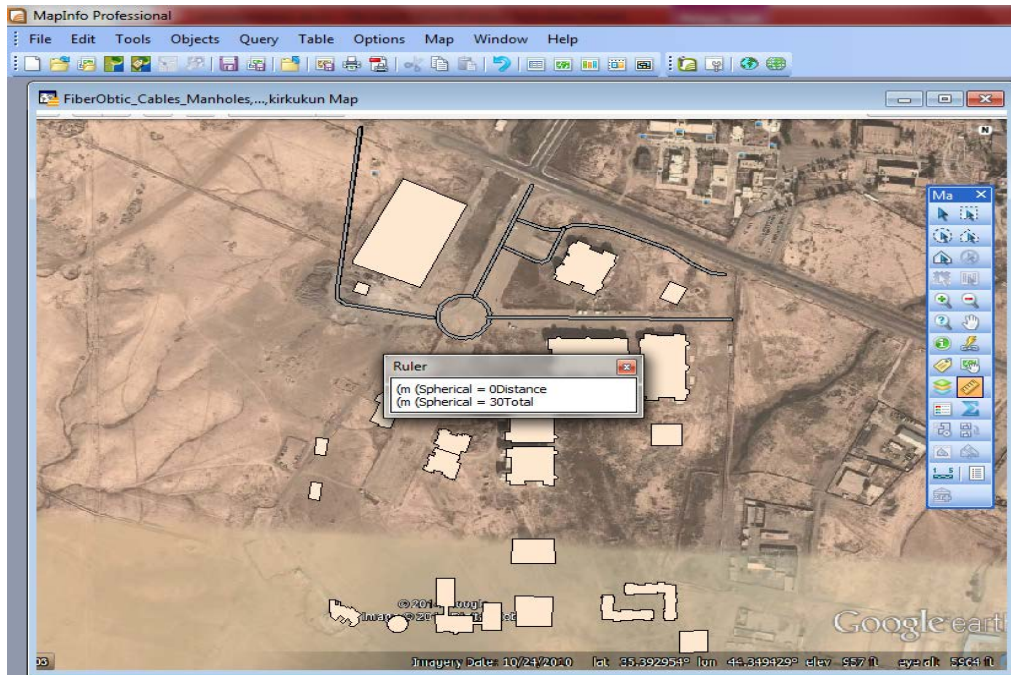
Figure 37 Ruler tool for entering route width.

Also, to fill the route length field automatically we chose "**Table>Update Column**" to access the update column dialogue box. Then, we specify the route table and choose the length column and get the value from the route table; we use the Assist button to access the (ObjectLen (obj, "m") expression. The purpose of using the dialogue box in Figure 38 is to place the graphic information, length of street, into the length columns. So that information can be viewed in a browser window.
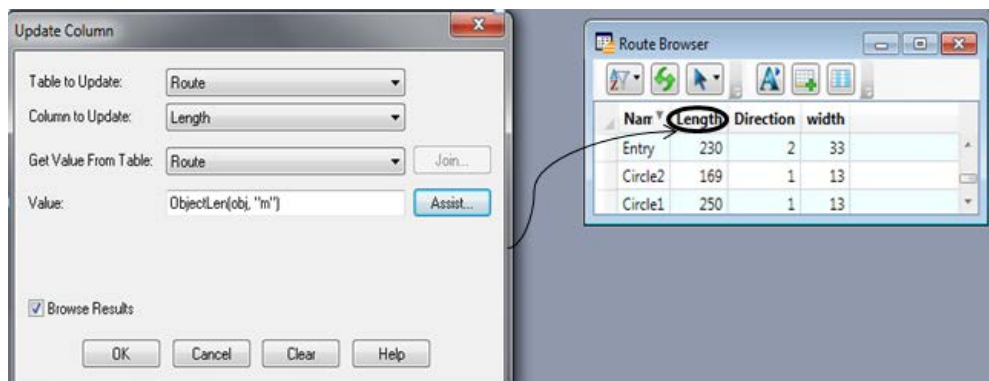
Figure 38 Add length of street.

After completing the drawing of the route layer, we can also add the infrastructure layers (fibre-optic cables network, sewage network and rainfall network) over the combined layers. The infrastructure layer data were in CAD format. The data were converted to MapInfo format by export/import MapInfo routines. Then, they were rotated and shifted to the real coordinates by using coordinates taken from base map layers and the other layer data were transformed with respect to them. The style settings were made for infrastructure layer lines to differentiate the types from one another with graphical representation as shown in Figure 39.
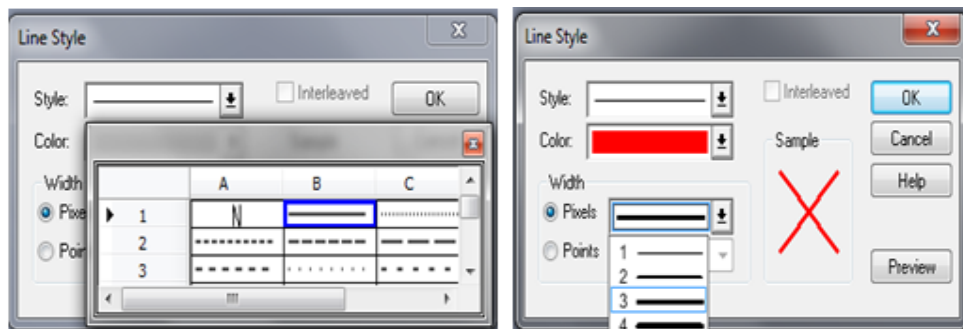
Figure 39 Selecting line styles to differentiate infrastructure layers.

The fiber-optic cable lines were drawn in red with a line width of two as shown in Figure 40, the sewage network lines were drawn in pink as shown in Figure 41 and the rainfall network lines were drawn in blue as shown in Figure 42.
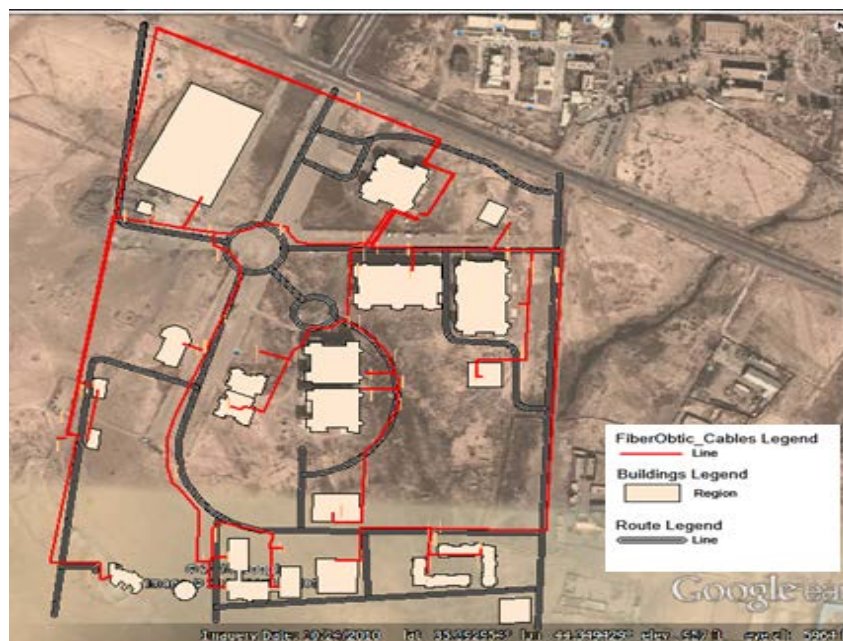
Figure 40 Fiber-optic network layer shown on campus base maps.

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The fiber-optic network attributes are tabulated in Table 2.

Table 2 Database Attribute of Fiber-Optic Network Lines.

Name	Type	Explanation
ID	Integer	Unique element identifier
Length	Float	Length of Cables
Pair_Capacity	Integer	Capacity of Cables
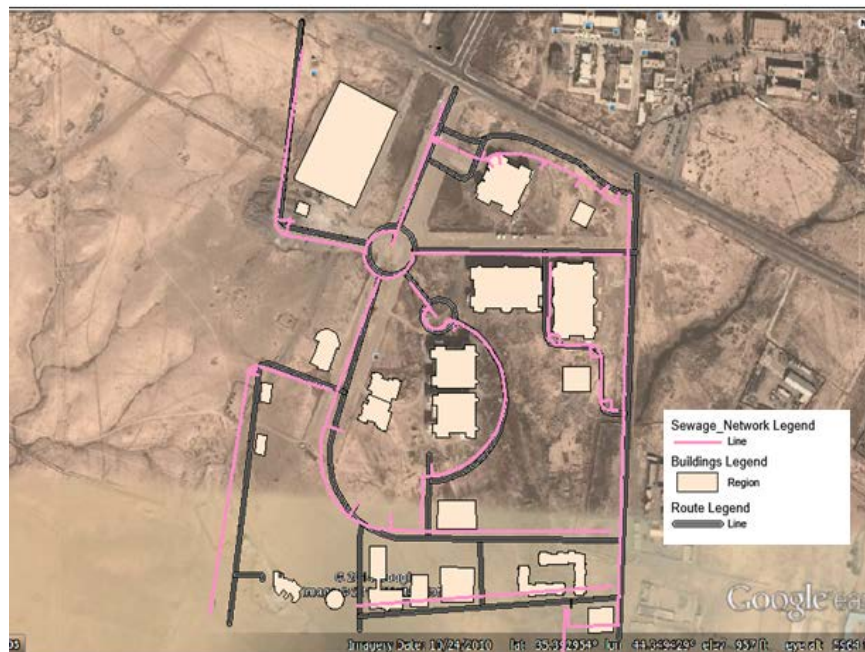
Figure 41 Sewage network layer shown on campus base maps.

The sewage network layer attributes are tabulated in Table 3.

Table 3 Database Attributes of Sewage Network Layers

Name	Type	Explanation
ID	Integer	Unique Element Identifier
Length	Float	Length of Line
Type	Char	Type of pipe
Diameter	Integer	Diameter of Line
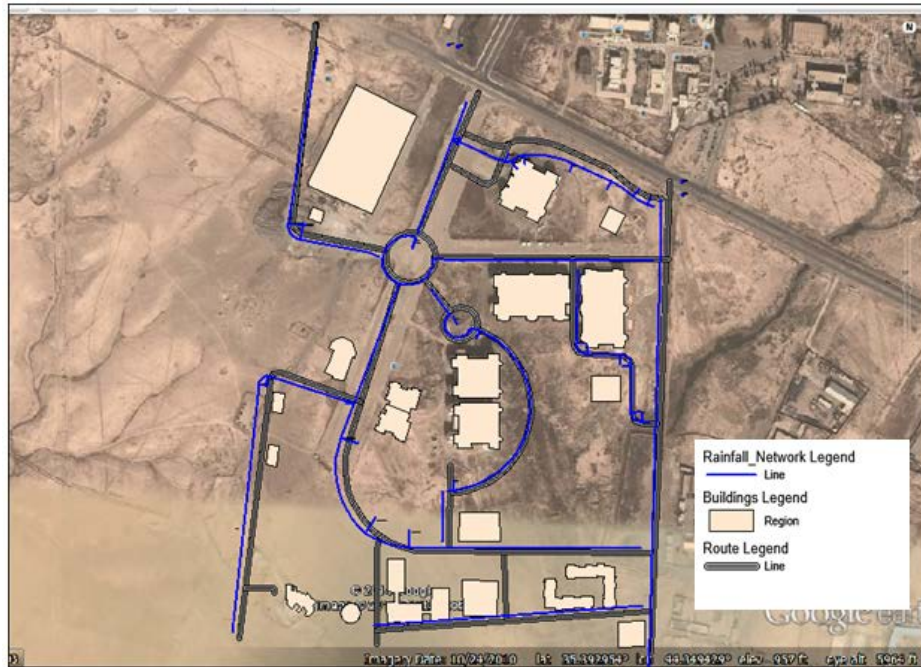
Figure 42 Rainfall network layer shown on campus base maps.

The rainfall network layer attributes are tabulated in Table 4.

Table 4 Database Attributes of Rainfall Network Layer

Name	Type	Explanation
ID	Integer	Unique Element Identifier
Length	Float	Length of Line
Type	Char	Type of sewer pipe
Diameter	integer	Diameter of Line

Now we have all layers on one map as shown in Figure 43.
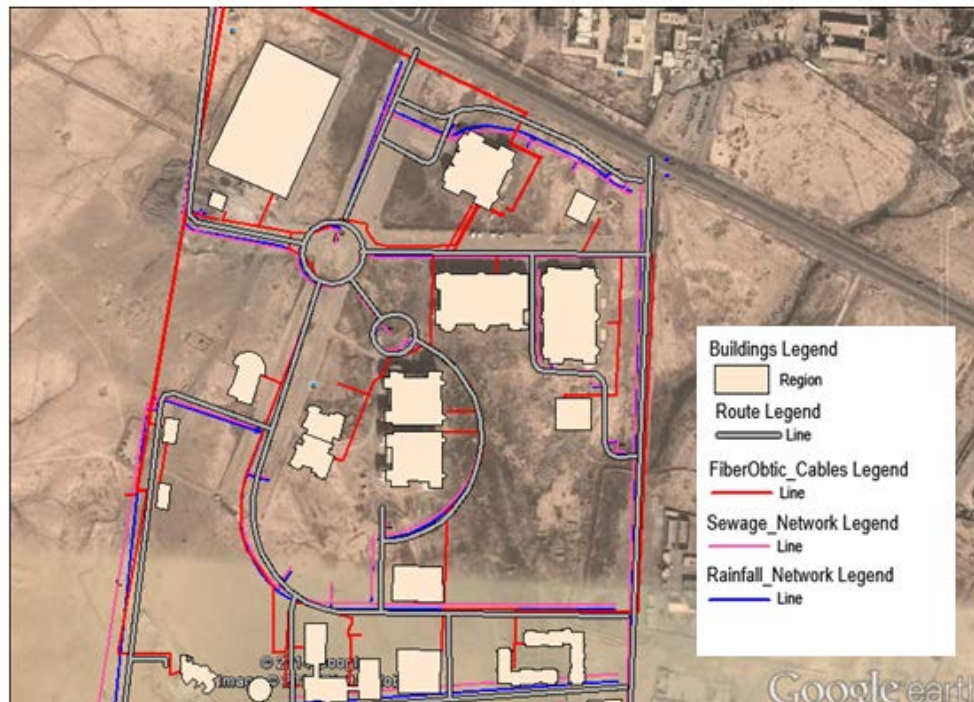
Figure 43 All layers: base map layers (roads, buildings) and infrastructure layer were shown in different colours.

5.2.4 Data analysis

Attribute data provided in this work can be used for analysis in a number of ways, such as:

- creating thematic maps,
- applying SQL queries,
- using browser window.

The first method in creating thematic maps is showing and colouring the university buildings according to some point of information (number of floors, construction year and area). In this way, the information about the map's underlying data is displayed graphically. Then "**Map>create thematic map"** is selected and one of thematic template types is selected and Next button is clicked as shown in Figure 44.
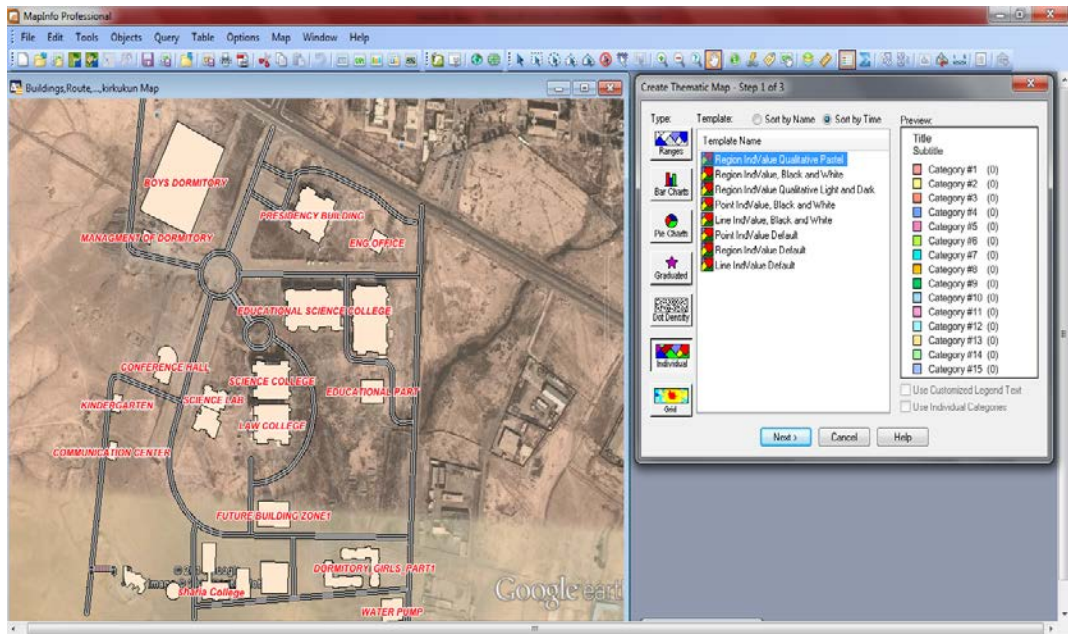
Figure 44 Create thematic map step 1.

We choose the "No of Floor" field from the building table, and press next. We can also preview the map's legend in the last step before displaying the map, and this allows the legend's label order to be changed. Then we press ok as shown in Figure 45.
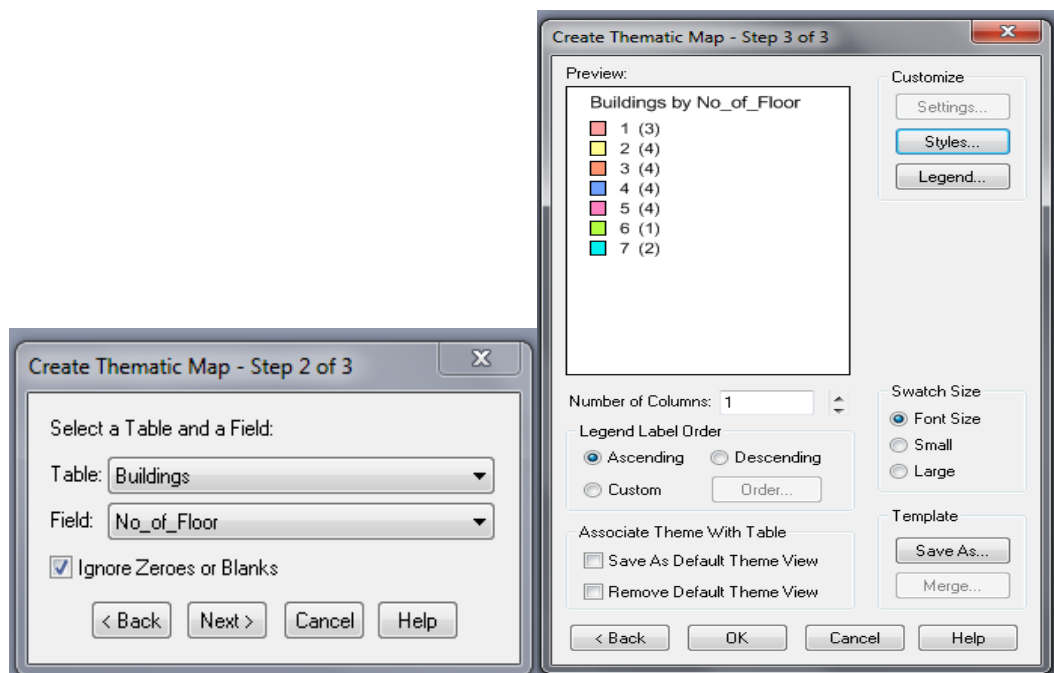
Figure 45 Create thematic map step 2 and step 3 by number of floors.

The results of displaying the thematic map by coloring the regions according to number of floors and theme legend are shown in Figure 46. The legend is the part of a map used to explain the meaning of different colors used on the map.
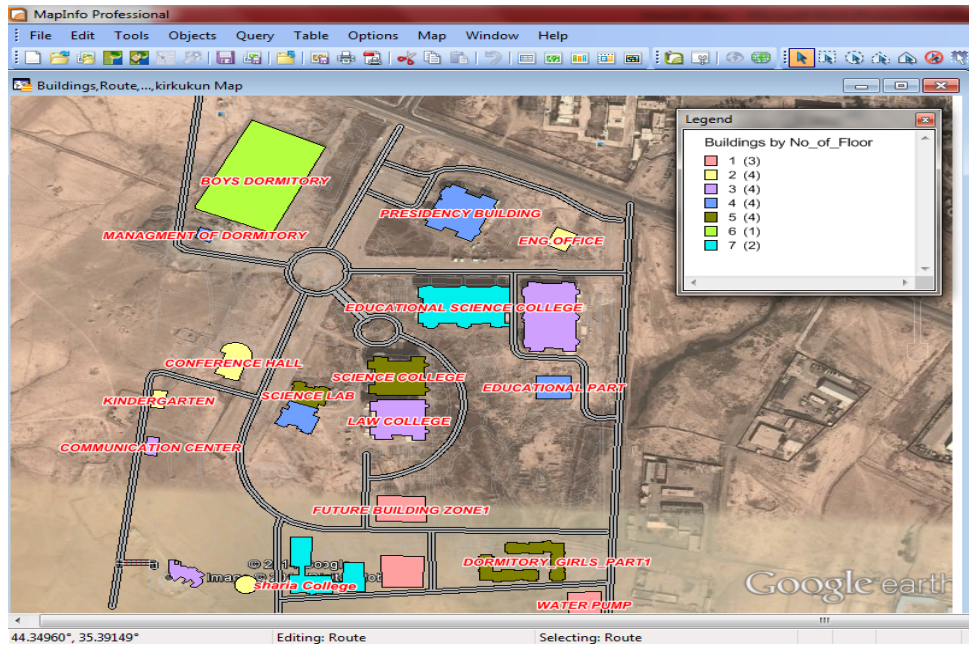
Figure 46 University buildings colored according to number of floors.

In the same way as the previous step we create a thematic map by coloring the regions according to construction year, as shown in Figure 47.
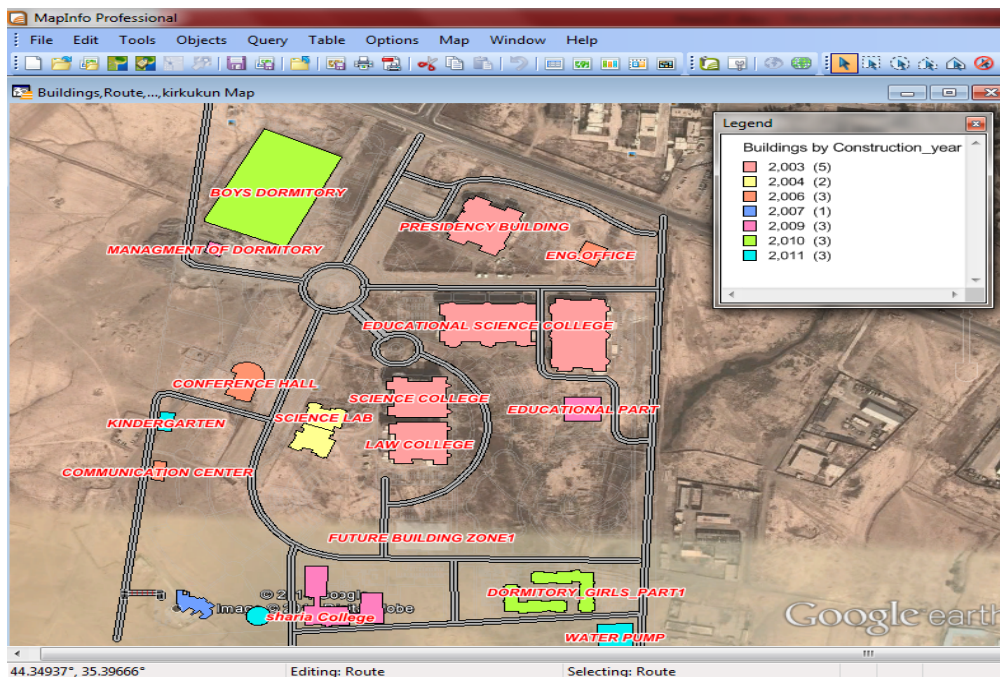
Figure 47 University buildings colored according to construction year

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Also, we create another thematic map according to "Area_Sq_m" of buildings. The figure below shows thematic map coloring of the buildings according to "Area_Sq_m" and legend for the ranges of the theme, as can be seen in Figure 48.
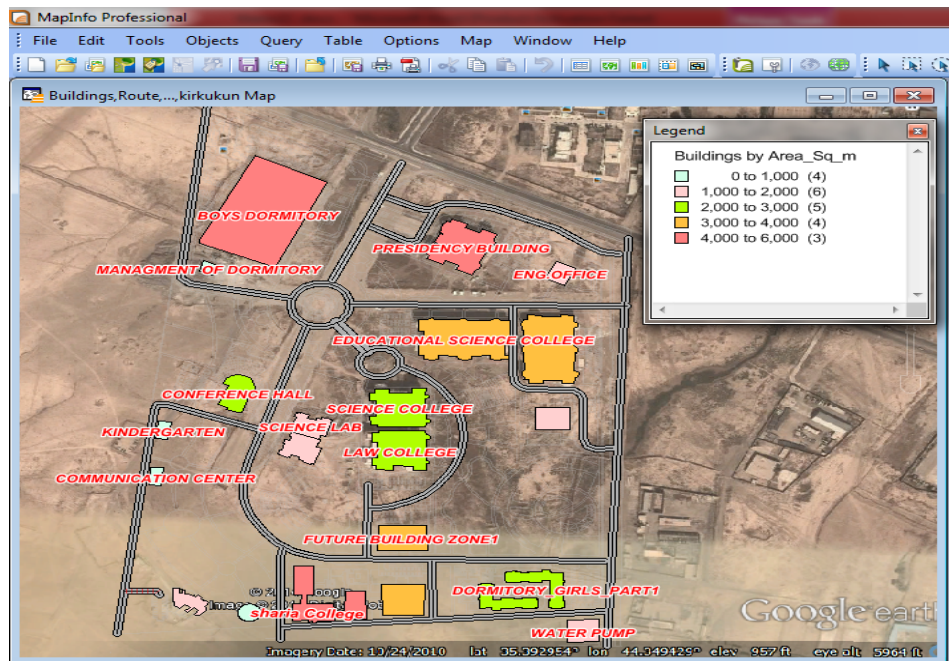
Figure 48 University buildings colored according to Area_Sq_m.

Also, by creating thematic maps with respect to diameters of pipes in the sewage network layer all pipe diameters are depicted in a different color, as shown in Figure 49.
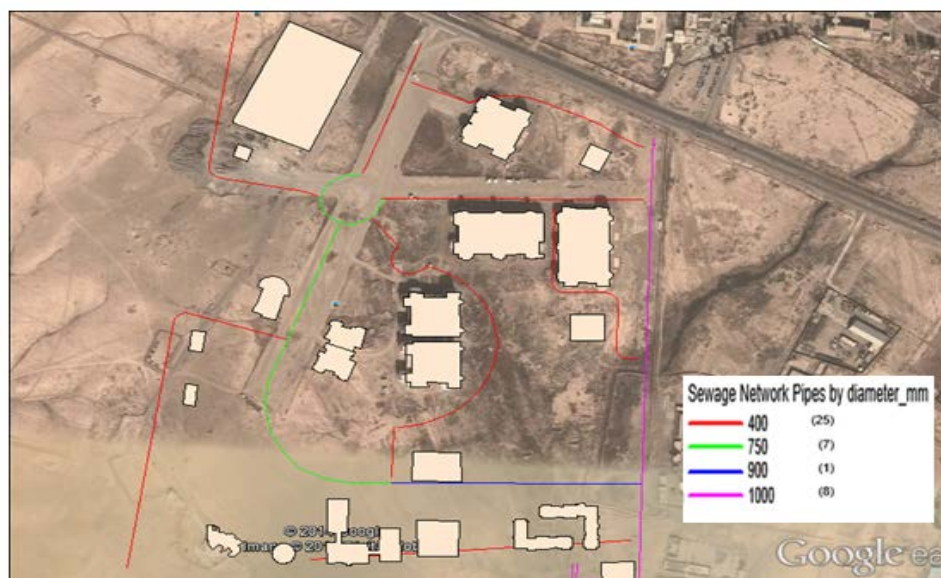
Figure 49 Using thematic maps to control the attribute data of pipes.

The second method is applying an SQL query by choosing "**Query > SQL Select"** to query data from fiber-optic layer as shown in Figure 50, and to list the sum of length of cables according to capacity, as shown in Table 5.
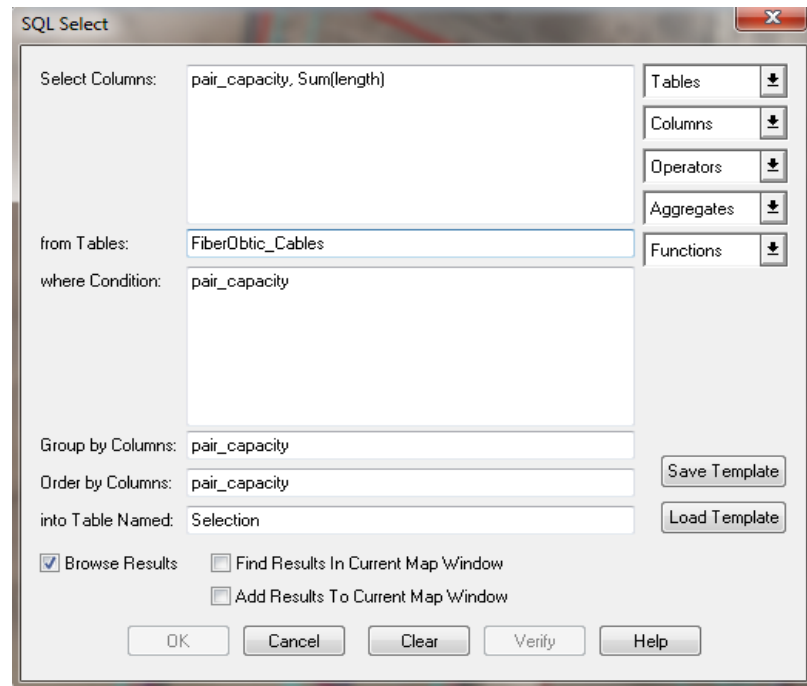
Figure 50 SQL Select to Query Data from infrastructure layer (fiber optic) table.

Table 5 List Sum of Length for Fiber-Optic Cables According to Capacity

pair_capacity	Sum(length)
20	58
50	149
100	496
150	559
200	1,260
250	8
300	43
350	397
400	368
500	712
600	113
750	52
800	106
1,000	632

In the same way as the previous step we will get the window as shown in Figure 50 and apply an SQL query to query data from the sewage network layer, and to list the sum of length pipes according to diameter, as shown in Table 6.

Table 6 List Sum of Length for Pipes According to Diameter

diameter_mm	Sum(length)
400	3,316
750	821
900	385
1,000	1,053

The third method is that the attribute data of layers can be displayed in a browser window and the whole data can be controlled.

In addition to the above methods, there is a distinctive and powerful way to visualize and analyze data, this method is a prism mapping feature, it lets to take a flat map and extrude features to any height. To create a prism map, we choose "**Map > Create Prism Map**". Then, we choose the building layer and to create an expression (No of floor*4) as column value. Also on Appearance group, we select the Background colour and the Light colour: This act as a cover to the buildings. Then we click OK as shown in Figure 51.
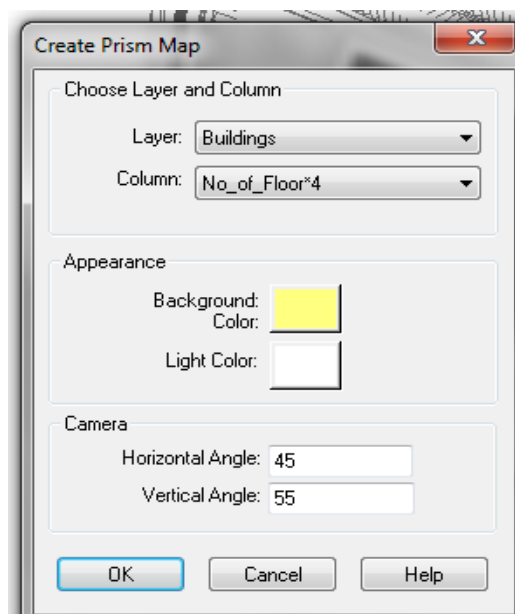
Figure 51 Create prism map.

The result of prism maps is offer another way to create a three-dimensional view of a map. In this prism map, according to a specified column value (number of floors) from the building table, the height of the building is raised. Each geographical object becomes a prism, allowing us to compare data values of objects relative to each other according to the height of each prism as shown in Figure 52.
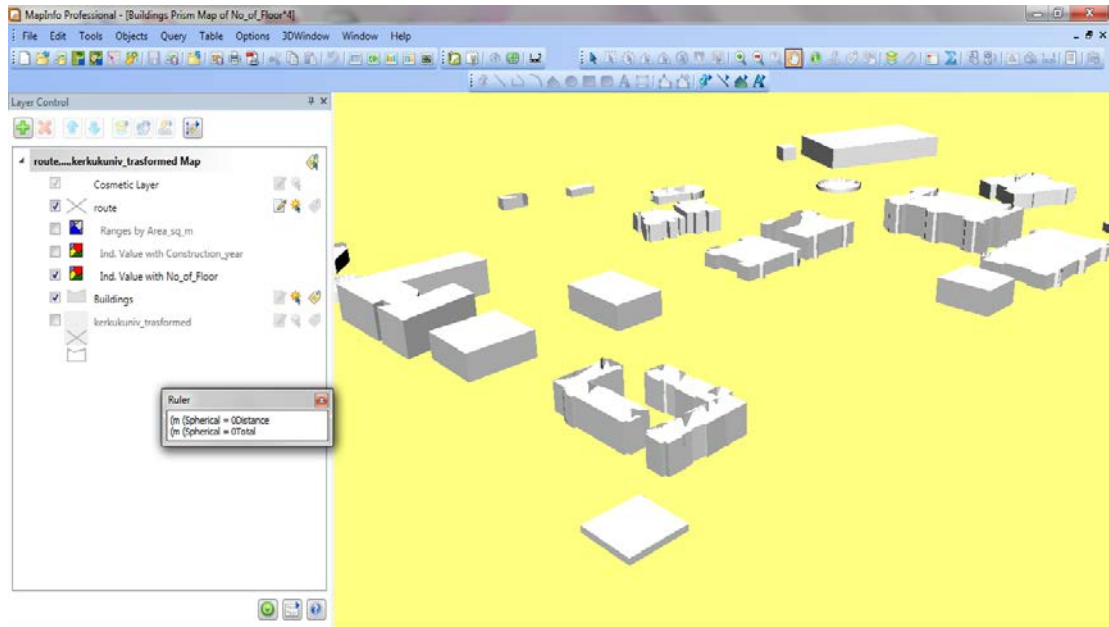
Figure 52 Prism map to create a three-dimensional view of the campus buildings.

5.3. Construction of 3D Model for Campus Scene in Google SketchUp

The software used to construct the three-dimensional model of the campus was SketchUp. This is powerful 3D modelling software and easy to use and was released in 2006 by Google Inc. and is currently owned by Trimble Navigation Ltd [65]. It is a more specialized software tool and can be used to deal with rendering, material processing and other effects of 3D modelling, which allows surface rendering in variable styles. Models created in SketchUp can be exported to Multipath format.

In a 3D model, the main objects that can be modelled are the following: ground, buildings, transportation network, bodies of water, vegetation objects and electric/power lines. In this study we use the Google SketchUp program to create a very realistic three-dimensional model. It requires the correct models to be added

according to the CAD file annotation and then reviews it with the actual campus situation as much as possible.

The first step was to import the CAD (2D drawing file) directly into Google SketchUp. This file consists of footprints of buildings, roads and other objects. The process includes modelling of the campus using various tools in SketchUp by modifying their architecture and model surface of buildings, landscape and roads by giving extrusion through thickness (with respect to floor numbers, road thickness, existing topography etc.). Figure 53 shows extrusion of the footprint of campus buildings.
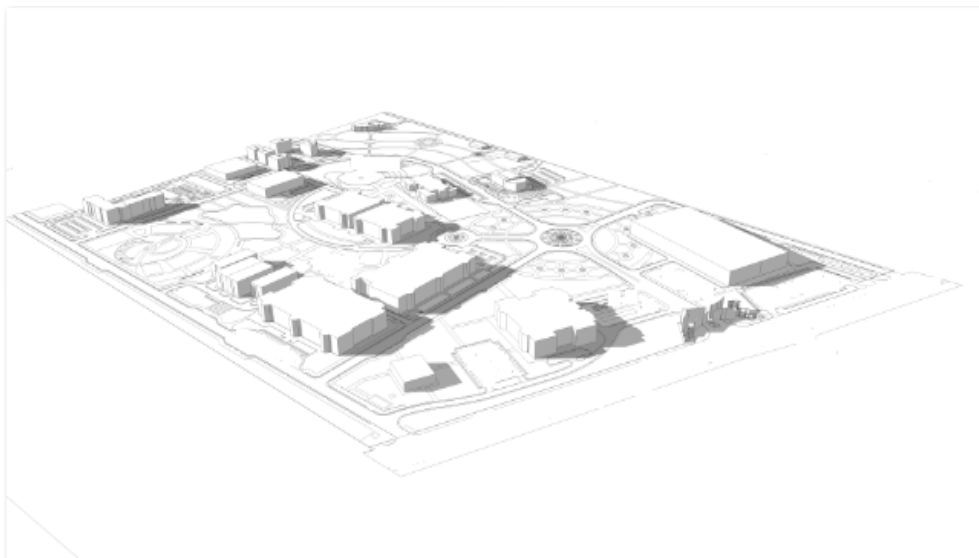
Figure 53 Extruding the footprint of the campus buildings.

Once the buildings and raw model are completed, materials and colours are given to selected surfaces. And in order to make the 3D model more realistic, we can use some SketchUp library 3D symbols such as trees, cars, street lights, the flag and the 3D green space. The Google SketchUp program was used to achieve the establishment of a 3D visualization of the University campus as shown in Figure 54.
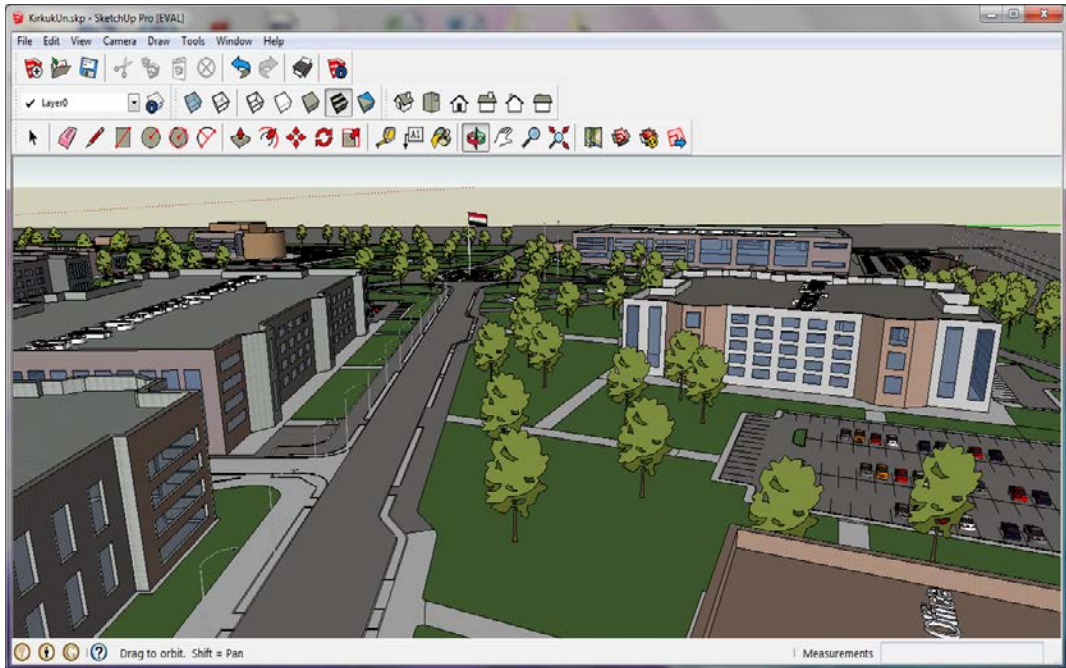
Figure 54 The results view in Google SketchUp.

After completing the 3D design of the university campus the SketchUp model is exported to Autodesk Lumion 3.0 (rendering and video-making program) as a file extension of COLLODA (.dae) format, as shown in Figure 55.
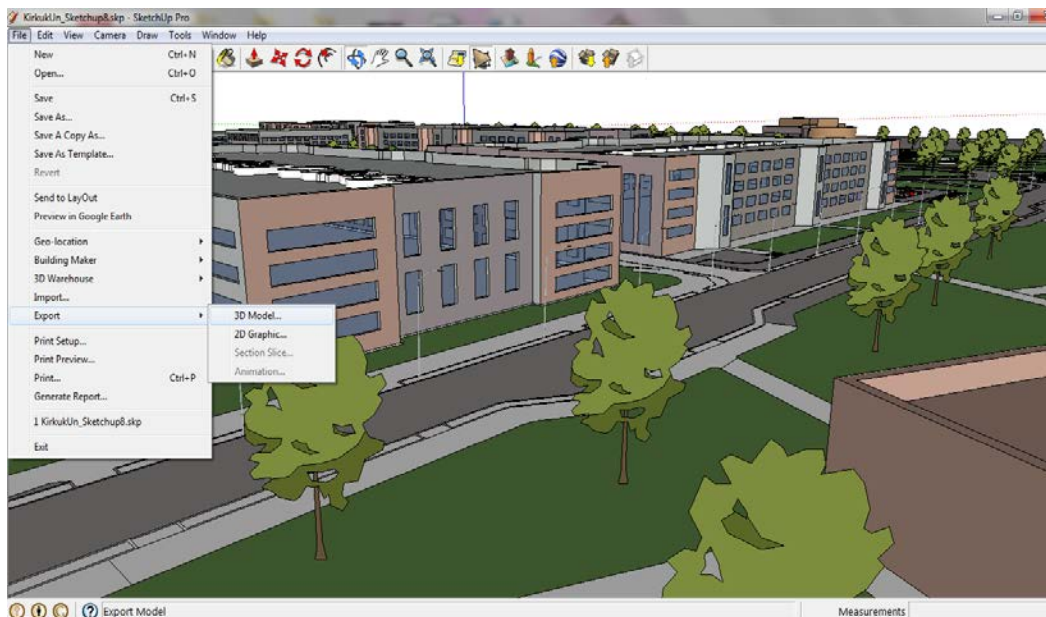
Figure 55 Export SketchUp model as file extension of COLLODA.

5.4. Animation

Animation refers to the rapid presentation of a sequence of images to create an illusion of movement. The basic workflow for animation is as follows:

1) Start with software that has the ability to create renderings or still images of 3D computer models from one camera perspective.

2) Move the camera ever so slightly in one direction or another and capture the image several times.

3) After all the images are captured, import them into a version of a sequencer where they are played rapidly one after another at a specified film speed and saved into a single file that is recognized by movie-playing software.

In our case, the computer software used by animators that desire realism leverage is Lumion 3D software. This is an essential 3D visualization tool for creating high-resolution images for architectural demonstrations. It produces impressive, high-quality videos very quickly and is extremely easy to use [69]. Lumion leverages key-frame animation. This is great for animators because the only requirement is to pick a series of camera positions with a mouse navigator. Lumion figures out all the camera frames and creates a seamless animation.

Three-dimensional models were imported into Lumion from SketchUp software as a file extension of COLLODA (.dae) as shown in Figure 56.
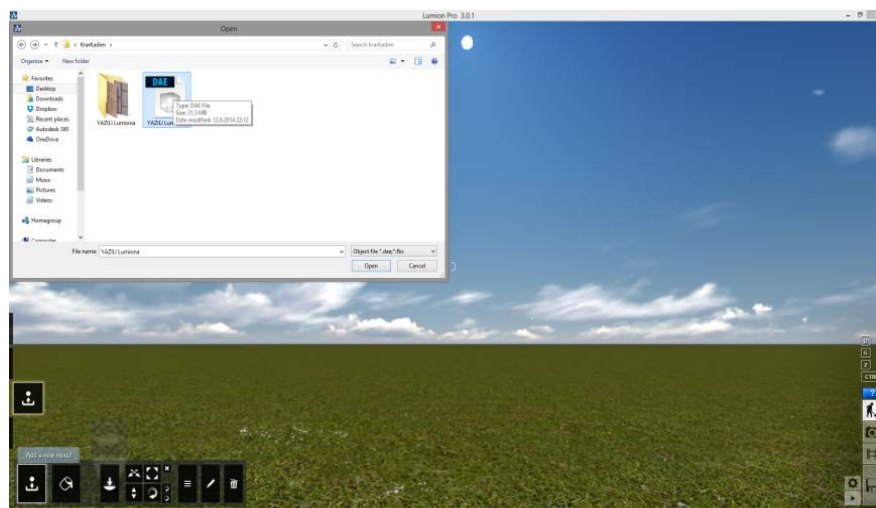
Figure 56 Import the SketchUp model into Lumion.

Lumion offers a huge library of materials, colors, textures, 3D objects (cars, plants and trees) and water types that can be manipulated and put together with our 3D model to create the perfect scene so that we can choose any material to assign different surfaces, as can be seen in Figure 57.

Figure 57 Assigning materials to the 3D model.

After finishing the assignment of materials, the light, shadow, sun and cloud positions are attached in Lumion for an existing specified location. The trees and grass are attached to the model by Lumion with respect to the climate of the location.

In order to make a movie, different camera positions are attached to Lumion as shown in Figure 58 and the movie will move into those specific cameras during the timeline of the movie as shown in Figure 59.

Figure 58 The different camera locations to create a camera path.

Figure 59 Generating a movie based on different camera locations.

Video can also provide rendering for each frame if the resolution and video quality are high enough. So, 1280x720 is preferred. We saved our entire movie as an MP4 format.

5.5. Multimedia Hotlinking

This approach involves integrating multimedia in GIS [66]. A multimedia GIS database integrates various types of data such as text data, picture data (still and moving pictures) and graphical data (3D campus model). Then these multimedia files are hotlinked to the corresponding files in the GIS.

In our case, picture of feature attraction such as buildings to hotlinked to their respective feature locations. First, we add a character field and name of the field to the building table. After that, we enter the picture file path to the field for each row in the building table. We create a separate folder for all the building pictures to be linked to the attribute table of the building feature on the map. Paths of the three-dimensional model of the campus from SketchUp and video from Microsoft Windows Media Player files were similarly entered into the building table. Now the building table contains the active objects, we need to set the HotLink options for the table. And to create more than one hotlink for a layer: click the HotLink options button on the layer control. So we add three columns, picture, video and drawing, then save options to the table as shown in Figure 60.
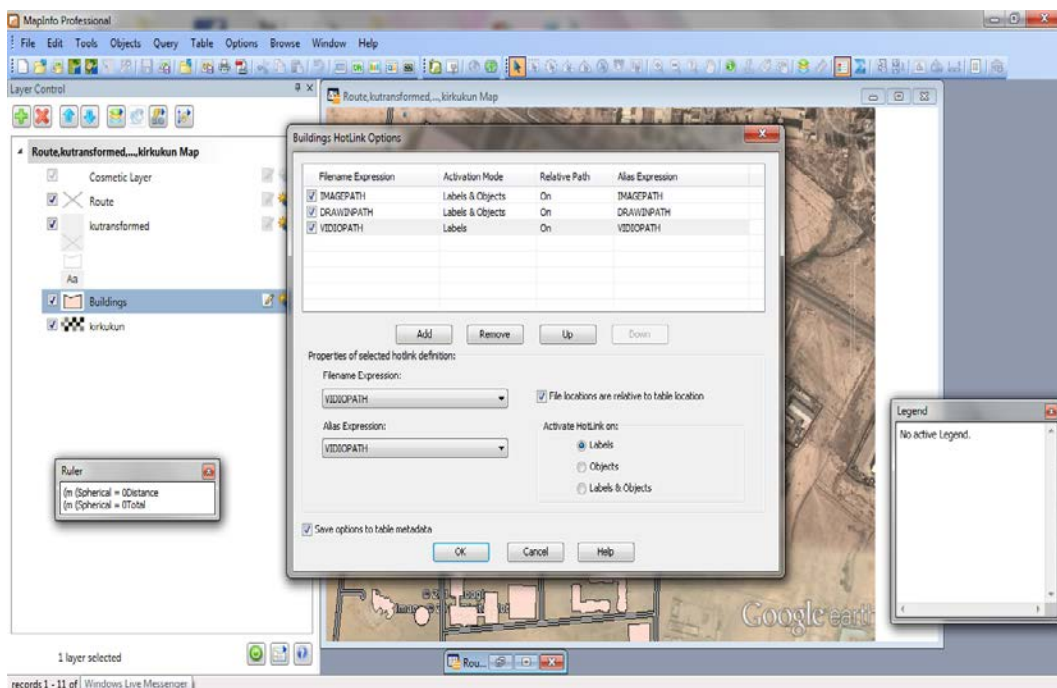
Figure 60 HotLink a multimedia files to GIS database.

To access multiple hotlinks, we select the Hotlink tool from the main toolbar menu. Then click on an area with multiple hotlinks on the map to see the list. All the components of the multimedia GIS database are shown in Figure 61.
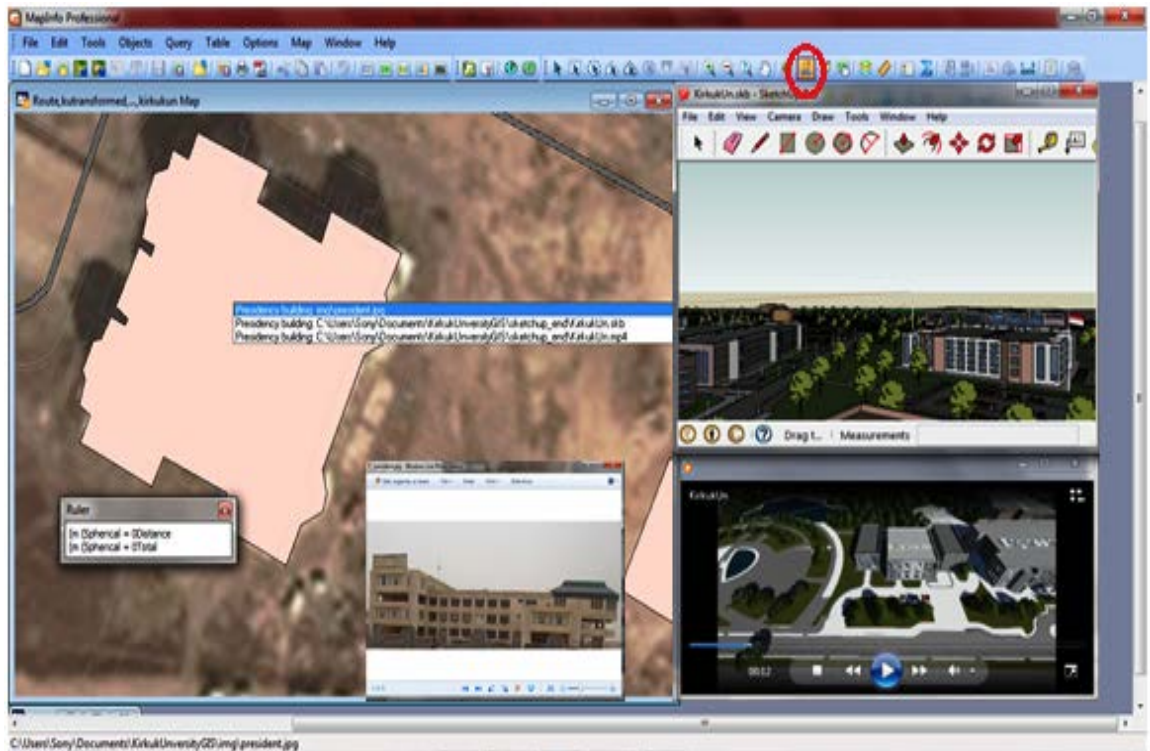
Figure 61 Presentation the components of the multimedia GIS database including still and moving pictures and a 3D model.

CHAPTER 6

APPLICATION

6.1. The Source Program

The C# .NET programming language that has been used as a source program for this application is an object-oriented scripting language for MapInfo GIS and can be used for automating tasks, adding new capabilities and building applications. The source code for this application is divided into many scripts and each is used for a specific purpose.

6.2. General View of GIS-Based CIS

A GIS desktop application-based CIS of Kirkuk University is not available to users outside of the campus. It is can only be used by administrative and academic personnel, visitors and students via the passwords that are given to them as shown in Figure 62. Kirkuk University users access the services in various categories after login.

Figure 62 Login window.

This information system is map based. Figure 63 shows the system interface, including ribbon, side toolbar, map window, measurement tool and other functional areas. This is also a "user-friendly" experience provided by the system interface, allowing the user in a natural and intuitive way to interact with the system. Buildings, main roads and some of the infrastructure layers are the basic geographic information of the University shown in the 2D view. The basic functions including pan, zoom in, zoom out, inquire by location and attribute, search for features, work with measuring distances, spatial analysis, query data, status bar units, change layer properties and add data are some of the abilities of the GIS-based CIS of Kirkuk University. In a 3D view provided by the system, one could rove and would not get lost through the locations in the whole map.
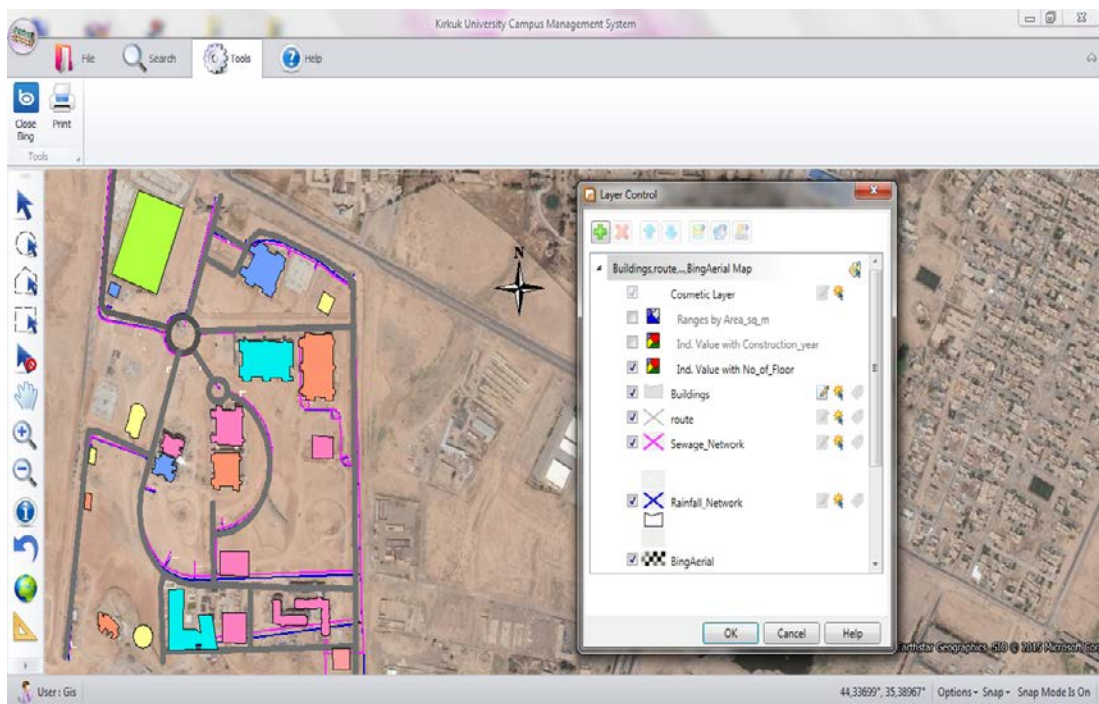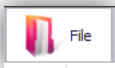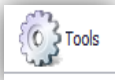
Figure 63 General view of GIS-based campus information system.

6.3. Using Campus Information System

6.3.1 Ribbon

The "**ribbon**" includes several tabs that each displays a different set of command buttons when selected. The purpose of the ribbon is to provide the ability to quickly find the commands that are needed to complete a task within the system. Because ribbons make commands visible, these commands can be used by the user to his advantage while recognizing without remembering them and that's a usability advantage. The ribbon is a user interface element displayed across the top of a graphic user interface (GUI) located directly below the title bar in the applications. However, the ribbon can be minimized to make more space available on screen. Table 7 gives a description of the ribbon on the general view of the Kirkuk campus information system and its functionalities.

Table 7 Descriptions of Tabs and Command Buttons.

Ribbon tabs	Ribbon command button	Function
File	Open Table	To open a variety of types of additional tables (which are a data file on the device), in order to add more information (layers) to the map window.
	Exit	To exit from the system.
Search	Query Engine	Query engine for query data according to tabular attributes by building a query expression.
Tools	Open Bing	Open Bing; use this button to add a Microsoft Bing Aerial layer to a map. The map refreshes and displays the Bing Aerial layer as a base image (the bottom layer of the map).
	Print	Used to produce professional-quality maps for printing or other output of active project view.

6.3.2 The main toolbar

The main toolbar contains tool buttons, and is used to provide rapid access to particular commands or options. When a user moves the cursor onto buttons, their names are shown in a tool tip text. A toolbar description is given in Table 8.

Table 8 Description of Tool Buttons

Button Name	Function
Select	Use the Select tool to select objects one at a time.
Radius Select	Use to select all objects that fall within a given radius, by clicking and dragging the mouse away from the centre point to draw a circle around the point and report the radius of the circle in the Status Bar (lower right corner of the screen).
Polygon Select	Use to select map objects within a polygon that the user draws on a map.
Marquee Select	Use to select objects within a rectangle, by clicking and dragging to create a dotted rectangle around selected objects.
Unselect All	Use to deselect all of the selected objects.
Pan	Drags the display map in the direction we move the cursor.
Zoom in	Zooms in at a point we click on or zooms in on a rectangle we drag.
Zoom out	Zooms out from a point we click on or zooms out to include a rectangle we drag.
Info tool	Use Info tool to display the attribute data and multimedia – image, video, 3D model of selected object shown in a view.
Back view	To undo the last map window view.
First view	Display view of campus map location on a world Bing Map.
Ruler	Use to determine the distance between two points on the map.
Layer Control	Use to accesses the layer control window so we can specify how the various tables in a map window are layered and displayed.

6.3.3 Using general functions

Guidelines for general usage of the campus map are as follows:

1. Click on the button [icon]. A layer control window will pop up. Layers and themes of the map are shown in the window.
2. Turn layers and themes on and off by clicking a checked box in front of it to view the desired layers and themes.
3. Additionally, click on the Editable icon [icon] to make the layer editable, the Selectable icon [icon] to make a layer selectable in the map window, and Automatic Labels icon [icon] to label a layer automatically.
4. Zoom in or out of the campus map by using zoom tools.

5. Click on the Ruler button [icon] to display the Ruler window, and click any point on the map, then move the cursor to the desired point on the map. The Ruler window will show the distance in meters of drawn line, as well as the total distance of the drawn object; it also shows the spherical distance, which is calculated depending on the projection of the map. In addition, the Ruler window can be used with the marquee select, polygon select and radius select tools.

6.3.4 Viewing the Kirkuk University campus

Clicking the "Info" button in order to view information for the area and get a view to the scenery within the campus as shown in Figure 64, the steps are as follows. Click on the "Info" button in the main toolbar and select an object to view.

1. A window (window's name depends on the name of the base table in which it is stored) will pop up. We can view the attribute data that is associated with a selected object.
2. Click on the "Show Building Image" button in the building window. An image window will pop up to display the image. Also, by clicking next and previous button and if the video clip is available, a video clip window will pop up automatically.
3. Click on the "Show Drawing file" button. A Google SketchUp program window will pop up and display the 3D Kirkuk campus model.
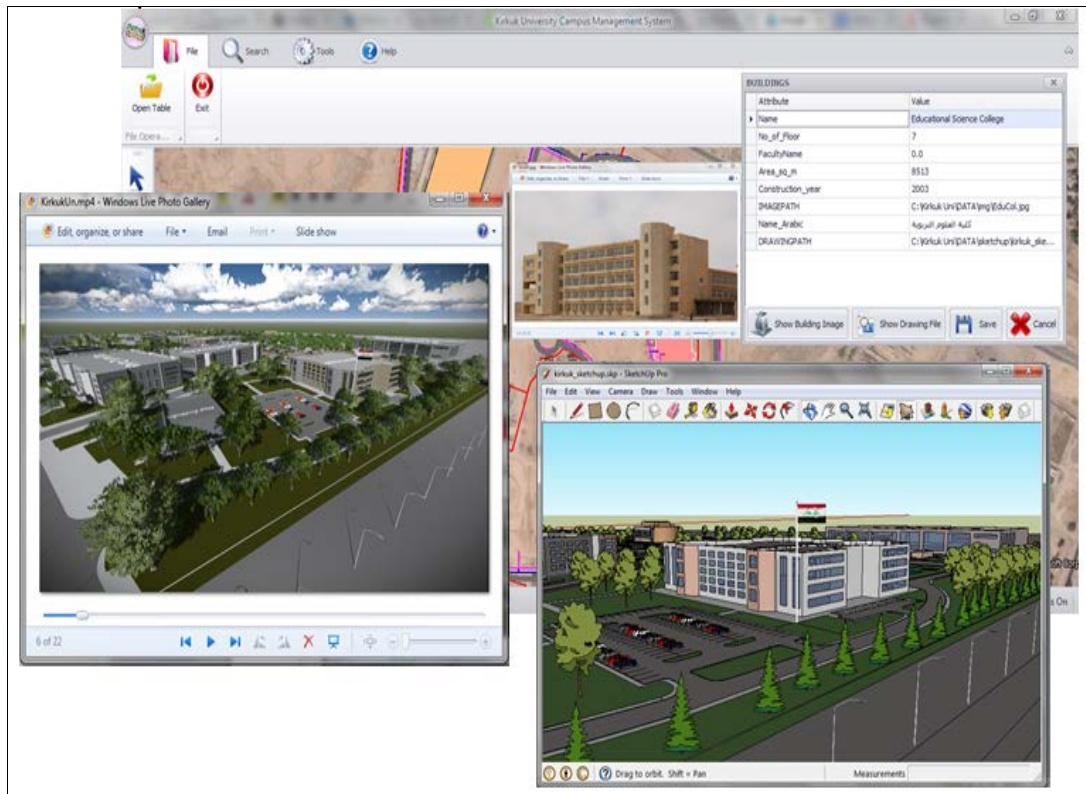
Figure 64 A multimedia queries to display information about the selected object.

Also, we can view the tabular attribute value for some of the infrastructure of the campus to provide a reliable basis for management and planning.

Otherwise, use the ⊕ button on the main toolbar to view the location of the campus map on a world map (Bing Maps), as shown in Figure 65.
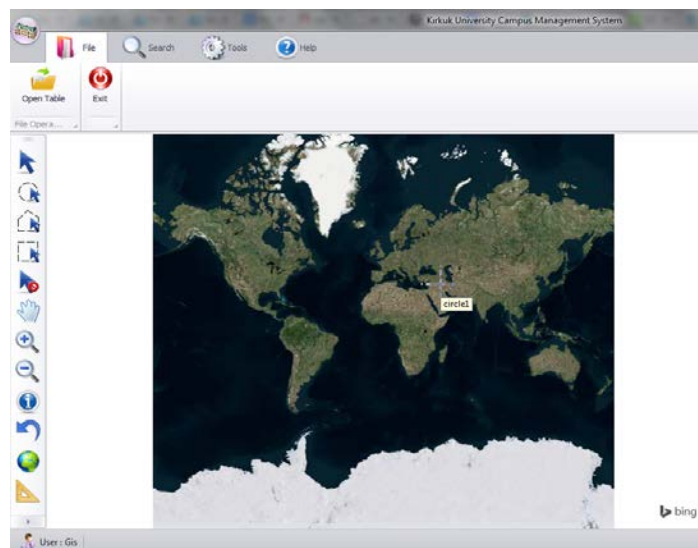
Figure 65 View campus locations on a world map (Bing Maps).

6.3.5 Searching for features on Kirkuk University campus

The following are steps for searching desired features such as buildings and routes and for getting information about infrastructure layers at Kirkuk University.

1. Click on the button in the search tab. A "Query Engine" window will pop up on the screen. A query is a mathematical question that one pose to tabular data to collect information.

2. Click on the "TABLES" box. A list of table names drops down and you can choose the table from which to select the records.

3. The chosen table in the "TABLES" box generates the list of columns in the "COLUMNS" dropdown list. Select the desired column from it.

4. From the "OPERATOR" dropdown list, select the operator. This list contains symbols of mathematical and logical operations. The mathematical operators include less than, greater than, equal to and not equal to signs; these symbols are used to create mathematical formulae. The logical operator "LIKE" can be used with two wild card characters (`_' and `%'). The `_' character matches a single character. The `%' character matches zero or more characters.

5. Type the desired value in the "VALUE" text box or click on the button to generate the list of attribute values in the "VALUE" dropdown list which is related to the uses in the column in the "COLUMNS" box.

6. Click on the search button. The query records will be displayed in the right pane of the "Query Engine" window. The "Record Count" in the left pane of the "Query Engine" window indicates the total number of records currently displayed within the "Query Engine" window.

7. Select the record from the right pane of the "Query Engine" window, then click on the show button. The selected feature will be enlarged in the zoomed-in view to fill the map window and is enclosed by the dotted line. A resulting feature from a "Query Engine" window is shown in Figure 66.
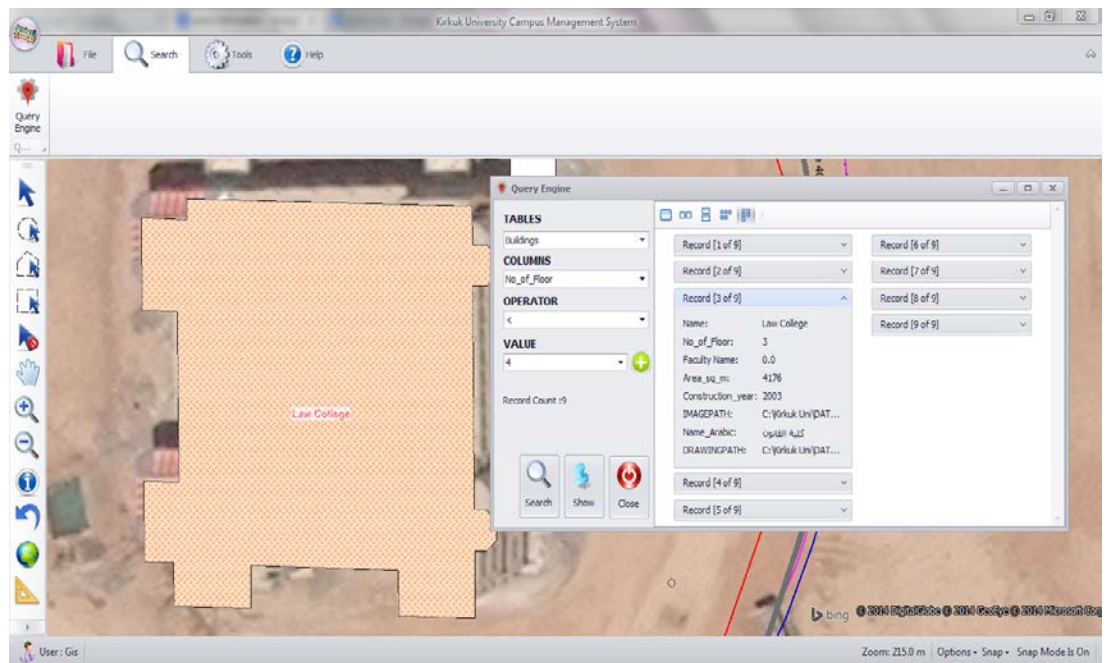
Figure 66 Searching for a feature on Kirkuk campus.

6.3.6 Using the status bar

The spatial location of the status bar along the lower edge of the window is used to provide helpful information about the map. On the right side of the status bar, as shown in Figure 67, click the arrow on the right of the "Options" box to display a menu of the three options that allow us to display cursor coordinates, the map scale on screen, or the zoom level of the current map window on the status bar. Choose the cursor location. When the cursor is placed over a map, the status bar only displays the X and Y coordinates of the cursor's location, depending on whether the location came from the mouse or a snapped node. When you move the mouse, the displayed location is rounded to the nearest pixel. When you snap to a node, the displayed location shows the exact coordinates as they appear in the map file. Also, the status bar indicates the snap status.
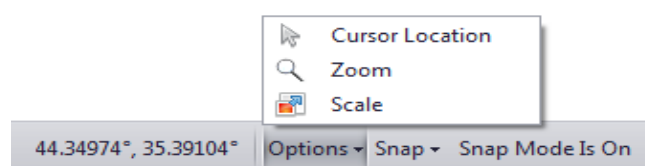
Figure 67 The status bar of a map window.

6.3.7 Using the "Print" button

Click on the print button in the "Tools" tab. A print layout window will pop up, which contains a set of tool buttons on the left side, as shown in Figure 68. These tool buttons enable us to save active project view as image, page setting, add text, text setting, select, unselect, drag, zoom in, zoom out, and prints active project view. The "Add Text" tool button is used to add text placeholders to our layout window. In addition, the layout window contains a frame that acts like a placeholder used for specific element legends and a text placeholder for a map title used.
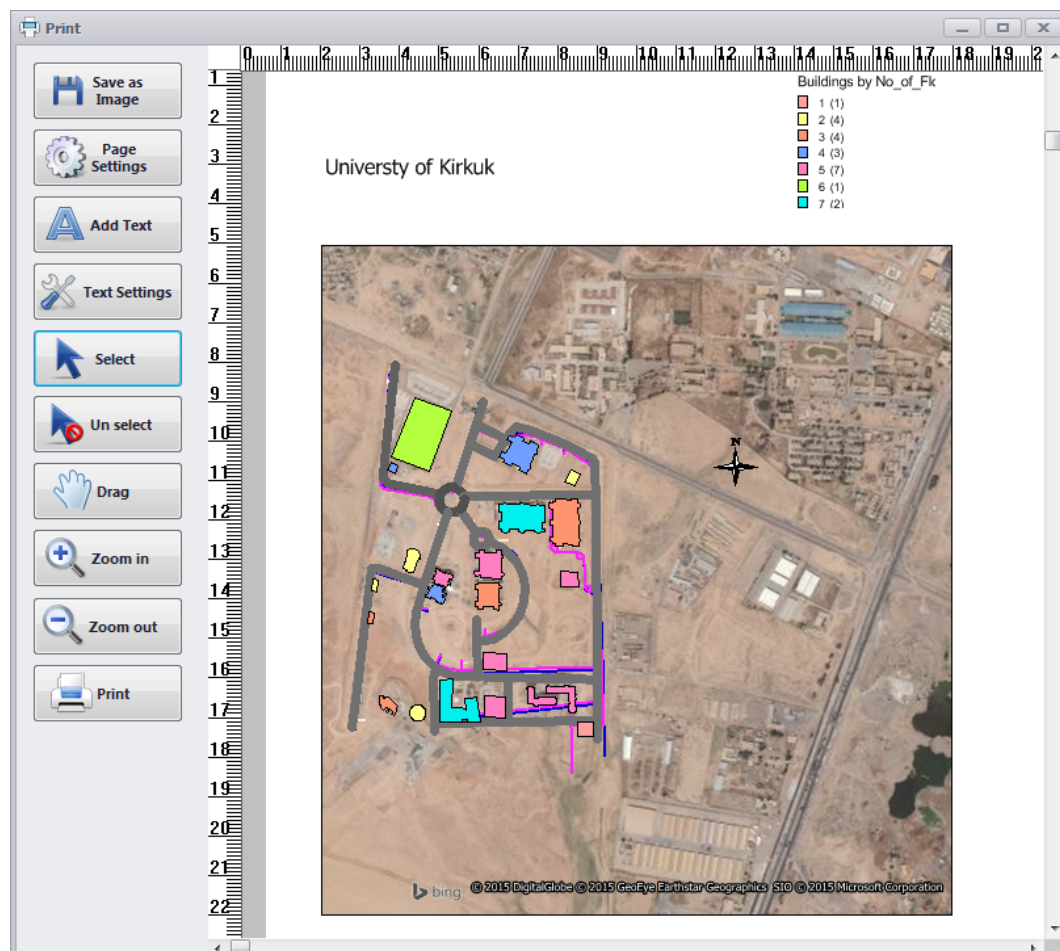
Figure 68 "Print" layout window.

CHAPTER 7

CONCLUSION AND FUTURE WORK

A university campus has complex infrastructures; their function is literally such as a city in themselves in terms of their spatial sizes, structure (different buildings, roads, infrastructure, landscape, etc.), and numbers of students and personnel. Therefore, a campus information system should bear the characteristics of an urban information system as well. In this study, data was collected, processed, and integrated with non-spatial data to perform single or multi-dimensional analyses. Moreover, the spatial and non-spatial data integration capability makes the system easy to understand. The CIS of Kirkuk University was designed as an information system that has a user-friendly interface for both trained and untrained users, open to constant updates, and capable of responding to all the needs of users, and carrying out analyses. This interface also provides the user with rapid and easy access to multimedia information regarding campus structure. In addition, the system has advantages in terms of time, cost, data consistency, saves a lot of manpower and material resources, storage capability for storing the existing data in a regular structure, distance and area calculations, and retrieve information easily and close to reality; thus, an individual who has little or no knowledge of statistical data analysis can even make accurate decisions. This advantage makes it an adequate tool for all decision-makers. The three-dimensional perspective views and animations cover more details and offer more explanations about the University campus also, convey information more effectively to users than traditional 2D, static maps. It has a special importance for enabling users to visualize complicated urban planning information in a 3D way, and to evaluate to simulate building plans.

How is it possible to help students, visitors and other inexperienced people easily find their way around the campus? This system enhances visitors' experience and helps them save time; the user can easily locate any part of the area, just like walking on the campus.

The GIS based CIS has established the base infrastructure to enable space planning, management, and locating underground cables and pipes for maintenance. So, the system will be available to the technical administration staff at the University, according to their needs, giving them access to the system data, and improving productivity at the management and service level both for planning and maintenance purposes. Furthermore, the technical staff in collaboration with the spatial planning of the campus can continue to broaden the inputs of the system to expand them to fulfill the future demands. The Kirkuk University is still a growing campus area with new faculty buildings, sports area, dormitories, and accommodation for academic staff etc. So the system will be available to the campus's topographical and geological requirements to be worked on them carefully to make decisions about suitable areas.

As a result, this GIS-based CIS has the following capabilities: allowing users to discover the Kirkuk University via its search engine, and to create interactive queries from a database. A number of queries can be implemented through the system interface to answer many questions relating to facilities on the campus. The system will be very useful to both the management and the user for locating facilities on the University campus.

Like any research project of new technology introduction, this project also has some limitations. Major limitation of this study, difficulties in obtaining clean data, we couldn't get all Kirkuk University's area's layers, we drew the layers as they are shown in graphic map after digitized, edited, and integrated it with google earth, this was also a time consuming factor. Another limitation was the unavailability of the map level non-spatial data, we faced difficulties for getting information in details; therefore we put some of this data by using MapInfo tools for example length, width of roads, and areas of the buildings. Also we put some of this data as estimate just to make the application tool to run. In addition, the buildings picture, we collect it from internet, may be not exactly in fact, they can be changed as well.

In spite of these limitations, the goal of this thesis is to make a modest contribution to understand the complexities related to GIS technology introduction in a developing country's Universities, Kirkuk University and in other Iraqi Universities as well.

The biggest contribution, it can be argued, comes from developing an awareness about the potential of the technology and also about the challenges to making it work effectively in practice. I feel that this study has helped to plant a seed that can be cultivated in the future into a full blown and useful application.

In order to expand the system we need two critical factors concerning data quality: to develop and reformat the database in the system, data must be relevant, accurate, timely and up-to-date, and presented in a clear and understandable way, because inappropriate data will produce inaccurate knowledge, which will lead to wrong decisions and strategies. Also, staffs trained in GIS MapInfo Professional software are needed: to maintain the system and to perform several specific functions. These functions include database administration, system management and system analysis.

This study is not a completely finished study. Its databases and types of analysis could be changed easily depending on necessities. Furthermore, development of a Web-based GIS applications, analyzes and queries could be the next step of this study. In addition to these, a staff information system could be integrated into this system. So the system will provide to students, academic and administrative staff with easy access to necessary information, while other outside users can access limited information just about the campus location.

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APPENDICES A

CODE

Program.cs (taken from Mapinfo mapbasic sammples dotnet integrated mapping)

```csharp
using System;
using System.Collections.Generic;
using System.Windows.Forms;

namespace MapInfo.MiPro.Samples.IM
{
    static class Program
    {
        /// <summary>
        /// The main entry point for the application.
        /// </summary>
        [STAThread]
        static void Main()
        {
            Application.EnableVisualStyles();

    Application.SetCompatibleTextRenderingDefault(false);
            Application.Run(new MapForm());
        }
    }
}
```

Mapform.cs

```csharp
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Runtime.InteropServices;
using System.Text;
using System.Windows.Forms;
using System.IO;
using MapInfo;

namespace MapInfo.MiPro.Samples.IM
{

    //
    // A demonstration of how to do Integrated Mapping (the
reparenting of a
    // MapInfo Professional map window into other applications)
using .Net.
    //
    public partial class MapForm : Form, ICallbackNotify
    {
        // Id of the map window being reparented
        private string _mapWindowId = "";

        // HWND of the window being reparented
        private System.IntPtr _hWnd;

        // Mapping of map tool names to tool command ids
        private Dictionary<string, int> _toolIdMap;
```

```csharp
            // ID of the custom OLE menu item on the map window's
context menu
            private const uint _customItemId = 10000;

            // Reference to the callback object
            private MapInfoCallBack _callbackObject;



            // Store a reference to MapInfo Professional's COM
interface
            private MapInfoApplication _mapInfoApp;
            private MapInfoApplication MapInfoApp
            {
                get { return _mapInfoApp; }
            }

            // A File Open dialog that the user can use to open
one or more .TAB files
            private OpenFileDialog _openFileDlg;
            private OpenFileDialog OpenDlg
            {
                get
                {
                    if (_openFileDlg == null)
                    {
                        _openFileDlg = new OpenFileDialog();
                        _openFileDlg.Filter = "MapInfo
Tables (*.tab)|*.tab";
                        _openFileDlg.Multiselect = true;
                        _openFileDlg.RestoreDirectory =
false;
                        _openFileDlg.InitialDirectory =
Environment.GetFolderPath(Environment.SpecialFolder.MyDocuments);
```

```csharp
                    }
                    return _openFileDlg;
            }
        }


        // Constructor
        public MapForm()
        {
            InitializeComponent();

            InitializeMapToolCombobox();
        }



        // Given a list of .TAB filenames, open the tables
and display them in a map
        private void NewMap(string[] tableList)
        {
            string aliasList = "";

            // Open each TAB file
            foreach (string tablepath in tableList)
            {
                // Create alias string for the table
                string alias =
Path.GetFileNameWithoutExtension(tablepath);
                alias = alias.Replace(" ", "_");

                // Open the table
                MapInfoApp.Do("Open table \"" + tablepath
+ "\" as " + alias);
```

```
                    // Add new table's alias to the list
                    if (aliasList == "")
                    {
                        aliasList += alias;
                    }
                    else
                    {
                        aliasList += ", " + alias;
                    }
                }

                // Create map window, reparenting it to our map
panel
                MapInfoApp.Do("Set Next Document Parent " +
this.mapPanel.Handle + " Style 1");
                MapInfoApp.Do("Map From " + aliasList);

                // Save the ID of the newly created window
                _mapWindowId = MapInfoApp.Eval("WindowID(0)");

                // Call WindowInfo with 12 (WIN_INFO_WND) to get
the Windows HWND.
                // If the user resizes the form, we need the
HWND to update the map size.
                _hWnd =
(System.IntPtr)long.Parse(_mapInfoApp.Eval("WindowInfo(FrontWindo
w(),12)"));

                // Now that there is a map, enable the Zoom In
and Zoom Out buttons
                this.buttonZoomIn.Enabled = true;
                this.buttonZoomOut.Enabled = true;
            }
```

```csharp
private void CloseWindow(string windowId)
{
    // Close the window
    MapInfoApp.Do("Close window " + windowId);
}


private void CloseAllTables()
{
    MapInfoApp.Do("Close All");
}


private void Form1_Load(object sender, EventArgs e)
{
    InitializeComObject();

    AddMapperShortcutMenuitem();
}


private void Form1_FormClosed(object sender,
FormClosedEventArgs e)
{
    // Unregister the callback object
    MapInfoApp.UnregisterCallback(_callbackObject);
}


private void Form1_ResizeEnd(object sender, EventArgs
e)
```

```csharp
            {
                // The form has been resized.
                if (_mapWindowId != "")
                {
                    // Update the map to match the current
size of the panel.
                    MoveWindow(_hWnd, 0, 0,
this.mapPanel.Width, this.mapPanel.Height, false);
                }
            }

            [DllImport("user32.dll")]
            static extern bool MoveWindow(IntPtr hWnd, int X, int
Y, int nWidth, int nHeight, bool bRepaint);



            private void InitializeComObject()
            {
                // Create the MapInfo Professional object
                _mapInfoApp = new MapInfoApplication();

                // Set parent window for MapInfo Professional
dialogs
                _mapInfoApp.Do("Set Application Window " +
this.Handle);

                // Create the callback object
                _callbackObject = new MapInfoCallBack(this);

                // Register the callback object with
Professional
                _mapInfoApp.RegisterCallback(_callbackObject);
            }
```

```csharp
            // Set up the combo box that lets the user choose a
map tool
            private void InitializeMapToolCombobox()
            {
                // Create the dictionary collection
                _toolIdMap = new Dictionary<string, int>();

                // Add "Select" tool to combobox and dictionary

        this.comboBoxMapTool.Items.Add(Properties.Resources.MapTool
_Select);

        _toolIdMap.Add(Properties.Resources.MapTool_Select, 1701);

                // Add "Pan" tool to combobox and dictionary

        this.comboBoxMapTool.Items.Add(Properties.Resources.MapTool
_Pan);
                _toolIdMap.Add(Properties.Resources.MapTool_Pan,
1702);

                // Add "Zoom In" tool to combobox and dictionary

        this.comboBoxMapTool.Items.Add(Properties.Resources.MapTool
_ZoomIn);

        _toolIdMap.Add(Properties.Resources.MapTool_ZoomIn, 1705);

                // Add "Zoom Out" tool to combobox and
dictionary
```

```csharp
        this.comboBoxMapTool.Items.Add(Properties.Resources.MapTool
_ZoomOut);

        _toolIdMap.Add(Properties.Resources.MapTool_ZoomOut, 1706);

                // Set the combobox item to Select
                comboBoxMapTool.SelectedIndex = 0;
            }



        // Add a custom item to the Map window's context menu
        private void AddMapperShortcutMenuitem()
        {
                // Issue Alter Menu command, adding an OLE
menuitem.
                // When the user chooses a custom OLE menuitem
from the context menu,
                // MapInfo Professional calls
MapInfoCallback.MenuItemHandler,
                // which in turn calls the OnMenuItemClick item
below.
                string cmd = string.Format(@"Alter Menu
""MapperShortcut"" Add ""Custom Item"" ID {0} calling OLE
""MenuItemHandler""", _customItemId);
                _mapInfoApp.Do(cmd);
            }



        // Display the File Open dialog to let the user
choose table(s) to open.
        private void openToolStripMenuItem_Click(object
sender, EventArgs e)
```

```
            {
                    // Prompt the user to open one or more TAB files
                    if (OpenDlg.ShowDialog(this) == DialogResult.OK)
                    {
                            // Close window and tables, if they exist
                            if (_mapWindowId != "")
                            {
                                    CloseWindow(_mapWindowId);
                                    CloseAllTables();
                                    _mapWindowId = "";
                            }
                            // Create a new map
                            NewMap(OpenDlg.FileNames);
                            // Enable the tool picker
                            comboBoxMapTool.Enabled = true;
                    }
            }


        private void exitToolStripMenuItem_Click(object
sender, EventArgs e)
            {
                    // Close form to end the application
                    this.Close();
            }


        private void aboutToolStripMenuItem_Click(object
sender, EventArgs e)
            {
                    this.ShowMessage("Demonstration of integrated
mapping, using Windows Forms.");
            }
```

```csharp
        // Handle the selection of a different tool from the
combo box.
        private void
comboBoxMapTool_SelectionChangeCommitted(object sender, EventArgs
e)
        {
            // Get the current combobox selection
            string selectedText =
comboBoxMapTool.SelectedItem.ToString();
            // Get the command id
            int commandId = _toolIdMap[selectedText];
            // Issue command to change the map tool
            _mapInfoApp.Do("Run Menu Command " + commandId);
        }


        public void ShowMessage(string msg)
        {
            MessageBox.Show(this, msg);
        }


        #region ICallbackNotify Members


        // The method called when the user chooses the custom
OLE menuitem.
        public void OnMenuItemClick(uint id)
        {
            if (id == _customItemId)
            {
```

```csharp
                        MessageBox.Show(this, "Custom menu item
was clicked.");
                }
        }


        // The method called when the MapInfo Professional
status bar text changes.
        // This can happen due to changes in the map view
(zoom level) or selection,
        // or can happen because the user highlights an item
on the map's context menu.
        public void OnStatusBarTextChanged(string text)
        {
                bool b = statusStrip1.InvokeRequired;

                // Replace any occurrences of "\t" (which can be
included when the status bar
                // is displaying map zoom etc.) with spaces.
                toolStripStatusLabel1.Text = text.Replace("\t",
"       ");
        }


        // The method called when the map window changes,
e.g. layers added.
        public void OnWindowContentsChanged(uint windowId)
        {
                // TODO:  If your application needs to respond
to changes in the map
                // contents, add appropriate code here.
        }
```

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```
            #endregion

            private void buttonZoomIn_Click(object sender,
EventArgs e)
            {
                    zoomMap(0.5);   // zoom in (show an area half as
wide)
            }



            private void buttonZoomOut_Click(object sender,
EventArgs e)
            {
                    zoomMap(2.0);  // zoom out (show an area twice
as wide)
            }



            private void zoomMap(double zoomFactor)
            {
                    if (_mapWindowId != "")
                    {
                            // Call:  MapperInfo(id,
MAPPER_INFO_DISTUNITS)
                            // to get a units string such as "mi" or
"km"
                            string strUnit =
MapInfoApp.Eval("MapperInfo( " + _mapWindowId + " , 12)");

                            // Call:  MapperInfo(id, MAPPER_INFO_ZOOM)
                            double dZoom =
Double.Parse(MapInfoApp.Eval("MapperInfo( " + _mapWindowId + " ,
1)"));
```

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```
                         dZoom *= zoomFactor;

                         dZoom = Math.Min(dZoom, 10000000);

                         dZoom = Math.Max(dZoom, 0.0001);

                         // Apply the new zoom level with a
statement of this form:

                         //     Set Map Window 123456 Zoom 123.456
Units "mi"

                         string cmd = string.Format(@"Set Map
Window {0} Zoom {1} Units ""{2}""", _mapWindowId, dZoom,
strUnit);

                         MapInfoApp.Do(cmd);
                }

         }


     }
}
```

MapInfoCallBack.cs

```
using System;
using System.ComponentModel;
using System.Windows.Forms;
using System.Runtime.InteropServices;
using System.Collections.Generic;
using System.Text;


namespace MapInfo.MiPro.Samples.IM
{
```

```
//=======================================================
==========
// Interface that includes the callback methods.
// Your application must provide a COM-visible class that
implements
// these methods.  MapInfo Professional will call these
methods
// at appropriate times.
// Implemented in MapInfoCallback class (see below).
//=======================================================
==========
public interface IMapInfoCallback
{
        // Method called by MapInfo Professional when window
changes
        int WindowContentsChanged(UInt32 windowID);

        // Method called by MapInfo Professional when the
status bar text changes
        int SetStatusText(string message);

        // Method called by MapInfo Professional when user
chooses custom OLE menuitem
        void MenuItemHandler(string commandInfo);
}


//=======================================================
==========
// Interface defining methods used to notify client of
events.
// Implement these methods in your Windows Forms
application.  The
```

```
      // MapInfoCallback class calls these methods at appropriate
times.
      //
      // Note that Control classes (such as Form) implement the
      // ISynchronizeInvoke interface.
      //========================================================
==========
      public interface ICallbackNotify : ISynchronizeInvoke
      {
            // Method called by MapInfoCallback class when user
chooses custom OLE menuitem
            void OnMenuItemClick(uint id);

            // Method called by MapInfoCallback class when the
status bar text changes
            void OnStatusBarTextChanged(string text);

            // Method called by MapInfoCallback class when window
changes
            void OnWindowContentsChanged(uint windowId);
      }



      //========================================================
==========
      // Callback class.  Provides methods called by MapInfo
Professional.
      //========================================================
==========
      [ClassInterface(ClassInterfaceType.None)]
      [ComVisible(true)]
      public class MapInfoCallBack : IMapInfoCallback
      {
```

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```csharp
        // Reference to object that gets notified when a
callback occurs
        private ICallbackNotify _callbackClient;

        // Delegates used to call ICallbackNotify methods on
the appropriate thread
        public delegate void OnMenuItemClickDelegate(uint
id);
        public OnMenuItemClickDelegate
_onMenuItemClickDelegate;

        public delegate void
OnStatusBarTextChangedDelegate(string text);
        public OnStatusBarTextChangedDelegate
_onStatusBarTextChangedDelegate;

        public delegate void
OnWindowContentsChangedDelegate(uint windowId);
        public OnWindowContentsChangedDelegate
_onWindowContentsChangedDelegate;

        // Constructor that takes a ref to an object that
implements ICallbackNotify
        public MapInfoCallBack(ICallbackNotify
callbackClient)
        {
            // Save reference to callback client
            _callbackClient = callbackClient;

            // instantiate our delegates
            _onMenuItemClickDelegate = new
OnMenuItemClickDelegate(_callbackClient.OnMenuItemClick);
```

```csharp
                _onStatusBarTextChangedDelegate = new
OnStatusBarTextChangedDelegate(_callbackClient.OnStatusBarTextCha
nged);
                _onWindowContentsChangedDelegate = new
OnWindowContentsChangedDelegate(_callbackClient.OnWindowContentsC
hanged);
        }


        // Callback method invoked when contents of a map
window change
        public int WindowContentsChanged(uint windowId)
        {
            if (_callbackClient != null)
            {
                // Notify client.  Use the client app's
InvokeRequired property to
                // make sure the call is invoked on the
appropriate thread.
                if (_callbackClient.InvokeRequired)
                {

    _callbackClient.Invoke(this._onWindowContentsChangedDelegat
e, new Object[] { windowId });
                }
                else
                {

    _callbackClient.OnWindowContentsChanged(windowId);
                }
            }
            // Return value does not matter
            return 0;
        }
```

```csharp
            // Callback method invoked when the status bar text
changes
            public int SetStatusText(string text)
            {
                  if (_callbackClient != null)
                  {
                        // Notify client.  Use the client app's
InvokeRequired property to
                        // make sure the call is invoked on the
appropriate thread.
                        if (_callbackClient.InvokeRequired)
                        {

     _callbackClient.Invoke(this._onStatusBarTextChangedDelegate
, new Object[] { text });
                        }
                        else
                        {

     _callbackClient.OnStatusBarTextChanged(text);
                        }
                  }
                  // Return value does not matter
                  return 0;
            }

            // Callback method invoked when a OLE menuitem has
been clicked
            public void MenuItemHandler(string commandInfo)
            {
                  if (_callbackClient != null)
                  {
```

```csharp
                        // Parse out the menuitem id
                        string[] args = commandInfo.Split(',');
                        if (args.Length >= 8)
                        {
                            uint id = uint.Parse(args[7]);

                            // Notify client.  Use the client
app's InvokeRequired property to
                            // make sure the call is invoked on
the appropriate thread.
                            if (_callbackClient.InvokeRequired)
                            {

    _callbackClient.Invoke(this._onMenuItemClickDelegate, new
Object[] { id });
                            }
                            else
                            {

    _callbackClient.OnMenuItemClick(id);
                            }
                        }
                    }
                }
            }
        }
```

MapForm.Designer.cs

```csharp
namespace MapInfo.MiPro.Samples.IM
{
    partial class MapForm
    {
```

```csharp
        /// <summary>
        /// Required designer variable.
        /// </summary>
        private System.ComponentModel.IContainer components =
null;

        /// <summary>
        /// Clean up any resources being used.
        /// </summary>
        /// <param name="disposing">true if managed resources
should be disposed; otherwise, false.</param>
        protected override void Dispose(bool disposing)
        {
            if (disposing && (components != null))
            {
                components.Dispose();
            }
            base.Dispose(disposing);
        }

        #region Windows Form Designer generated code

        /// <summary>
        /// Required method for Designer support - do not
modify
        /// the contents of this method with the code editor.
        /// </summary>
        private void InitializeComponent()
        {
         this.mapPanel = new System.Windows.Forms.Panel();
         this.menuStrip1 = new
System.Windows.Forms.MenuStrip();
```

```
            this.fileToolStripMenuItem = new
System.Windows.Forms.ToolStripMenuItem();
            this.openToolStripMenuItem = new
System.Windows.Forms.ToolStripMenuItem();
            this.exitToolStripMenuItem = new
System.Windows.Forms.ToolStripMenuItem();
            this.helpToolStripMenuItem = new
System.Windows.Forms.ToolStripMenuItem();
            this.aboutToolStripMenuItem = new
System.Windows.Forms.ToolStripMenuItem();
            this.comboBoxMapTool = new
System.Windows.Forms.ComboBox();
            this.label1 = new System.Windows.Forms.Label();
            this.statusStrip1 = new
System.Windows.Forms.StatusStrip();
            this.toolStripStatusLabel1 = new
System.Windows.Forms.ToolStripStatusLabel();
            this.buttonZoomIn = new
System.Windows.Forms.Button();
            this.buttonZoomOut = new
System.Windows.Forms.Button();
            this.menuStrip1.SuspendLayout();
            this.statusStrip1.SuspendLayout();
            this.SuspendLayout();
            //
            // mapPanel
            //
            this.mapPanel.Anchor =
((System.Windows.Forms.AnchorStyles)(((System.Windows.Forms.Anch
orStyles.Top | System.Windows.Forms.AnchorStyles.Bottom)
                        | System.Windows.Forms.AnchorStyles.Left)
                        |
System.Windows.Forms.AnchorStyles.Right)));
```

```
          this.mapPanel.BackColor =
System.Drawing.SystemColors.Window;
          this.mapPanel.BorderStyle =
System.Windows.Forms.BorderStyle.Fixed3D;
          this.mapPanel.Location = new System.Drawing.Point(10,
74);
          this.mapPanel.Name = "mapPanel";
          this.mapPanel.Size = new System.Drawing.Size(470,
346);
          this.mapPanel.TabIndex = 0;
          //
          // menuStrip1
          //
          this.menuStrip1.Items.AddRange(new
System.Windows.Forms.ToolStripItem[] {
          this.fileToolStripMenuItem,
          this.helpToolStripMenuItem});
          this.menuStrip1.Location = new
System.Drawing.Point(0, 0);
          this.menuStrip1.Name = "menuStrip1";
          this.menuStrip1.Size = new System.Drawing.Size(490,
24);
          this.menuStrip1.TabIndex = 1;
          this.menuStrip1.Text = "menuStrip1";
          //
          // fileToolStripMenuItem
          //
          this.fileToolStripMenuItem.DropDownItems.AddRange(new
System.Windows.Forms.ToolStripItem[] {
          this.openToolStripMenuItem,
          this.exitToolStripMenuItem});
          this.fileToolStripMenuItem.Name =
"fileToolStripMenuItem";
```

```
            this.fileToolStripMenuItem.Size = new
System.Drawing.Size(35, 20);
            this.fileToolStripMenuItem.Text = "&File";
            //
            // openToolStripMenuItem
            //
            this.openToolStripMenuItem.Name =
"openToolStripMenuItem";
            this.openToolStripMenuItem.Size = new
System.Drawing.Size(123, 22);
            this.openToolStripMenuItem.Text = "&Open...";
            this.openToolStripMenuItem.Click += new
System.EventHandler(this.openToolStripMenuItem_Click);
            //
            // exitToolStripMenuItem
            //
            this.exitToolStripMenuItem.Name =
"exitToolStripMenuItem";
            this.exitToolStripMenuItem.Size = new
System.Drawing.Size(123, 22);
            this.exitToolStripMenuItem.Text = "E&xit";
            this.exitToolStripMenuItem.Click += new
System.EventHandler(this.exitToolStripMenuItem_Click);
            //
            // helpToolStripMenuItem
            //
            this.helpToolStripMenuItem.DropDownItems.AddRange(new
System.Windows.Forms.ToolStripItem[] {
            this.aboutToolStripMenuItem});
            this.helpToolStripMenuItem.Name =
"helpToolStripMenuItem";
            this.helpToolStripMenuItem.Size = new
System.Drawing.Size(40, 20);
```

```
            this.helpToolStripMenuItem.Text = "&Help";
            //
            // aboutToolStripMenuItem
            //
            this.aboutToolStripMenuItem.Name =
"aboutToolStripMenuItem";
            this.aboutToolStripMenuItem.Size = new
System.Drawing.Size(152, 22);
            this.aboutToolStripMenuItem.Text = "&About...";
            this.aboutToolStripMenuItem.Click += new
System.EventHandler(this.aboutToolStripMenuItem_Click);
            //
            // comboBoxMapTool
            //
            this.comboBoxMapTool.DropDownStyle =
System.Windows.Forms.ComboBoxStyle.DropDownList;
            this.comboBoxMapTool.Enabled = false;
            this.comboBoxMapTool.FormattingEnabled = true;
            this.comboBoxMapTool.Location = new
System.Drawing.Point(106, 47);
            this.comboBoxMapTool.Name = "comboBoxMapTool";
            this.comboBoxMapTool.Size = new
System.Drawing.Size(121, 21);
            this.comboBoxMapTool.TabIndex = 0;
            this.comboBoxMapTool.SelectionChangeCommitted += new
System.EventHandler(this.comboBoxMapTool_SelectionChangeCommitted
);
            //
            // label1
            //
            this.label1.AutoSize = true;
            this.label1.Location = new System.Drawing.Point(12,
50);
```

```
            this.label1.Name = "label1";
            this.label1.Size = new System.Drawing.Size(88, 13);
            this.label1.TabIndex = 1;
            this.label1.Text = "Active Map Tool:";
            //
            // statusStrip1
            //
            this.statusStrip1.Items.AddRange(new
System.Windows.Forms.ToolStripItem[] {
            this.toolStripStatusLabel1});
            this.statusStrip1.Location = new
System.Drawing.Point(0, 428);
            this.statusStrip1.Name = "statusStrip1";
            this.statusStrip1.Size = new System.Drawing.Size(490,
22);
            this.statusStrip1.TabIndex = 2;
            this.statusStrip1.Text = "statusStrip1";
            //
            // toolStripStatusLabel1
            //
            this.toolStripStatusLabel1.Name =
"toolStripStatusLabel1";
            this.toolStripStatusLabel1.Size = new
System.Drawing.Size(10, 17);
            this.toolStripStatusLabel1.Text = " ";
            //
            // buttonZoomIn
            //
            this.buttonZoomIn.Enabled = false;
            this.buttonZoomIn.Location = new
System.Drawing.Point(248, 45);
            this.buttonZoomIn.Name = "buttonZoomIn";
```

```
            this.buttonZoomIn.Size = new System.Drawing.Size(75,
23);
            this.buttonZoomIn.TabIndex = 3;
            this.buttonZoomIn.Text = "Zoom In";
            this.buttonZoomIn.UseVisualStyleBackColor = true;
            this.buttonZoomIn.Click += new
System.EventHandler(this.buttonZoomIn_Click);
            //
            // buttonZoomOut
            //
            this.buttonZoomOut.Enabled = false;
            this.buttonZoomOut.Location = new
System.Drawing.Point(342, 45);
            this.buttonZoomOut.Name = "buttonZoomOut";
            this.buttonZoomOut.Size = new System.Drawing.Size(75,
23);
            this.buttonZoomOut.TabIndex = 4;
            this.buttonZoomOut.Text = "Zoom Out";
            this.buttonZoomOut.UseVisualStyleBackColor = true;
            this.buttonZoomOut.Click += new
System.EventHandler(this.buttonZoomOut_Click);
            //
            // MapForm
            //
            this.AutoScaleDimensions = new
System.Drawing.SizeF(6F, 13F);
            this.AutoScaleMode =
System.Windows.Forms.AutoScaleMode.Font;
            this.ClientSize = new System.Drawing.Size(490, 450);
            this.Controls.Add(this.buttonZoomOut);
            this.Controls.Add(this.buttonZoomIn);
            this.Controls.Add(this.statusStrip1);
            this.Controls.Add(this.comboBoxMapTool);
```

```csharp
            this.Controls.Add(this.label1);
            this.Controls.Add(this.mapPanel);
            this.Controls.Add(this.menuStrip1);
            this.MainMenuStrip = this.menuStrip1;
            this.MinimumSize = new System.Drawing.Size(450, 450);
            this.Name = "MapForm";
            this.Text = "Map Viewer";
            this.FormClosed += new
System.Windows.Forms.FormClosedEventHandler(this.Form1_FormClosed
);
            this.ResizeEnd += new
System.EventHandler(this.Form1_ResizeEnd);
            this.Load += new
System.EventHandler(this.Form1_Load);
            this.menuStrip1.ResumeLayout(false);
            this.menuStrip1.PerformLayout();
            this.statusStrip1.ResumeLayout(false);
            this.statusStrip1.PerformLayout();
            this.ResumeLayout(false);
            this.PerformLayout();

        }

        #endregion

        private System.Windows.Forms.Panel mapPanel;
        private System.Windows.Forms.MenuStrip menuStrip1;
        private System.Windows.Forms.ToolStripMenuItem
fileToolStripMenuItem;
        private System.Windows.Forms.ToolStripMenuItem
openToolStripMenuItem;
        private System.Windows.Forms.ToolStripMenuItem
exitToolStripMenuItem;
```

```
            private System.Windows.Forms.ToolStripMenuItem
helpToolStripMenuItem;
            private System.Windows.Forms.ToolStripMenuItem
aboutToolStripMenuItem;
            private System.Windows.Forms.ComboBox
comboBoxMapTool;
            private System.Windows.Forms.Label label1;
            private System.Windows.Forms.StatusStrip
statusStrip1;
        private System.Windows.Forms.ToolStripStatusLabel
toolStripStatusLabel1;
        private System.Windows.Forms.Button buttonZoomIn;
        private System.Windows.Forms.Button buttonZoomOut;
    }
}
```

CURRICULUM VITAE

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B.Sc.	Al-Anbar University, Information System	2003
High School	Al-Wasity High School,Kirkuk	1999

WORK EXPERIENCE

Year	Place	Enrollment
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FOREIN LANGUAGES
Arabic, English, Turkish