Introduction to Geographic Information Systems (GIS) and Mapping

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Me - Jeff Blossom

- M.A. degree in Geography from Denver University
- Geographic Information Specialist
- Cartographer

Work at the Harvard Center for Geographic Analysis, helping professors and students create maps and geographic analysis.
Center for Geographic Analysis (CGA)

• Founded in 2006

• A member organization of the Institute for Quantitative Social Science (IQSS)

• Serves the entire University – anyone with a HUID
Our mission

To support research and education that relies on geographic information.
What is GIS?

Geographic Information System (GIS) defined:

A collection of computer hardware and software designed for **capturing**, **storing**, **updating**, **manipulating**, **analyzing**, **displaying**, and **publishing** all forms of geographically referenced information.

- People performing different roles are required.
- Common methodologies are applied within a GIS.
Geographic Coordinate System – a common reference used to map things on Earth.

- Use lines of longitude and latitude.

42.3744,-71.1166 is the latitude, longitude location of Harvard Yard

- Any location on Earth can be represented by the intersection of a longitude, latitude line.
**Geographic Coordinate System – a common reference used to map things on Earth.**

- Longitude – values in **red**, range from 180 to -180
- Latitude – values in **black**, ranging from 90 to -90

**There are also other coordinate systems that use units of **meters** or **feet** instead of longitude and latitude.**
Demonstration:

• Finding latitude, longitude with google maps.
• Mapping information with batchgeo.com
Geographic Information Systems (GIS)

Geographic feature representation: *points, lines, polygons*

Points – U.S. City centers

Lines – U.S. Interstates

Polygons – U.S. States

Polygons – Building footprints. Raster – Aerial image
Geographic Information Systems (GIS)

Information about the geographic features – stored in tabular form

- **Points** – U.S. Cities
  - Honolulu, HI
  - Juneau, AK
  - Boise City, ID
  - Olympia, WA
  - Salem, OR
  - Carson, NV
  - Sacramento, CA
  - Phoenix, AZ
  - Salt Lake City, UT
  - Cheyenne, WY
  - Denver, CO

- **Lines** – U.S. Interstates
  - Data for various interstates with columns for HWY_TYPE, NAME, SPEED_MPH, ZIP_L, ZIP_R, and STATE.

- **Polygons** – U.S. States
  - Data for various states with columns for STATE_NAME, SQMI, and POP2000.
Geographic Information System (GIS)

- Hardware
- Software
- Data
- Methodology
- People
- Management

A common set of tools and procedures

A well managed system of information
What is GIS? (Geographic Information Systems)

A pan-able and zoom-able map – so that little girl can see places above Argentina and Chile.
An **intelligent** map to answer your questions:

*How to get from place A to place B (network routing)?*
An **intelligent** map to answer your questions:

*What exist at the same location (overlay)?*
An **intelligent** map to answer your questions: 
*Where are the **hot spots**?*
A spinning globe with elevated terrain – so to give you a realistic view of places on earth.

... and more
Why Maps?

Maps are a form of communication that show:

Geographic context

Maps showing the locations of Nevada and Kansas.
Maps are a form of communication that show:

Similarities and differences between places

Population Density (Blockgroup)

Union Square does not seem to be distinct from its neighbors in terms of population density when examined at the blockgroup level of aggregation. This map does reveal, however, an interesting area of higher population density a short distance to the south, just south of the Cambridge boundary, along Cambridge Street. Although these people live a short distance to Union Square, their walking distance is much greater owing to the railroad tracks.
Maps help us reconstruct history, or plan for the future.

1830

Railroads in the United States
Why Maps?
Maps help us conceptualize, reconstruct history, illustrate the present, or plan for the future.
## GIS requires the use of software

<table>
<thead>
<tr>
<th>Desktop Geographic Information software</th>
<th>Geo-Visualization</th>
<th>Remote sensing</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArcGIS</td>
<td>Microsoft Virtual Earth (free)</td>
<td>ERDAS Imagine</td>
</tr>
<tr>
<td>QuantumGIS <em>(free, Mac)</em></td>
<td>ArcGIS Explorer (free)</td>
<td>IDRISI</td>
</tr>
<tr>
<td>MapInfo</td>
<td>Google Earth (free)</td>
<td>MultiSpec (free)</td>
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<tr>
<td>Intergraph</td>
<td>Free online mapping services</td>
<td>Graphic editing</td>
</tr>
<tr>
<td>GE Smallworld</td>
<td>Google Maps</td>
<td>Illustrator</td>
</tr>
<tr>
<td>AutoCAD</td>
<td>Yahoo! Maps</td>
<td>Photoshop</td>
</tr>
<tr>
<td>Bentley Systems</td>
<td>Microsoft Maps</td>
<td>Gimp (free)</td>
</tr>
<tr>
<td>Carlson</td>
<td>Mapquest</td>
<td>Office software</td>
</tr>
<tr>
<td>Maptitude</td>
<td>Batchgeocode.com</td>
<td>(for text and data editing)</td>
</tr>
<tr>
<td>Geoda</td>
<td>Social Explorer</td>
<td>MS Office</td>
</tr>
<tr>
<td>Global Mapper</td>
<td>GPSVisualizer</td>
<td>Open Office</td>
</tr>
<tr>
<td>uDig <em>(free, runs on Mac)</em></td>
<td>Many more....</td>
<td>Textpad</td>
</tr>
<tr>
<td>OpenMap <em>(free)</em></td>
<td></td>
<td>Wordpad</td>
</tr>
<tr>
<td>MapWindow <em>(free)</em></td>
<td></td>
<td>ConText <em>(free)</em></td>
</tr>
</tbody>
</table>
ArcGIS – Desktop software for Windows. The most robust GIS software available.
GIS on the web today

- ESRI
- Mango
- MapStory
- WorldMap
- CARTODB
- Leaflet
- geocommons
- Fusion Tables
- GIS
- hyperCities
GIS software demo – ArcMap
Doing GIS requires datasets in GIS format. One nice source to get global geographic data from: http://www.diva-gis.org/gdata
GIS data sources

http://gis.harvard.edu/resources/data
Transportation, demographic, crime, economic, elevation, weather, air quality, geology, soils....

http://hgl.harvard.edu – Harvard Geospatial Library
GIS data sources

Historic maps can also be data sources
GIS project samples
The greatest human migration began 70,000 years ago in Africa. With a mere eye-blink in evolutionary time, our ancestors had reached the last continental corner of the Earth—Tierra del Fuego, at the freezing tip of South America. It was a journey of about 22,000 miles.

Theories about our species’ routing out of Africa abound. Many scientists favor a route following the newly exposed seabeds near the Bab el-Mandeb Strait between Africa and Arabia. From there our ancestors spread into the Levant, Europe and Asia before finally reaching land’s end in the Americas.

The reasons for this explosive diaspora of humans are complex—and the topic of much debate. Many scientists point to a drop in sea levels, creating land bridges for early wanderers to trudge across. This map uses sea floor elevation data to depict this drop in sea level.
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A WALK THROUGH TIME

Roughly 200,000 years ago humans migrated from the East Africa Rift area - "Start" on the map below - into different parts of Africa.

At around 60,000 years ago humans migrated out of Africa to the rest of the world, making it to the tip of South America about 10,000 years ago.

Paul Salopek will literally walk through these "time bands" of human settlement.

For this map the Fuller projection was used to "straighten" this near circum-global route to better emphasize the sheer length of the 21,000 mile walk.

Numbers on the map represent thousands of years before present.

Time bands were produced using interpolation from fossil sites with cartographic smoothing applied. Many theories exist regarding precise dates of human migration. Direction is not true on this map.

MAP BY JEFF BLOSSOM, CENTER FOR GEOGRAPHIC ANALYSIS, HARVARD UNIVERSITY. SOURCES: NGM.COM, FSB, DATA AND MAPS.
The Global Positioning System Constellation

- GPS is a global navigation satellite system developed by the U.S. Department of Defense, managed by the U.S. Air Force. Free for anyone to use.
- Provides geographic locations at any time, anywhere.
- 24 - 32 earth orbiting satellites
A GPS satellite

Contains solar panels for power, an atomic clock, and a radio transmitter that continuously broadcasts the time and the satellite’s position.
A GPS mapping receiver
Walking Jeddah

Date: May 21 - 24, 2013
Total distance: 63 miles (101 km)
Total days: 3
Elevation gain: 0 ft
Maximum daily temperatures: 100° - 102° F (38° - 39° C)

Disembarking at this ancient port city in Saudi Arabia, Paul sets off on foot for Jeddah's northern edge, trekking more than 60 miles through a teeming metropolis where the sidewalks are rendered inert by an addiction to the internal combustion engine — and aversion to summer heat. As he walks the vacant streets, Paul documents his urban journey in typical Out of Eden Walk fashion: with words, photographs and video. We invite you to tag along.

Share this: Twitter · Facebook · Google+
Latitude, longitude coordinates from Paul Salopek’s GPS:

<table>
<thead>
<tr>
<th>Lat</th>
<th>Long</th>
<th>Elev</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
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<td>52.23512</td>
<td>262.58</td>
<td>2016-05-20T03:46:54Z</td>
</tr>
</tbody>
</table>
Paul’s route on a web map
Walking Jeddah

MAY 21–24, 2013 / JEDDAH, SAUDI ARABIA / TOTAL DISTANCE: 63 MILES (101 KM)

Paul treks more than 60 miles through a teeming metropolis where the sidewalks are rendered inert by an addiction to the internal combustion engine.

Turbulent Origins

Sacred to three of the world’s great religions, rich in petroleum and cockpit of ethnic and religious conflicts, the region known as the Levant lies at a crossroads. The area is home to ancient cities with monumental architecture, and today is a region of great change. It is a place where history, modernity, and conflict coexist.
Turbulent Origins

Between 1300 and 1000 BC, the Hittite and Egyptian empires fell in the Levant, and new arrivals (including Aramaeans and Phoenicians) moved in to take their place.
Turbulent Origins

19th-20th century A.D.
Jews fleeing racist pogroms in Russia and Eastern Europe and, later, genocide in Nazi-conquered Western Europe, migrate to their ancestral homeland in the British Mandate of Palestine, a territory carved from the ruins of the Ottoman empire after WWI.

Sacred to three of the world's great religions, rich in petroleum and cockpit of ethnic and religious struggle, Israel remains a political and social battleground.
1948 A.D.: The British withdraw. The first Arab-Israeli war ends with Israel’s independence. An estimated 750,000 Palestinian refugees are displaced by the fighting, planting the seeds of grievance and turmoil.
Turbulent Origins

2011 A.D.: A brutal civil war in authoritarian Syria, stoked by the Arab Spring uprisings, starts a massive exodus of refugees. At least 2 million people stampede across borders to take shelter in refugee camps in Turkey, Lebanon and Jordan.

Sacred to three of the world’s great religions, rich in petroleum and cockpit of ethnic and religious unrest, Syria is at the heart of the Middle East’s religious, ethnic, economic and political conflicts.
2014 A.D.: A jihadist invasion of Iraq sends some 500,000 hapless people scrambling for safety to the semi-autonomous Kurdish enclave in the north of that country. And so the heartbeat—and heartache—of human migration continues in the Levant.
Source: Photo from the *Roads of Arabia: Archaeology and History of the Kingdom of Saudi Arabia* exhibit in the Louvre by the Saudi Commission for Tourism & Antiquities
Pilgrimage Routes

Home to Islam’s two holiest cities — Mecca and Medina — the Hejaz has long been a fabled destination for travelers. Millions of Muslim pilgrims performing hajj, centuries of camel caravans loaded with incense and gold, early European explorers, and the enigmatic British soldier and scholar T.E. Lawrence (“Lawrence of Arabia”) — all have been drawn to the Hejaz, an austere and ancient crossroad of burning dunes, thriving ports and blue mountains in northwestern Saudi Arabia...

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• Thank you!
• Questions?