Geographic Information System using ArcGIS 10 and Open Source MapWindow
Methodology and Comparative Study

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Abstract: Geographic Information System (GIS) is an IT system capable of capturing, storing, analyzing, and display-ing geographically data. We present a comparison between ArcGIS 10 and MapWindow 4.0 in creating a (GIS) for a study area to clarify the similarities and the differences. Upon the application of the GIS system using the two mentioned different software tools, we will provide the methodology and a related compari-son. The *ESRI® ArcGIS* is an integrated geographic information system (GIS) for managing a digital data-base, working with maps and geographic information. It provides an infrastructure for making maps, analy-sis, presentations of geographic information available for organizations, communities and openly on the Web. *MapWindow* is free of charge, extensible geographic information System (GIS) that can be used as an open-source alternative to desktop GIS to develop and distribute custom spatial data analysis tools. It is a "Programmable Geographic Information System" that supports manipulation, analysis, and viewing of geo-spatial data and associated attribute data in several standard GIS data formats. It is also considered a map-ping tool, a GIS modeling system, and a GIS application programming interface (API); all in one conven-ient redistributable package. It was developed by MapWindow Open Source Team to address the need for a GIS programming tool that could be used in engineering research, without requiring end users to purchase a complete GIS system, or become GIS experts.

We had used MapWindow in many applications and always proved efficient. We found Open Source MapWindow GIS as efficient as the commercial GIS system for important applications (Mapping, Naviga-tion, Tracking etc.) in addition to its being free of charge. We had been using it in our applications and re-search work such as: OSGIS for BAU and in Navigation and Tracking to be used by interested users on the web.

1 INTRODUCTION

Easy access to spatial data for a wide range of users in governmental organizations and large companies led to great development in the implementation of Spatial Data Infrastructures (SDI) (Rajabifard and Williamson, 2001), (Crompvoets et al., 2004). Hundreds of new spatial portals and systems for spatial data dissemination have been built worldwide lately (GeoConnections, 2009). Building an SDI requires a range of software tools that depend on geospatial data provider, service provider, or data user. To support these ongoing implementation efforts, free and open source projects have started. Reviews of Free and Open Source Software for GIS (FOSS4GIS) and its utility have become more common, as the free software solutions start to

replace proprietary software (Reid and Martin, 2001). Categories of GIS software have been identified by Steiniger (Steiniger and Weibel, 2009), (Steiniger and Hay, 1998), which include desktop GIS, Spatial Database Management Systems (Spatial DBMS), web map, server GIS, web GIS clients, mobile GIS, and GIS libraries and extensions.

In the following we are comparing some of these packages.

2 MapWindow

This is a mapping tool, a GIS modeling system, and a GIS application programming interface (API) which was developed by Dr. Daniel P. Ames and a group of student programmers at Utah State

University (Appleman, 1998). It was developed to address the need for a GIS programming tool that could be used in engineering research and project software, without requiring to purchase a complete GIS system, or become a GIS expert. It is available free of charge and can be sued to develop custom spatial data analysis tools (http://www.map window.org/). Developers can write Plug-ins to add additional functionality such as models, special viewers, hot-link, handlers, and data editors, and pass these to users. It includes standard GIS data visualization features, database functions such as attribute table editing, shape file editing and data converters. Dozens of Standard GIS formats are supported, including Shape files, GeoTIFF, ESRI format, ASCII and binary grids. It includes a complete ActiveX component to instantly add GIS capabilities to the user's existing software product (MapWinGIS; FOSS4G). Additional geo-processing components are available for .NET-compatible Languages. Components of MapWindow are:

-*The* Main Application: This is the central interface where, the user may view data elements such as Shape files and Grids and the Core Components

-*The* components which operate underneath. The three main components are: (a) MapWinGISwhcih is an ActiveX control which may be placed into any project in any programming language that supports ActiveX. This is the main map component - if the user wants to write a program that displayed shape data, for example, the user could use this control for the display portion of the user's program. (b) MapWin Interfaces: This is also called the "Plug-in Interface", this is a dll file which will allow the user to write the user's own plug-ins to the main application. This may be done from any programming Language which supports the creation and use of Microsoft .NET 2.0 Dynamic Link Libraries (dlls). (c) MapWinGeoProc: This is a .NET library of geoprocessing functions, including tools for managing projections, clipping and buffering. This Library is under very active development with new capabilities appearing Often.

3 ArcGIS 10

The ESRI® ArcGIS System is an integrated geographic Information system (GIS) consisting of:
(a) Arc GIS Desktop software which is an integrated suite of Advanced GIS applications
(b) Arc SDE® gateway which is an interface for

managing Geodatabases in a database management system (DBMS)
(c) Arc IMS® software which is an Internet-based GIS for distributing Data and services.
Arc GIS provides a framework for implementing GIS for single user or for many users. It can be extended with additional software, such as Arc Pad® for Windows® CE devices.
Components of ArcGIS desktop are:
1.ArcMap: This is the GIS application used for all map-based tasks including cartography, map analysis, and editing. In this tool, the user basically works with maps. Arc Map permits viewing a map, a geographic data and a layout view to implement advanced GIS tasks.
 2. Arc catalog: This is an application to organize and manage all GIS data, with browsing tools to find geographic information, managing metadata and to define the schema structure for the geographic data layers.
3. Arc toolbox: Arc Toolbox is a simple application containing many GIS tools used for geoprocessing tasks (GIS Fundamentals).

ArcGIS Desktop License Levels:
ArcGIS allows better data analysis, relationship definition, pattern recognition and optimal informed decision making. It is available in three license levels: basic, standard, or advanced (formerly ArcView, ArcEditor, or ArcInfo). They share the core applications, user interface, and development environment, but each provides more GIS functionality
ArcInfo is the highest level of licensing and functionality. It is a full featured GIS system with access to all functions. It includes advanced data analysis and modeling, feature management and processing and data conversion for CAD, raster, DBASE, and coverage formats (http://en.wikipedia.org/).
ArcEditor is a standard ArcGIS level of licensing and functionality. It provides the standard and basic ArcGIS functions such as complete GIS data editing capabilities, automate quality control, and use of raster-to-vector conversion.
ArcView is the basic ArcGIS level of licensing and functionality. It is a powerful toolkit for mapping, reporting, and map-based analysis such as visual modeling, and spatial analysis of a process or workflow, creation of interactive maps from files, database, and online sources, and generation of reports and charts.
ArcReader is a free application to view and use maps created with ArcMap and the optional ArcGIS

Publisher extension. ArcReader works on maps in PMF format. Because Arc Reader is free, any user can install it easily.

4 STUDY AREA AND METHODOLOGY

For application and comparison purposes we used the Zahran Street area in Amman; see Figure 1.
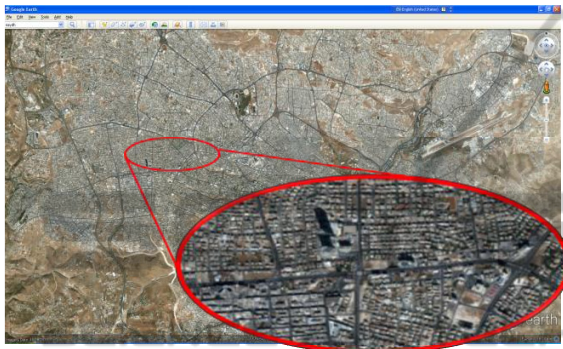

Figure 1: Amman Image and Zahran Street.

Figure 2 presents the flowchart of the methodology to create a GIS for the study area using ArcGIS 10.
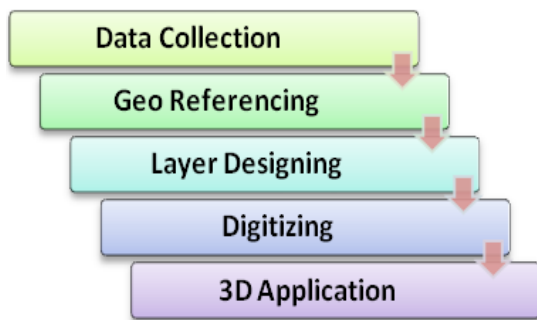

Figure 2: Flowchart of GIS Processing using ArcGIS 10.

- Data Collection: We collected data from Satellite images with coverage for Zahran Street area in Amman, Jordan (Google Earth); see Figure 3. **Google Earth** Program is a virtual global map and geographic information program which maps the Earth's surface by the superimposition of images of varying resolution obtained from satellite imagery, aerial photography and GIS 3D globe (http://en.wikipedia.org/). The internal coordinate system of Google Earth is geographic coordinates (latitude/longitude) on the World Geodetic System of 1984 (WGS84) datum. It uses digital elevation model (DEM). The Google Earth Program is used for creating clip in **JPG** file to get the needed

Figure 3: Image Clip for Zahran Area (Google Earth).

information such as buildings, streets, and hotels; see Figure 3.

- Projection: This is the process of translating real 3D world data to flat 2D view using a systematic mathematical transformation. We used Jordan Transverse Mercator (JTM) coordinate system (the modified Universal Transverse Mercator -UTM).

- Georeferencing: This deals with is assigning map coordinates and spatial location. It is also associating geographic data to a known coordinate system so that it can be viewed, queried, and analyzed with other geographic data. After applying the suitable projection upon the images, we applied the georeferencing process.

- Database Design: Upon adding a dataset to ArcMap, a layer is created. Each layer represents geographic data which relates the spatial data to the attribute data in order to achieve a brief view of the area. Many layers were created such as roads, buildings, land parcels, schools, mosques, embassies, banks, museums, churches, restaurants, among others. Creating layers in Arc Catalog needs the selection of multiple proprieties such as layer name, type, the used projection, number of column, and data type.

- Digitizing: This is the process of converting features into a digital format to create new data; see Figures 4 and 5.

- Other applications using ArcMap Include:
- The **Hyperlink** tool where you can access documents or Web pages related to features.
- **Converting AutoCAD File to Geodatabase:** We generated our contour map using AutoDisk Land Develop 2004 then we transferred it to shape file in ArcGIS 10 using ArcCatalog (Figure 6). Next, we createed a TIN in ArcMap.

Triangulated Irregular Network (TIN): This is a digital data structure used in GIS for the representation of a surface. It comprises a triangular network of vertices, which represent the physical
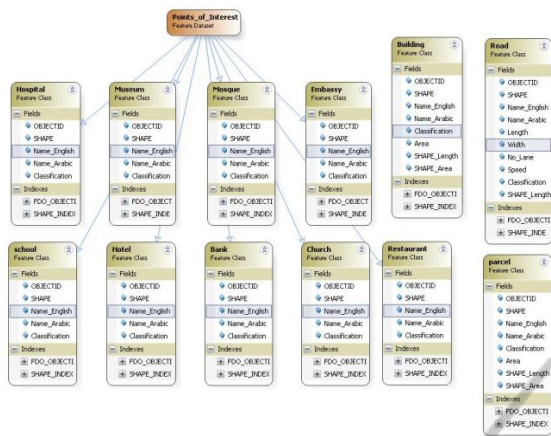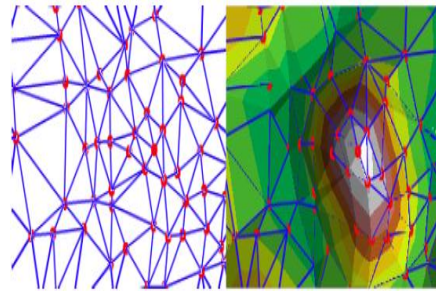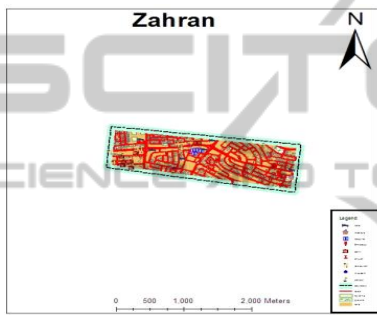
Figure 4: Database Design Process.

Figure 5: Digitizing of Zahran Street.

Figure 6: The Contour Map.

Figure 7: Nodes, Edges, and Faces of a TIN.

Figure 8: A TIN Layer.

Figure 9: A 3D Model View.

than in a raster DEM, with regularly distributed points.

Creating 3D Scene: ArcScene is a 3D visualization application that allows viewing the GIS data in 3D form (Figure 9). The purpose is to provide 3D fly-through, to overlay many layers of data in a 3D environment, and every layer of these in the 3D view can be handled differently.

MapWindow OSGIS: Data Processing contains the package of layers designing, digitizing, georeferencing and projection as in the flowchart shown in Figure 10. For the same application area, we created another GIS system using MapWindow software.
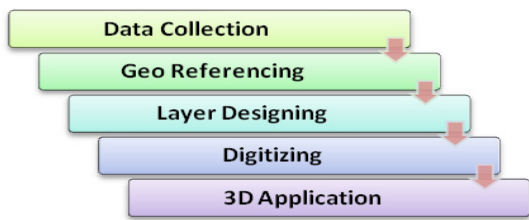
land surface or sea bottom (mass points), with associated coordinates in three dimensions connected by edges to form a triangular tessellation; see Figures 7 and 8.

TINs are often derived from the elevation data of a raster digital elevation model (DEM). An advantage of using a TIN over a raster DEM in mapping and analysis is that the points of a TIN are distributed variably based on an algorithm that determines which points are most needed to have an accurate representation of the terrain (Figure 8). Data input is therefore flexible and fewer points need to be stored

Figure 10: Flowchart of GIS using MapWindow 4.0.

- Data Collection: Satellite Images with coverage for the same area, the Zahran Street area, were taken from Google Earth Program **(JPG** file). Using Mapwindow, we got the same clip for the study area.

- Georeferencing: The correct location and shape of features need a framework for defining real-world locations, using established coordinate system, such as Cartesian coordinate system (before or after digitizing; see Figure 11).

Figure 11: Mapwindow Georeferenceing.

- Projection: We used the JTM projection in meters to apply the same projection on the images that was taken from Google Earth pro. After applying the suitable projection upon the images, we applied the georeference on them, both X and Y coordinates are georeferenced with projected coordinate system. By inputting the coordinates, three points are needed (Figure 11). After georeferencing and assigning projection to the image we could add rectifying image to Map Window.

- Layer Designing: Map Window creates shape files by adding shape file editor. Locate the "where do you want to save the shape file?" and locate the shape file type. Automatically shape file will be added on project. Before starting edit shape file, we need to assign projection to shape file by GIS tools (Figure 12). The final screen after editing all shape files can be seen in Figure 13.
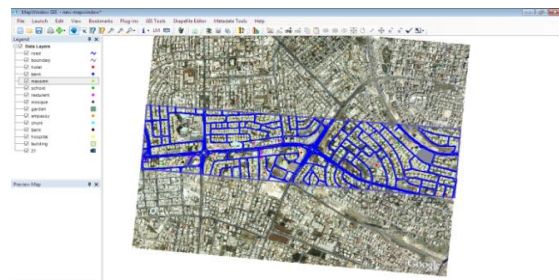

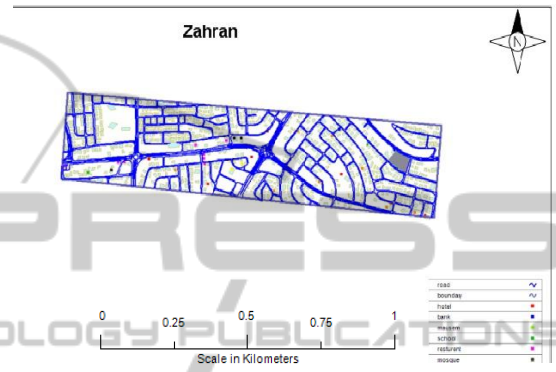Figure 12: Final Screen after Editing Shape Files.

Figure 13: Final map.

Comparison between ArcGIS 10 and MapWindow 4.0:
a) Georeferencing:
- ArcGIS 10 requires four points or more while MapWindow needs only three points.

b) Clip extraction:
- ArcGIS 10 extracts the cells of a raster that correspond to the areas defined by a mask; see Figure 14.
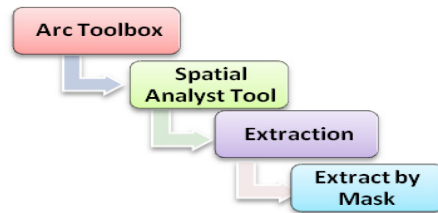

Figure 14: Extraction Steps in ArcGIS 10.

- MapWindow cannot perform extraction. In our project, we build shape file (boundary) to define the limits of the work area (Figure 15).

c) Geodatabase:
- In ArcMap 10, we built geodatabase from Arc Catalog (Figure 16). It provides a catalog window to organize and manage various types of geographic information for ArcGIS Desktop. The kinds of information that can be organized and managed in

Figure 15: Limits of the Work Area.

ArcCatalog include Geodatabases, raster files, map documents, globe documents, 3D scene documents, and layer files, Geoprocessing toolboxes, models, and Python scripts, GIS services published using ArcGIS servers, standards-based metadata for these GIS information items and much more. ArcCatalog organizes these contents into a tree view that allow the user to organize the GIS datasets and ArcGIS documents in order to search and find information items, and manage them. Arc Catalog is used to Organize the GIS contents, manage geodatabase schemas, search for and add content to ArcGIS applications, document contents, manage GIS servers, and manage standards-based metadata. All layers in the geodatabase have the same coordinates and projection.
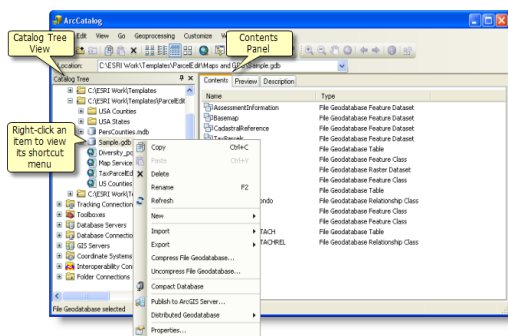

Figure 16: Geodata base building in ArcCatalog.

In MapWindow, we cannot build a geodatabase, but we can build shape file and for every shape file we must determine the projection.

d) Digitizing:

In ArcMap 10: In order to start digitizing, the user needs to open the Editor Toolbar and start an editing session. There are several options for making the edit more efficient.

In MapWindow: In order to start editing the shape files, the user needs to select the shape file editor from the plug-in, then select the shape file that the user needs to edit from legend and then the user

should press from the toolbar and start editing. To finish the editing process, the user just needs to right click.

e) Symbols:

In ArcMap 10, the user can use the default symbol or change some basic properties such as color and size or modify any of the properties and create own symbols.

In MapWindow, we can change color and size only.

f) Snap:

In ArcMap 10, Snapping allows the user to create features that connect to each other so the edits are more accurate.

In MapWindow: From shapefile Editor, the user needs to snap to all layers.

g) Topology:

In ArcMap 10: In general, topology is a set of rules which define the relationship between points, lines, and polygons. This can enable us to add a topology, point to new, and then click topology generation within right-click of the feature dataset to which you want topology ; see Figure 17.

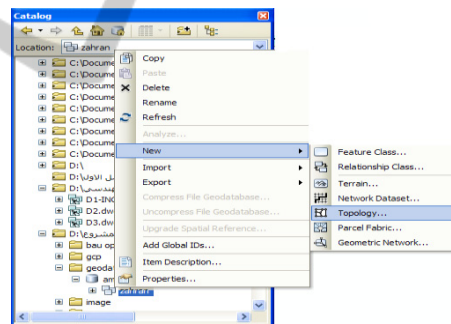In MapWindow, the user cannot perform topology operations.

Figure 17: Topology in ArcMap10.

h) Inputting the Attributes:

In ArcMap 10, by right clicking on layer, the user can select open attribute Table (you must open the editor by select start editing).

In MapWindow, the user needs to open attribute table but do not need to open the editor.

i) Layouts:

In ArcMap 10, from the layout view, the user can work with the map layout elements, such as titles, north arrows, and scale bars, along with the data frame, all of which are arranged on a page (Figure 19).

In MapWindow, the user cannot perform layout without the select print option; see Figure 19.
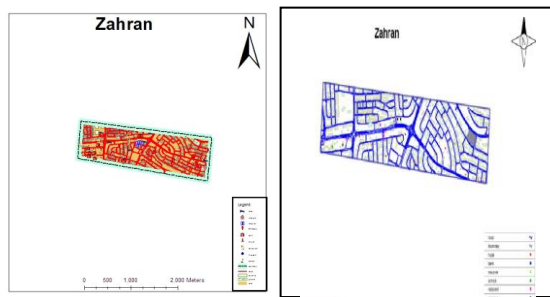
Figure 19: Layout in ArcMap 10 and MapWindow.

j) TIN:

In ArcMap 10, the user can generate TIN from 3D Analyst toolbar; see Figures 6 and 7. While in MapWindow, the user cannot generate TIN layers.

k) 3D Analyses:

In ArcMap 10, the user can generate 3D model using Arc Scene (Figure 8), while in MapWindow, he cannot generate a 3D model.

l) Hyperlinks:

In ArcMap 10, the user can do hyperlinks, while in Mapindow, hyperlinks do not exist.

5 SUMMARY AND CONCLUSIONS

To sum up, we can make the following comments and points:

- OSGIS was developed to address the need for a GIS programming tool, without the need to purchase a complete GIS system, or become a GIS expert.

- OSGIS is an alternative to desktop GIS that can be used as information system to distribute data to others and to develop custom spatial data analysis tools.

- OSGIS proved to be perfectly functional for many important applications such as mapping, navigation, tracking, among others.

- Users could use MTS as a platform and build a specialized application that can do the needed functions in order to distribute or sell directly to end users.

- OSGIS is a mapping tool, a GIS modeling system, and a GIS application programming interface (API) all in one convenient redistributable package.

- Developers can write Plug-ins to add additional functionality such as models, special viewers, hot-

link, Handlers, and data editors and pass these along to users.

- Dozens of Standard GIS formats are supported, including Shape files, GeoTIFF, ESRI format, ASCII and binary grids. Moreover, it includes a complete ActiveX component, which may be used to instantly add GIS capabilities to the user's existing software product. Additional geo-processing components are available for .NET-compatible Languages.

In conclusion, we are presenting an overall comparison between Arc GIS 10 and Map Window software tools; see Table 1.

Table 1: Comparison Between ArcGIS 10 and Map Window software tools.

Item	ArcGIS	MapWindow
Cost	Expensive	Free (open-source)
Georeference	(4) points at least	Needs only 3 points
Extraction	Extraction by arctoolbox	you cannot do Extraction
Database	geodatabase	shape file
Digitizing	start editing	We can do digitizing
Symbols	Change color , size and shape	Change color and size only
End Digitizing	stop editing	right click
Snapping	Automatic	Automatic
Topology	you can do topology	you cannot do topology
Input the attribute	can input the attribute	can input the attribute
layout	from layout view	from print
TIN	you can do TIN	you cannot do TIN
3D	you can do 3D	you cannot do 3D
Hyperlinks	you can do hyperlink	you cannot do hyperlink

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