WORLD'S DISPUTED TERRITORIES USING ARCGIS FOR ANDROID

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World's Disputed Territories Using ArcGIS for Android

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DEDICATION

I would like to dedicate this thesis to my parents, friends and family members, who always supported, encouraged me.

I also want to dedicate this thesis to my Professor Carl Eckberg for his continued support and encouragement.
ABSTRACT OF THE THESIS

World’s Disputed Territories Using ArcGIS for Android
by
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Geographic information systems (GIS) are used for creating maps with information about the map, that can be analyzed and managed. ArcGIS is a geographic information system that serves this purpose. GIS applications for android can be built using ArcGIS SDK for Android. Native GIS applications for android can be built. A wide range of GIS mapping capabilities like routing, geocoding, data visualization can be integrated online, and in some cases offline too. ArcGIS is a product of ESRI (Environmental Science and Research Institute) that aids in creating and developing location based mapping applications.

The aim of this project is to build an interactive ArcGIS tool using Android, which gives an outlook of the world’s disputed territories. This tool helps in achieving a better understanding of the world’s political standing and its territorial disputes. Major recognized territorial disputes are listed in the form of a drawer menu in Android, which when clicked displays the web map of that particular disputed area. Each mapped layout contains an info button which guides the user through the selection, with hyperlinks to webpages for further information.

The tool was developed in Android using ArcGIS libraries, sourced from ‘ArcGIS for developers’ website. Web maps in each layout were created from the ArcGIS developers web tool for creating and sharing web based maps. Each web map is sourced into the respective layouts using URLs (universal resource locators) and user permissions. The tool was built for educational purposes and hence its features are restricted in complexity, for easier understanding.
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CHAPTER 1

INTRODUCTION

A territorial dispute is a disagreement over the possession/control of land between two or more territorial entities or over the possession or control of land, usually between a new state and the occupying power [1]. This tool is designed to visualize the disputed territories of the world in the minimalistic way possible to get a better understanding for students who are interested in world politics and/or in Developing ArcGIS applications. The intent is to further extend this application so it can help geographers and political planners get a good understanding of the disputed territories. Environmental Science Research Institute (ESRI) has an outstanding presence in the field of Geographic Information Science (GIS) [2]. ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database [3]. ArcGIS is built around a geodatabase, which can use an object-relational database approach for storing spatial data. A geodatabase is a "container" for holding datasets, tying together the spatial features with attributes. The geodatabase can also contain topology information, and can model behavior of features, such as road intersections, with rules on how features relate to one another. ArcGIS web tool utilizes geodatabases those on the arcgis servers in the development of a web maps, which are used in this tool. This tool does not use a geodatabase, but might in a future revision.

MOTIVATION

There is no website or monograph that focuses on just the information of this android application, which is to say, current disputed over territory. Yet these disputes can pester, and escalate into truly major conflicts. It clearly important to understand these disputes and the
goal is to provide a single source that includes all such possible contentions, that could escalate into major conflicts.
CHAPTER 2

TECHNOLOGY

The emphasis of this chapter is on the technologies used in the implementation of this application. This tool was implemented in Android using the dependencies from ArcGIS SDK (Software Development Kit). Android was implemented in IDE (Integrated Development Environment) Android Studio. Android is a Mobile Operating System based on Java. In the following section we will discuss the technologies used in detail.

ANDROID

Android is a mobile operating system developed by Google, based on a Linux kernel. Android is architected in the form of a software stack comprising applications, an operating system, run-time environment, middleware, services and libraries. Positioned at the bottom of the Android software stack, the Linux Kernel provides a level of abstraction between the device hardware and the upper layers of the Android software stack. The Linux kernel provides a multitasking execution environment allowing multiple processes to execute concurrently. It would be easy to assume, therefore, that each Android application simply runs as a process directly on the Linux kernel. The Dalvik virtual machine was developed by Google and relies on the underlying Linux kernel for low-level functionality. It is more efficient than the standard Java VM in terms of memory usage, and specifically designed to allow multiple instances to run efficiently within the resource constraints of a mobile device. Figure 1 show the Android architecture.
Dalvik Virtual Machine is a type of JVM used in android devices to run apps and is optimized for low processing power and low memory environments. Unlike the JVM, the Dalvik Virtual Machine doesn’t run .class files, instead it runs .dex files. .dex files are built from .class file at the time of compilation and provides higher efficiency in low resource environments. The Dalvik VM allows multiple instance of Virtual machine to be created simultaneously providing security, isolation, memory management and threading support.

Coming to security in android, android applications run in a sandbox, an isolated area of the system that does not have access to the rest of the system's resources, unless access permissions are explicitly granted by the user when the application is installed.
**ArcGIS SDK for Android**

The computer map models, along with the tools for analyzing them, make up geographical information systems (GIS) [2]. Every possible map can be studied in GIS, with the right data – land, elevation, climate, political boundaries, population, energy, minerals, income and many other things. Esri (Environmental Systems Research Institute) is an international supplier of Geographic Information System (GIS) software, web GIS and geodatabase management applications. Esri uses the name ArcGIS to refer to its suite of GIS software products, which operate on desktop, server, and mobile platforms. ArcGIS also includes developer products and web services. More information on the following can be found in [5]. With the ArcGIS Runtime SDK for Android you can build apps that:

- Add high performance mapping and GIS capabilities to your Android apps
- Add and query content from your Organization (ArcGIS Online or Portal for ArcGIS) using the portal API
- Add layers from ArcGIS Server
- Work offline with basemaps and operational data
- Add local tile cache basemaps or maps in area of interest stored locally on device
- Display maps in all supported spatial references
- Use a rich set of tasks that leverage ArcGIS capabilities to analyze your maps and provide information to your users
- Add tools to let users edit data while out in the field, including allowing them to sync edits made offline when they back online
- Work with your devices' GPS
- Build offline and online routing applications
- Identify features in the map and view rich pop-ups authored in ArcGIS Online or add custom callouts
- Add graphics on top of the map; allow users to draw graphics or tap on them to view a pop-up window with information on the graphic
- Perform advanced geometric and spatial analysis operations locally
- Execute sophisticated geoprocessing tasks and display their results
- Search, query, and identify features using spatial or SQL criteria
- Match addresses to locations and vice-versa, even when you're offline
The ArcGIS Android SDK download contains everything you need to develop ArcGIS Android SDK apps. The folders in the SDK are described below:

- **doc**: API reference doc for arcgis android and arcgis android app toolkit APIs.
- **legal**: Licensing documentation
- **libs**: API jar libraries for arcgis-android and arcgis-android-app-toolkit, arcgis-android core native libraries, and third-party dependency jar libraries.
- **lib-project**: Local Android Library Project in AAR format.
- **res**: Localization files for localizing UI Popups.
- **resources**: Advanced symbology symbol resource files
- **samples**: Local sample projects in Android Gradle structure for importing into Android Studio.

**ANDROID STUDIO**

An Integrated Development Environment is programming environment typically consisting of a code editor, a compiler, a debugger, and a graphical user interface (GUI) builder. The important features, which an IDE provides, are:

- **Code editor**: Code editing capability which provides the feature of code refactoring. It corresponds to accessing the descriptions of the functions, their parameter list and it reduces the reference to the external documentation and hence speeds up the development time.
- **Debugger**: It helps in debugging the code by adding a watch to the variables in the code, which helps in monitoring the different values for the variables at different stages during the code execution.

Android Studio is the official integrated development environment (IDE) for the Android platform development. It also helps in putting breakpoints in between the code execution so that it becomes easier to find bugs using tools like JUnit and Versioning. It also contains a virtual machine which lets the user test applications on the desired Android OS version [4].

**DEVELOPMENT PLATFORM**

This part describes the various software applications used to develop this tool.

- **ArcGIS SDK for Android 10.2.7**.
- **Android OS version 5.0 (Lollipop) and Up**: It supports advanced features.
- Android Studio IDE platform is an IDE for writing, compiling, and running android programs.
- ArcGIS web toolkit: A web tool to develop web maps.

Table 1 shows the minimum hardware requirements.

<table>
<thead>
<tr>
<th></th>
<th>Windows</th>
<th>OS X</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS version</td>
<td>Microsoft Windows 10/8/7 (32- or 64-bit)</td>
<td>Mac OS X 10.8.5 or higher, up to 10.11.4 (El Capitan)</td>
</tr>
<tr>
<td>RAM</td>
<td>2 GB RAM minimum, 8 GB RAM recommended</td>
<td></td>
</tr>
<tr>
<td>Disk space</td>
<td>500 MB disk space for Android Studio, at least 1.5 GB for Android SDK, emulator system images, and caches</td>
<td></td>
</tr>
<tr>
<td>Java version</td>
<td>Java Development Kit (JDK) 8</td>
<td>Java Development Kit (JDK) 6</td>
</tr>
<tr>
<td>Screen resolution</td>
<td>1280x800 minimum screen resolution</td>
<td></td>
</tr>
</tbody>
</table>

Source: [5]

**GIS**

A geographic information system (GIS) is a computer system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data [2].

**Introduction to GIS**

Any system that refers to the information of a location on Earth’s surface can be considered as geographic information system (GIS) [2]. “A system for capturing, managing, analyzing, and displaying all forms of geographical information, spatially referencing earth.” – Department of the environment. It helps you answer questions and solve problems by looking at your data in a way that is quickly understood. In addition to localized operations, modern GIS systems are typically network enabled to cater to an increased demand for dynamic information, following the advent of the World Wide Web. Unfortunately, due to its complicated nature, there are only a few companies which develop GIS based system software, and ESRI is one of them GIS technology evolved through multiple parallel but separate applications across numerous disciplines. With cross platform GIS software, interoperable applications could also be created. After its beginning, GIS technology has proven to be indispensable for a wide range of applications, and among these are geology,
archaeology, urban planning, marketing, logistics, aviation, agriculture and geographic history. All of these fields require the use of GIS to a great extent. A rapidly expanding use can be described as “story telling using GIS”.

**How Does GIS Work**

GIS works by combining a database management system (DBMS) with a computer mapping system [2]. Thematic information which describes a feature is stored as a row of data in the database. This is called attribute data. Location of each feature is linked to the data in attribute of each row. This can also be called as spatial data. Information about the world is first of all stored by GIS as a collection of thematic layers, which are linked together by geography. GIS performs some tasks in order to complete its work. Firstly, it takes data in digital format, so basically GIS performs digitizing on the data as the data can be of maps or aerial photographs. After taking the data one often starts with map making, which is extremely important to GIS. The data will be continuous and scale free as it is GIS based cartography. After the map making step, it starts manipulating the data to be compatible with the system under use. After data manipulation, geographic information is stored in simple files for small projects, while data for large projects is stored in a large DBMS. After storing the data, the next step is querying it and analyzing the data. After this, visualization of the output is the last step for which GIS provides the provision to attach reports to maps.

**Advantages of GIS**

- GIS is the go-to technology for making better decisions about locations: where to place restaurants, highways and other landmarks.
- GIS based maps and visualizations greatly assist in understanding situations and storytelling.
- Many organizations have a primary responsibility of maintaining authoritative records about the status and change of geography. GIS provides a strong framework for managing these types of records with full transaction support and reporting tools.
- GIS is becoming essential to understanding what is happening and what will happen in geographic space.
- GIS is now found in most new automobiles and smart phones, starting with GPS.
CHAPTER 3

DISPUTED TERRITORIES

INTRODUCTION

Territorial disputes are a major cause of wars and terrorism as states often try to assert their sovereignty over a territory through invasion, and non-state entities try to influence the actions of politicians through terrorism [1]. International law does not support the use of force by one state to annex the territory of another state. The UN Charter says: "All Members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state, or in any other manner inconsistent with the Purposes of the United Nations."

BORDER DISPUTE

The term border dispute (or border conflict) applies to cases where a limited territory is disputed by two or more states, where each contending state publishes its own maps to include the same region which would invariably lie along or adjacent to the recognized borders of the competing states, such as the Abyei region which is contested between Sudan and South Sudan [6]. With border conflicts, the existence of the rival state is not being challenged (such as the relationship between the Republic of China and People's Republic of China, or the relationship between South Korea and North Korea), but each state will merely render the shape of the rival state as not containing the claimed territory - this in spite of who actually governs the land and how it is recognized in the international community [7].

OCCUPIED TERRITORIES

An occupied territory in general is a region distinct from the recognized territory of the sovereign state but which the occupying state controls, usually with military forces [1]. Sometimes, a long-term occupation is generally maintained as a means to act upon a territorial claim, but this is not a prerequisite as occupation may also be strategic such as
creating a buffer zone as a preventive move to prevent a rival power obtaining control or a means of coercion such as a punishment, to impose some internal measures or for use as a bargaining chip. For example Iraq once occupied Kuwait, and was in turn occupied by the USA. This application does not deal with ethnic groups continually striving for territory and self-governance, such as the Kurds. The focus is in territories disputed by two or more countries.
CHAPTER 4

WORLD’S DISPUTED TERRITORIES

The world is divided in countless ways, by seas, cultures, languages, religions and wealth [8]. But the most contentious divide is that of the political borders. They can be traced back to the early Egyptian Dynasties and have shaped the history that we know today. As a result of their long history, borders are ever changing and continually disputed. Some disputes end up being peaceably solved, some end in war, and some continue to this day. Some of the disputed territories are discussed below.

SOUTH CHINA SEA

The South China Sea is a marginal sea that is part of the Pacific Ocean, encompassing an area from the Singapore and Malacca Straits to the Strait of Taiwan. The area's importance largely results from one-third of the world's shipping sailing through its waters and that it is believed to hold huge oil and gas reserves beneath its seabed [3]. Several countries have made competing territorial claims over the South China Sea. Such disputes have been regarded as Asia's most potentially dangerous point of conflict. Both People's Republic of China (PRC) and the Republic of China (ROC, commonly known as Taiwan) claim almost the entire body as their own, demarcating their claims within what is known as the nine-dotted line, which claims overlap with virtually every other country in the region. Competing claims include:

- Indonesia, China, and Taiwan over waters NE of the Natuna Islands
- The Philippines, China, and Taiwan over Scarborough Shoal.
- Vietnam, China, and Taiwan over waters west of the Spratly Islands. Some or all of the islands themselves are also disputed between Vietnam, China, Taiwan, Brunei, Malaysia, and the Philippines.
- The Paracel Islands are disputed between the PRC/ROC and Vietnam.
- Malaysia, Cambodia, Thailand and Vietnam over areas in the Gulf of Thailand.
- Singapore and Malaysia along the Strait of Johore and the Strait of Singapore.
The Kashmir conflict is a territorial conflict between India, Pakistan, and to a limited degree, China. It started just after the partition of India [9]. India and Pakistan have fought three wars over Kashmir, including the Indo-Pakistani Wars of 1947 and 1965, as well as the Kargil War. Furthermore, the two countries have been involved in several skirmishes over control of the Siachen Glacier. India claims the entire state of Jammu and Kashmir, and, as of 2010, administers approximately 43% of the region. They control Jammu, the Kashmir Valley, Ladakh, and the Siachen Glacier. India's claims are contested by Pakistan, which administers approximately 37% of Kashmir, namely Azad Kashmir and the Northern Areas, or Gilgit-Baltistan. China currently occupies Demchok district, the Shaksgam Valley, and the Aksai Chin region. China's claim over these territories has been disputed by India since China took Aksai Chin during the Sino-Indian War of 1962 [9].

The root of conflict between the Kashmiri insurgents and the Indian Government is tied to a dispute over local autonomy [9]. Democratic development was limited in Kashmir until the late 1970s and by 1988 many of the democratic reforms provided by the Indian Government had been reversed. Non-violent channels for expressing discontent were thereafter limited and caused a dramatic increase in support for insurgents advocating violent secession from India. In 1987, a disputed state election created a catalyst for the insurgency when it resulted in some of the state's legislative assembly members forming armed insurgent groups [9]. In July 1988 a series of demonstrations, strikes and attacks on the Indian Government began the Kashmir Insurgency.
CHAPTER 5

SETUP DEVELOPER’S ENVIRONMENT

This chapter mainly focuses on setting up the developing environment using ArcGIS for android and Android Studio. This application is designed to make the installation easy and convenient for the end user.

ANDROID STUDIO AND THE ESRI ARCGIS MAVEN REPOSITORY

Maven

Maven is a build automation tool used primarily for Java projects. Maven addresses two aspects of building software: first, it describes how software is built, and second, it describes its dependencies [5]. Contrary to preceding tools like Apache Ant, it uses conventions for the build procedure, and only exceptions need to be written down. An XML file describes the software project being built, its dependencies on other external modules and components, the build order, directories, and required plug-ins. It comes with pre-defined targets for performing certain well-defined tasks such as compilation of code and its packaging. Maven dynamically downloads Java libraries and Maven plug-ins from one or more repositories such as the Maven 2 Central Repository, and stores them in a local cache [5]. This local cache of downloaded artifacts can also be updated with artifacts created by local projects.

Adding Maven Repository’s URL

Using the maven repository url, android studio downloads all the required arcgis files and keeps them local for execution of the application. Use the following code example to add the maven repository's URL and the ArcGIS Runtime SDK for Android dependency to your
project. Esri's repository is not open source, so you must specify a URL. Project root build.gradle file.

```groovy
repositories {
  jcenter()
  // Add the following ArcGIS repository
  maven {
    url 'https://esri.bintray.com/arcgis'
  }
}
```

### Adding Dependencies

Android Studio projects contain a top-level build file and a build file for each module. The build files are called build.gradle, and they are plain text files that use Groovy syntax to configure the build with the elements provided by the Android plugin for Gradle. In most cases, you only need to edit the build files at the module level. The app module build.gradle file, within the dependencies block, add a directive to include the ArcGIS Runtime SDK for Android dependency to your app.

```groovy
dependencies {
  // Add ArcGIS Runtime SDK for Android dependency
  compile 'com.esri.arcgis.android:arcgis-android:10.2.7'
}
```

### Adding Packaging Options

The app module build.gradle file, within the android block, uses the following code example to add a packaging options directive. This excludes duplicate files from the Android Package (APK) file created when you build your app, preventing build errors.

```groovy
packagingOptions {
  exclude 'META-INF/LGPL2.1'
  exclude 'META-INF/LICENSE'
  exclude 'META-INF/NOTICE'
}
```
Required Permissions for Features

Android is a permissions-separated operating system. Depending on what ArcGIS capabilities you use in your app, you may need to add permissions to your manifest, as follows. Be sure not to include permissions for capabilities not included in your app.

ArcGIS capabilities that require permissions:

Access to the Internet (most apps will require this)

Access to files on disk (some apps will require this)

Access to the device's GPS will require fine location permissions

Apps that use MapView will require using OpenGL 2.x.

The following code example (for the AndroidManifest.xml file) includes permissions for all capabilities. Note that OpenGL is included as a feature.

```xml
<uses-feature android:glEsVersion="0x00020000" android:required="true"/>
<uses-permission android:name="android.permission.INTERNET"/>
<uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE"/>
<uses-permission android:name="android.permission.ACCESS_FINE_LOCATION"/>
```
CHAPTER 6

THE APP

HOW TO USE THE APPLICATION

This chapter talks about the starting point of the application, which is the application’s main layout window. It is the main entry point to all the features implemented in this application. When it starts its execution, the web maps are loaded, and zoomed to be centered at San Diego State University. You will also see the Toolbar with a toggle to open the drawer layout which contains a list of disputed territories.

NOTE: To fully use the apps, web access is required since the maps are bulky and not stored on the Android phone.

Action Bar Drawer Toggle

The "Action Bar Drawer Toggle" in Figure 2 to the left of the title ‘Disputed territories’ can reveal the list of disputed territories in the order of continents. An ActionBarDrawerToggle is the region when pressed displays the drawer layout of the application where there are menu items. Functionality of a toggle is to switch between the layouts to provide easy access to main menus of the tool. The "Toolbars" section contains the title of the application. Sliding the drawer, in Figure 3, displays the menu items. The info “Floating Button”, when clicked, displays a dialog which gives information on the menu item selected.
Figure 2. Start layout when the application is launched.
Figure 3. Drawer Layout when the toggle is pressed.
Mapview Layout

Figure 4 shows the result of touching Cyprus (not shown) in the list in Figure 3.

This layout is the most important layout in the application. It loads the related web map when a menu item is selected. ESRI’s map view layout is where we define how a map is displayed. In this case the map is a web map stored in ArcGIS’s servers. It is loaded using its url attribute. The link to the web map is loaded by the url attribute in the map layout.
Floating Button

The "Floating Button", the icon containing ‘I’ in the lower right corner of Figure 4, will display a dialog which contains information about the selected menu item which in this case is a disputed territory. The dialog also contains external links where users can find more information. Figure 5 is the layout view with a dialog containing information after the floating button is clicked.

Figure 5. Dialog after clicking info floating button.
CHAPTER 7

FUTURE ENHANCEMENTS

This application is simple, yet good at visualizing disputed territories. This application tries to do a really good job in visualizing the disputed territories. However the dataset is restricted to territorial disputes between countries. It can be extended to territorial disputes between states in a country, or include historic disputes that led to significant conflicts.

Some enhancements that can be taken into interest are as follows:

- The application uses web maps with the world topographic map as the base map. A feature that can display different base maps like world rivers map, world oceans map etc., for clearer description and presentation of a disputed territory.

- Web maps are very slow to load. The maps can be localized using ArcGIS server for local maps. This can reduce the time in buffering and make the application faster.

- The feature of application switching (switching dynamically between maps) can be implemented in the further versions of ArcGIS SDK for Android which, current SDK does not support.
CHAPTER 8

SUMMARY AND CHALLENGES

In summary, this application helps geographers, political science students, historians and political planners to learn and visualize data on the world’s disputed territories. The challenge was to add layers, and graphics for the layer to the web map for subsequent download to a phone.

When a menu item is selected from the drawer layout, the application had a problem with switching the activity and displaying the map with graphics. Activity switching is not supported by the SDK version of ArcGIS for Android. This was not implemented in this version of application.

In future versions of this SDK we might be able to implement the activity switching which would make the coding less complicated and the app more dynamic.
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WORKS CONSULTED

