GIS LEARNING TOOL FOR OTTOMAN EMPIRE

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DEDICATION

I would like to dedicate this thesis to my husband and my parents who have always supported and encouraged me in all my accomplishment.
ABSTRACT OF THE THESIS

GIS Learning Tool for Ottoman Empire
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The aim of this thesis is to create a GIS (Geographic Information systems) tool employing current technology to provide a geographic computer interactive and user friendly tool that will help students to learn more about Turkey from the crusades until the end of the growth of the Ottoman Empire. The time period covered is roughly from 1000AD to 1300AD.

This GIS tool has been developed in core JAVA. MOJO (Map Objects Java Edition) is used for showing the layers of the map. Each Crusade, and the geographical boundaries for each Ottoman sultan were established as a layer on the map. The layers created are point layers or polygon layers or line layers. Users have the ability to customize the tool to suit their individual interests, select layers of their choice and click. By using this GIS tool, the user can click on various points which might represent battles located on the map; this will display a webpage for that point giving detailed information about that battle, as to how it started, where it happened, the casualties in the battle from both sides, who won and background information about the belligerents involved in those battles. There is also a 'family tree' of Turkish rulers, and by clicking on a ruler, one gets a Wiki biography about that ruler.
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CHAPTER 1

INTRODUCTION

With the explosive growth of technology, learning methodologies have changed drastically. Developments in multimedia technologies and internet are basic enablers of e-learning which makes the learning process more interesting and more effective. Especially young people learn more using computer-based instruction than they do with conventional ways of teaching. The application is intended for self study, or assigned individual or small group projects.

The aim of this thesis to provide an interactive learning tool for students who want to have a better understanding of Turkey from the Crusades until the end of the growth of the Ottoman Empire. This is accomplished with an interactive learning tool which enables the user to display information about an event through hotlinks, add layers, remove layers. Many layers, web pages and external web links are used to provide as comprehensive a tool as possible.

This thesis is developed using java technologies and Map Object Java Edition which is one of the many product developed by ESRI (Environmental Systems Research Institute) which is an international supplier of Geographic Information System software, web GIS and geodatabase management applications [1]. By using MOJO, developers can build customizable cross-platform GIS applications. It also makes it easy to retrieve and query geographic based data.

The thesis report is organized into 8 chapters. The first two chapters are an introduction to the thesis and the technologies that were used in the development of the tool. Chapters 4, 5 introduce the toolbars and their functionalities in detail. Chapter 6 introduces the features of the GIS tool, giving screenshots for different features of the tool. Chapter 7 and 8 discuss some challenges faced during the implementation of this tool and present some future enhancements.
CHAPTER 2

TECHNOLOGY

This thesis is developed by using Java and its packages, MapObjects Java Edition and Swing. We prefer Java because it is platform independent, easy to deploy and has other important features which are discussed later in this chapter. MapObjects Java Edition is written by ESRI (Environmental Systems Research Institute) to work with GIS (Geographic Information System), and is affectionately called MOJO (Map Objects Java Objects). The main purpose of Swing is to create a GUI (Graphical User Interface) with ease and speed.

2.1 WHAT IS JAVA?

Java was first released by Sun Microsystems in 1995 with the main property of being a programming language as well as a computing platform. Java provides lots of reusable code, a huge library and an execution environment. Since Java is platform independent, Java programmers do not need to worry about environment details where the Java application is running. Java has a component called JVM (Java Virtual Machine) which recognizes and understands the difference between operating systems. These differences are handled by JVM and Java class libraries. Instead of an executable code, Java compiler produces highly optimized ByteCode which is executed by JVM. What makes Java more portable than some languages such as C, C++ is this ByteCode.

The important features of Java are as follows:

- **Simple**: Java has simpler syntax than C++. There is no need for pointer arithmetic (or even a pointer syntax), structures, unions, virtual base classes, and so on [2].

- **Object Oriented**: By using Java, we can take advantage of important features of object oriented programming such as modularity, extensibility, and reusability. All these features increase efficiency of software-development, provide improved maintainability, as a result enable lower development cost. In Java, everything must be defined in classes, making Java more purely OOP than C++.

- **Secure**: Java has a lot of features that allow us to develop secure software. Java was designed to make certain kinds of attack impossible such as overrunning the runtime stack (a common attack of worms and viruses), corrupting memory
outside or inside its own space (no pointer arithmetic) and reading or writing files without permission.

- **Platform Independent**: JVM itself is platform independent. It can work on a wide variety of platforms. Java code is compiled into ByteCode executed by JVM and this enables Java programs to run on different kinds of environments. Once JVM is installed on a certain system, we can run all Java programs.

- **Easy Deployment**: Java applications are translated into ByteCode and can be packaged into a Jar (Java archive) file. If whatever the application needs is packaged into an executable Jar file, the application can run by simply clicking or double click on Jar file [3].

- **Dynamic**: While a Java application is running, the required code can be added to the application. Libraries can freely add new methods and instance variables without any effect on clients [4].

### 2.2 MapObjects Java Edition

MapObjects Java Edition is a toolkit for a Java developer which enables development of server or client side GIS or mapping applications with complete functionality without having any other ESRI software. MapObjects Java Edition works well both J2SE (Java 2 Platform, Standard Edition) and J2EE (Java 2 Platform, Enterprise Edition) environments. It consists of 100% pure Java mapping APIs (Application Programming Interface) and is distributed in the form of a Jar files. By using MapObjects Java Edition, it is easy and very fast to develop applications that have functionality such as toolbar, dynamic symbol control, query dialogs, overview & insert map, and intelligent legends that make the applications user-friendly. The applications built by MapObjects Java Edition give the ability to the end user to combine local data with Internet and intranet data to create their own customized maps and integrate with existing application architecture [3]. Map Objects is often referred to as component architecture, and is a bit similar to Visual Basic.

Important features of the MapObjects Java Edition are as follows [5, 6, 7]:

- **MapObjects**—Java Edition is ideal for integrating GIS and mapping functionality into an existing or planned architecture.

- **MapObjects**—Java Edition is free set of mapping software components and allows access to more base objects and gives us much more flexibility to create our own customized GIS tools.

- **MapObjects**—Java Edition has pre-built tool bars such as SelectionToolbar and ZoomPanToolBar which give the user a lot of functionality such as accessing database to get detailed information about selected features on the map, aiding
the user in defining a database SQL style query which can be used to select certain feature from a map and panning, zooming through a map.

- MapObjects—Java Edition allow us to easily add additional toolbars and menus using standard Java classes, borrowing MOJO methods where needed.
- MapObjects—Java Edition has a method to interactively add layers using the GUI, a standard feature in a dynamic interactive map. And of course we are able to remove layers as well.
- MapObjects—Java Edition lets us create a layer from point data, in the world coordinate system, and display this on a local base map.
- MapObjects—Java Edition supplies many True Type Fonts for rendering points which makes it possible to select a symbol from these fonts and use them in a point theme in a place of the usual “base symbols”, which are usually circles or rectangles. This device is particularly useful in maps which have a large number of point themes. It is also possible to show the symbols in the appropriate legend in the table of contents. Icons can also be selected that are external to MOJO.
- MapObjects—Java Edition has an AttributeTable class, which makes it possible to display entire the attribute table for a layer. But using the Java JTable class much more versatile attribute tables can be created. In general, the embedding of MOJO in Java allows for almost unlimited customization.
- MapObjects—Java Edition has a number of projection classes. This feature allows users to choose a projected coordinate system.
- MapObjects—Java Edition provides the ability to save the map as an ArcXML file which is ESRI’s Arc extensible markup language.
- MapObjects—Java Edition has a legend editor which allows layers to be displayed in transparent and opaque format. It also has polygon options like Horizontal Fill, and Vertical Fill. These options make it possible to show several polygon layers at the same time because they are transparent with distinguishable patterns other than color.
CHAPTER 3

REQUIREMENTS

The goal of this interactive GIS tool is to give the user detailed information about Turkey from the Crusades to the Ottoman Empire. The thesis project has been developed under the guidance of Dr. Carl Eckberg from San Diego State University, Computer Science Department. Requirements are determined by the thesis supervisor, Dr. Carl Eckberg. The requirements are divided into three categories as follows:

- Data requirements
- Platform requirements
- Functional requirements

3.1 DATA REQUIREMENTS

Required data for this GIS Tool are composed of shape files, actual information about important events, images and related web links that are provided to the end user to access required information. The shape files are used as inputs to create layers of the map. The information about the important events such as battles and sieges that happened in Turkey from Crusades until the end of the growth of the Ottoman Empire are provided as data for the Hotlink Tool. Data about the Ottoman Empire are classified according to the significant sultans as follow:

- Osman I
- Murad I
- Selim I
- Mehmed II (Mehmed the Conqueror)
- Suleiman I (Suleiman the Magnificent)
- Selim II

3.2 PLATFORM REQUIREMENTS

Since a MOJO application is at heart a Java program, the application can be developed in almost any environment. Any Java IDE can be used as well.
3.3 Functional Requirements

Functional requirements contain all services and features that are provided by the GIS tool. All possible scenarios, behaviors and actions that will be performed on the UI were examined carefully to improve efficiency, functionality of the software. The GUI was designed to be as user friendly as possible.

The most significant functional requirements are as follows [8]:

The application should be packaged into an executable Jar file that allows a user to run the GIS tool by simply clicking on it independent of the platform.

Each Crusade and period of each Sultan should be represented by a respective layer.

The location of the important events such as battles and sieges should be represented on the map by, e.g. flag symbols from True Type Fonts by using an actual world coordinate system.

Each important event should be provided by the hotlink tool to give brief information to the user.

If more information is available, it is provided by local HTML pages and web links that are available on local HTML pages.

User should be allowed to add a new layer or remove an existing one.

It should provide a button to see the Ottoman Family Tree to understand relations between Sultans.

It should provide print button.

The tool should provide a help menu which informs the user about the GIS tool and introduces its functions.

When the application is started, the TOC (Table Of Contents) should be loaded with all required layers and all layers should be selected according to user's demand.

3.4 Prototype

Prototyping is one of the important parts of a product design process. It is built to understand the requirements before coding or design. It allows software developers to find out possible design alternatives, test performance and create scenarios for testing the product before starting the production of a new version. It is more suitable for products which have a lot of user interaction.
Some important features of the prototype model are as follows:

- End users are actively involved in the development. This provides the end user to get a better understanding of the requirements of the product being developed, allows ease of use and minimal training for the end user.
- By using Prototyping, errors and missing functionality can be detected much earlier and easier by quicker user feedback.
- Prototyping enables the developer to get a better understanding about the requirements of the products when the desired system needs to have a lot of interaction with the end users.

On the other hand, Prototype modeling is a slow process. Too much involvement of the client, which is not always preferred by the developer can cause too many changes which can result in a negative effect on the rhythm of the development team.

In this thesis, by using the prototype model, required data, platform and functionality of the GIS tool are determined delicately. I could take quick feedback from Dr. Eckberg about the user interface and the functionality of the GIS tool. Missing functionality and errors could be detected earlier.
CHAPTER 4

MAP OBJECTS TOOLBAR

The goal of this chapter is to introduce some standard tools used in GIS interfaces. Some of these tools are well known to all PC users such as zoom in, zoom out, pan, etc. and there is a simple way to add these to a MOJO application. This chapter explores some of the more popular tools on these tool bars.

Two main pre-built tool bars are implemented in this GIS Tool as follows:

- Zoom-Pan toolbar
- Selection toolbar

4.1 ZOOM-PAN TOOLBAR

The Zoom-Pan toolbar shown in Figure 4.1 enables user to perform nine important tasks such as zoom in, zoom out, zoom to full extent, etc.

Figure 4.1. ZoomPan toolbar.

These are the most important tools of Zoom-Pan toolbar:

- **Zoom To Full Extent:** Scrolls to the original display of the map.
- **Previous Extend:** Scrolls to previous display of the map has been saved on a stack.
- **Next Extend:** Scrolls to previous display of the map has been saved on a stack.
- **Zoom To Active Layer:** Scrolls the map to all selected features in the selected layer.
- **Pan In One Direction:** Drags the map in one direction (North, South, East, West)
- **Identify:** Identifies the selected feature of the selected layer and shows related information in an attribute table.

4.2 SELECTION TOOLBAR

Selection toolbar shown in Figure 4.2 is another pre-built tool bar that provides certain tools for the user.
By using these tools, user can perform a specific function on the selected layer which improves the GIS tool utility. Possible uses are creation of new layers and shape files, and highlighting of attributes of selected features (goal of another thesis).

These are the tools provided by Selection toolbar:

- **Find**: Opens a dialog window to initiate dialog for finding something in the layer. The dialog window can be provided by a single value. As a result of the process, selected map feature is shown in a yellow color.
- **Search**: Opens a dialog window for locating features based on a predefined "stored query".
- **Select Feature**: By using this tool, user can click features on the map and turn them yellow. It has options such as Rectangle, Circle, Line, Polygon.
- **Attributes**: Provides database facts about selected feature of the selected layer and displays them in an attribute table.
- **Buffer**: Opens a dialog window to construct a buffer polygon around currently selected features.
- **Query Builder**: Opens dialog window to help the user in describing a database SQL style query which can be used to choose certain feature from the map.
- **Clear All Selection**: Clears all the selected attributes on the map.
CHAPTER 5

CUSTOM TOOLBAR

This chapter focuses on a custom toolbar shown in Figure 5.1 that has been created using the Java swing and awt API's with MOJO methods to add additional functionalities for a user to provide a more powerful GIS tool.

Figure 5.1. Custom toolbar.

The major facilities provided by custom toolbar presented in Table 5.1 as follows:

Table 5.1. Custom Toolbar Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Tool Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Print Icon]</td>
<td>Print</td>
</tr>
<tr>
<td>![Add Layer Icon]</td>
<td>Add Layer</td>
</tr>
<tr>
<td>![Pointer Icon]</td>
<td>Pointer</td>
</tr>
<tr>
<td>![Distance Tool Icon]</td>
<td>Distance Tool</td>
</tr>
<tr>
<td>![XY Icon]</td>
<td>XY Tool</td>
</tr>
<tr>
<td>![Hotlink Icon]</td>
<td>Hotlink</td>
</tr>
</tbody>
</table>

5.1 PRINT

The print tool is attached easily by using a MOJO class named MOJOcom.esri.mo2.ui.bean.Print. When the user clicks on this tool, the screen in Figure 5.2 will appear.
5.2 **ADD LAYER**

Adding a layer is one of the major features of a dynamic interactive map. This tool allows the user to add a new layer to the table of contents (TOC). The Add layer tool is added to this GIS tool by using com.esri.mo2.ui.tb.LayerToolBar which is a class of MOJO. When user clicks on the tool, the dialog window in Figure 5.3 will be open which allows the user to select either shapefile, image files, ARC IMS and ARC SDE to add a new layer to the TOC.

5.3 **POINTER**

When the user clicks on some tool such as zoom in, the ability related with the tool is tied to mouse behavior. By using this tool, the user can remove the special behavior of the last tool selected and returns the cursor to its normal arrow icon. This tool is added to GIS tool using the MOJO class which is com.esri.mo2.ui.bean.Tool.

5.4 **DISTANCE TOOL**

By using this tool, the user can measure the distance between any two point on the maps in miles and kilometers. The distance is displayed at the bottom of the map in the status bar.

![Print screen.](image-url)
5.5 XY TOOL

XY tool is used to create a layer dynamically from a CSV file with the latitudes and longitudes of the location to be displayed. When the user clicks on this tool a pop up window will show up allowing the user to choose the file.

5.6 HOTLINK

Hotlink tool gives the user the ability to get the brief and the detail information about the selected point of the selected layer. In this project, the detail information is provided by the web files. For this GIS tool, Hotlink tool is established by using lightning bolt icon for both the tool and cursor value. Hotlink tool works with the active layer of the map. In order to use this tool, the user should select a layer from the TOC and then click the Hotlink tool. After these steps, the user can click on any point of the selected layer to get more information about that feature.
CHAPTER 6

SCREEN SHOTS

This chapter introduces the features of the GIS tool giving screenshots for different features of the tool. Each of these features will be demonstrated comprehensively.

1. Running the Turkey from Crusades to Ottoman Empire GIS Tool
   a. Click on the Ottoman_Empire.jar file.
   b. Turkey from Crusades to Ottoman Empire GIS Tool GUI will be shown in Figure 6.1.

2. Adding a Layer
   a. Click on the plus sign from the custom toolbar, or “Add Layer” from the file menu. It will open a pop up window.
   b. Navigate to the location of file to be added.
   c. Select the shape file (.shp file).
   d. Click Open (Figure 6.2).

3. Removing a Layer
   a. Select the layer from TOC.
   b. Click on the “Remove Layer” from the file menu
   c. Selected Layer would be deleted from the existing map (Figure 6.3).

4. Adding data file to display new locations on the map by using CSV file.
   a. Click on the XY tool. The pop up window will show up.
   b. Choose the CSV file which has the latitudes and longitudes of the location to be displayed (Figure 6.4).
   c. Data points would be shown immediately on the map (Figure 6.5).

5. Finding out the distance between any two points on the map.
   a. Click on Distance Toll.
   b. Press the mouse button down at one map point, then drag the mouse to second map point, release the mouse button.
   c. The distance between two points would be displayed at the bottom of the map in the status bar (Figure 6.6).
Figure 6.1. Showing the starting page on launch.

Figure 6.2. Add layer dialog window.
Figure 6.3. Remove layer from map.

Figure 6.4. Adding data to map.
Figure 6.5. CSV file is added.

Figure 6.6. Remove layer from map.
6. Hotlinks
   a. Selects the layer from TOC.
   b. Click on the hotlink icon and then clicks on the any point on the map.
   c. It will open dialog window which displays the brief information in form of text, and gives user the option to get more information in forms of web page (Figure 6.7).
   d. On clicking on the “More Information button”, the webpage will look like Figure 6.8.
   e. The user can click on the Wikipedia links on the webpage for more detailed information.

7. Legend Editor
   a. Select the layer, Click on the File and then Legend Editor
   b. This will show pop up window allowing user to change style and color of selected layer (Figure 6.9). Figure 6.10 shows the map after editing with legend editor.

8. Hotlinks
   a. Selects the layer from TOC.
   b. Click on the hotlink icon and then clicks on the any point on the map.
   c. It will open dialog window which displays the brief information in form of text, and gives user the option to get more information in forms of web page (Figure 6.7).
   d. On clicking on the “More Information button”, the webpage will look like Figure 6.8.
   e. The user can click on the Wikipedia links on the webpage for more detailed information.

9. Legend Editor
   a. Select the layer, Click on the File and then Legend Editor
   b. This will show pop up window allowing user to change style and color of selected layer (Figure 6.9). Figure 6.10 shows the map after editing with legend editor.

10. Zoom To Active Layer Tool
    a. Click on the zoom to active layer tool, it will zoom the map to all selected features in the selected layer (Figure 6.11).

11. Status Bar displays the current location of the cursor in terms of appropriate coordinates (Figure 6.12).
Figure 6.7. GIS tool with hotlink window.

Figure 6.8. Webpage after clicking on “More Information Button.”
Figure 6.9. Editing with legend editor.

Figure 6.10. New appearance of the map after editing with legend editor.
12. Ottoman Family Tree [9]
   a. Click on Ottoman Family Tree button, it will show the relation between members of the Ottoman dynasty in forms of web page (Figure 6.13)

   a. The layers in the Toc are displayed in the chronological order (Figure 6.14).
Figure 6.12. Status bar.
Figure 6.13. Ottoman family tree.
Figure 6.14. Layers in chronological order.
CHAPTER 7

CONCLUSION AND OBSTACLES

This GIS tool was developed to provide information about Turkey from the Crusades until the end of the growth of the Ottoman Empire. Each Crusade, and the Ottoman Empire geographical boundary with respect to each Ottoman sultan are represented by a distinct layer. This tool represents most of the important events on the map by providing detailed data through web pages and external links.

The major obstacle was collection of data for the shape files. To create a shape file for each geographical boundary for each sultan of the Ottoman Empire, all the coordinates were carefully collected. Some shape file which have more than one polygon were created using ArcView, and the rest of the shape files were generated using a Polyline polygon plotting for tool map object with the help of Dr.Carl Eckberg [16].

Representing the information involved with the thesis topic was another obstacle. Because of the vastness of the topic, it required a lot of study about the history and geography of the Crusades and Ottoman Empire to concisely present the relevant information to the user.
CHAPTER 8

FUTURE ENHANCEMENTS

This GIS application provides information about Turkey from the Crusades until the end of the growth of the Ottoman Empire. The application can have lot of modification and upgrades to refine the learning process and aid in imparting knowledge. Few enhancements to increase the scope of the thesis are listed below:

- Timelines can be added to show more information about a particular period.
- This tool could be converted in the form of an application that can run on all major smart phones.
- This project can be made a web based application, so that it can be accessible to many people without downloading it. Dynamic maps on a website require some care.
- The application tool can be made to translated into many languages to provide access for users whose first language is not English. The family tree feature is already partly bilingual.
- Period of time covered could be extended.
REFERENCES


