

Open Source, Scale and Reproducibility Using GIS: Discovering the World Beyond Point-and-Click and ArcGIS

Ömer Özak

Dept. Economics, SMU

Here's How I Do GIS

August 22, 2019

The Voyage of Homo-œconomicus into GIS

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Homo-œconomicus...or Economic Man

“the concept in many economic theories portraying humans as consistently rational and narrowly self-interested agents who usually pursue their subjectively-defined ends optimally.”

Plan for today

- 1 The Big Bang
- 2 The Dark Ages
- 3 The Age of Discovery
- 4 The Modern Era
- 5 The Future
- 6 Q&A

Why GIS?

The question that started it all

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- What is the effect of geographical isolation on economic development?
 - How to measure?
 - Measure for Pre-industrial era
 - Changes due to technology

Why a New Measure?

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- Common approach: Geodesic distances

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Country 1	Country 2	Distance	Country 1	Country 2	Distance
Costa Rica	Panama	514.3561	Germany	Poland	515.774
Phillipines	Brunei	1262.339	Yemen	Sudan	1254.947
Irak	Romania	2002.218	Ghana	Gambia	2002.745

Proposed Solution

Construct a measure that

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- Controls for

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Solution: The Voyage of Homo-œconomicus

Combine data on

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- Infantry movement

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- Human Mobility Index with Seafaring pre-1500CE (HMISea)

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- Human Mobility Index (HMI)
- Human Mobility Index with Seafaring pre-1500CE (HMISea)
- Human Mobility Index with Seafaring pre-steam engine
(HMIOcean)

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- Historical data on seafaring in Old World (pre-1500CE) (Casson, 1951, 1989)
- Historical data on seafaring (pre-steam engine) (García-Herrera, Können, Wheeler, Prieto, Jones, and Koek, 2005)

Optimal Paths

- With cost surface find minimum travel time between locations

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 - 200+ countries

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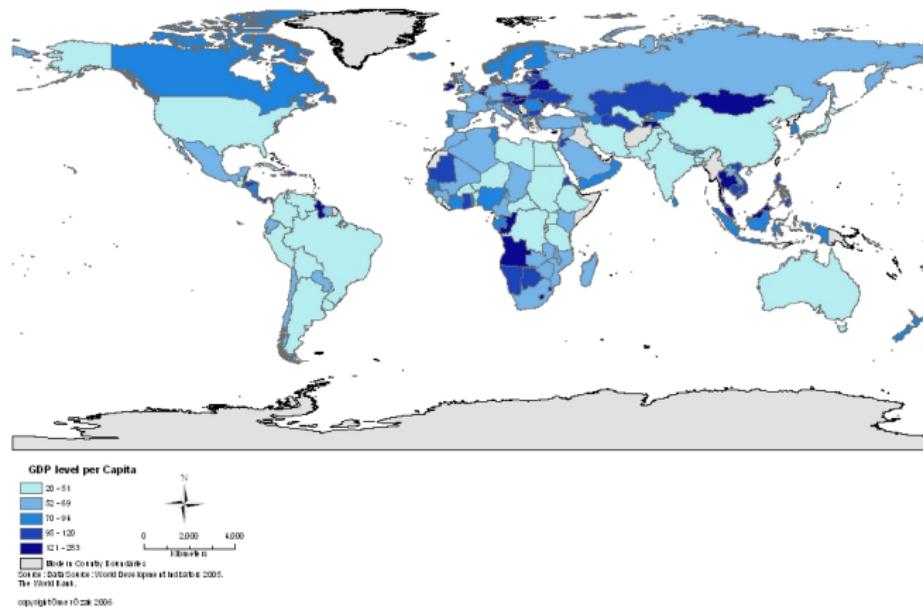
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 - Intro to ArcGIS (point-and-click)
 - Get data from TIGER or ArcGIS
 - Make maps using shapefiles in ArcGIS
 - Some spatial stats (compute Moran I & II)

Trade as share of GDP

Trade as Percentage of GDP in the World in year 2000



Homo-œconomicus meets GIS

Seems easy & straightforward... Thesis's gonna be ready in 2 weeks!

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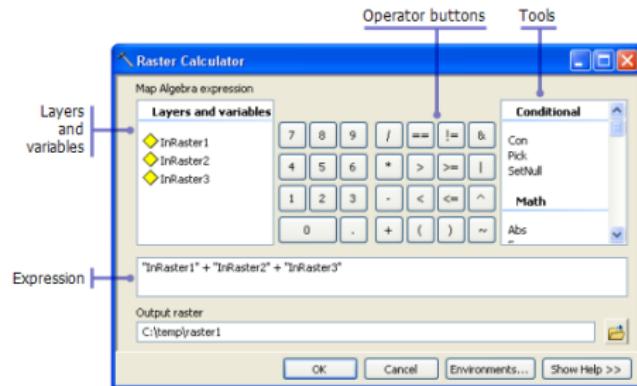
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- Shapefile \implies points, lines, polygons, etc.

Point-and-click and more in ArcGIS

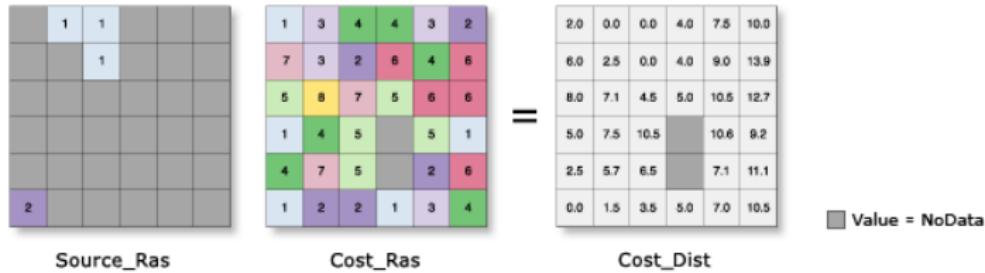
To solve my problem I need more tools...

- Raster Calculator



Point-and-click and more in ArcGIS

- Cost Distance Function



ArcGIS headache I

- Read manual and figured out how to do it...at least in theory...

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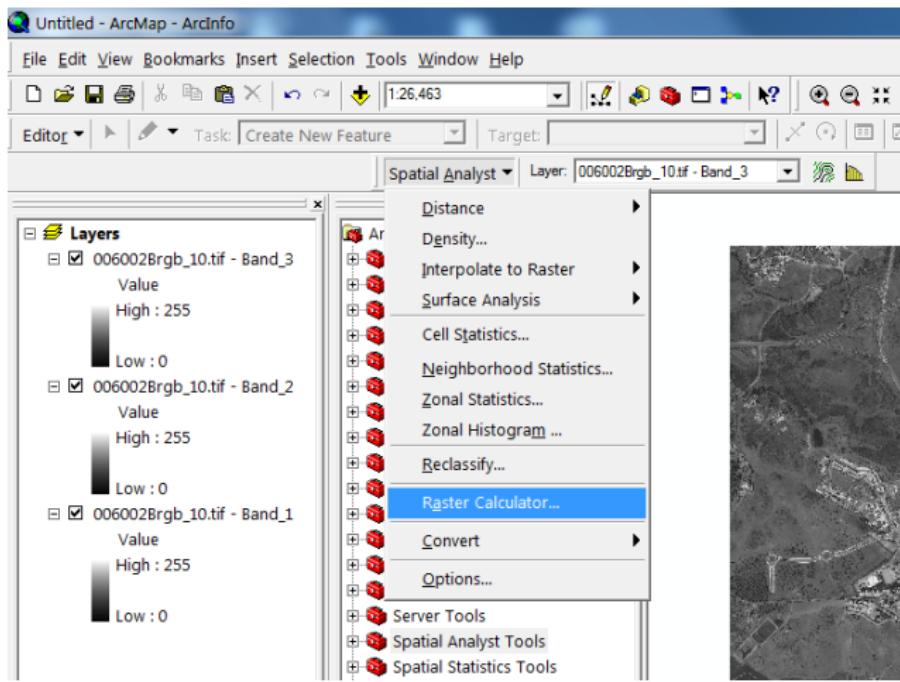
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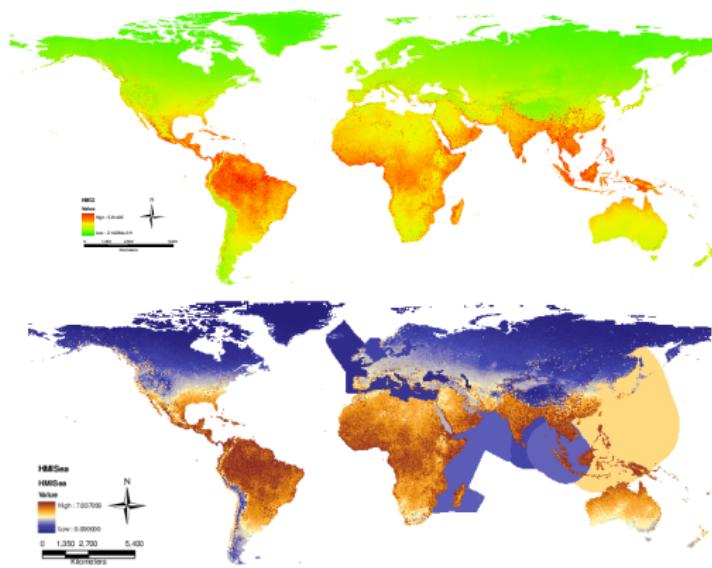
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 - Get access to 1 computer...

Produce Raster in ArcGIS

- Construct HMI data

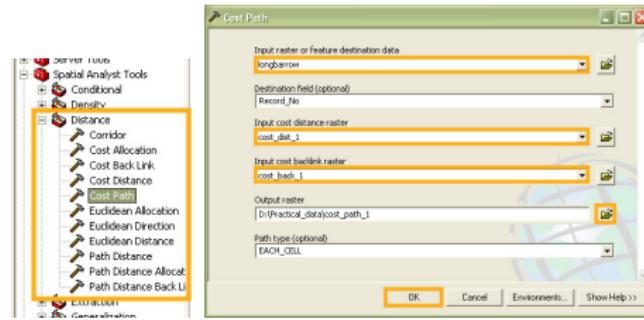


HMI & HMISea



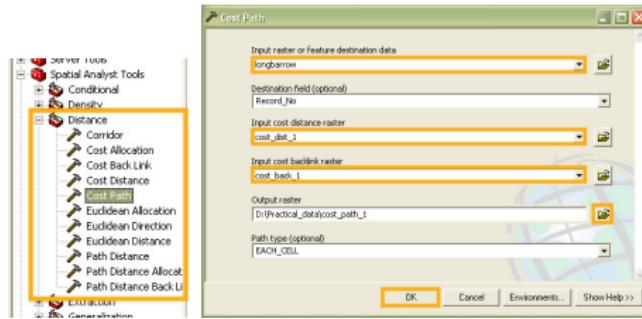
ArcGIS headache II

- Construct Optimal Routes and Times

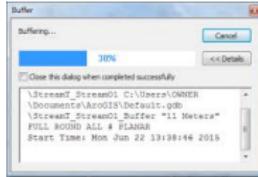


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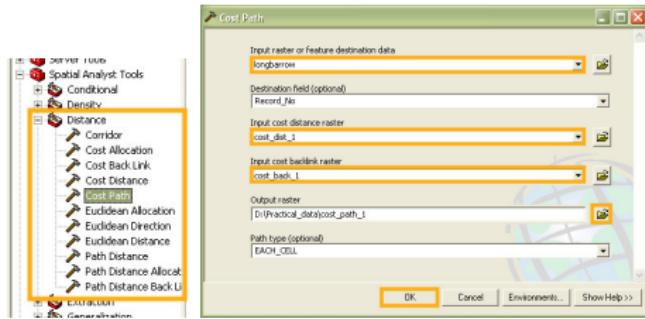


- Problem...it takes more than 1 day per source!

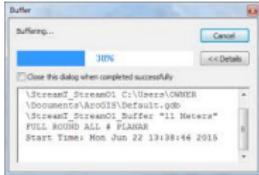


ArcGIS headache II

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- Problem...it takes more than 1 day per source!



⇒ > 1 year to compute data!!!

Solution...Parallelize!

- Find multiple computers and **repeat exact same** process for different sources



Solution...Parallelize!

- Find multiple computers and **repeat exact same** process for different sources

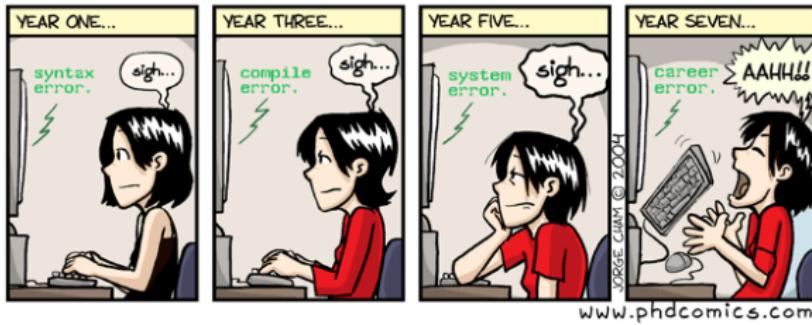


- Need scripting...still slow in ArcGIS!

OMG...Now what??!!



RESIGNATION: THE EVOLUTION OF THE SIGH



Main take aways

ArcGIS and point-and-click

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 - Not scripting friendly
 - Only Windows compatible

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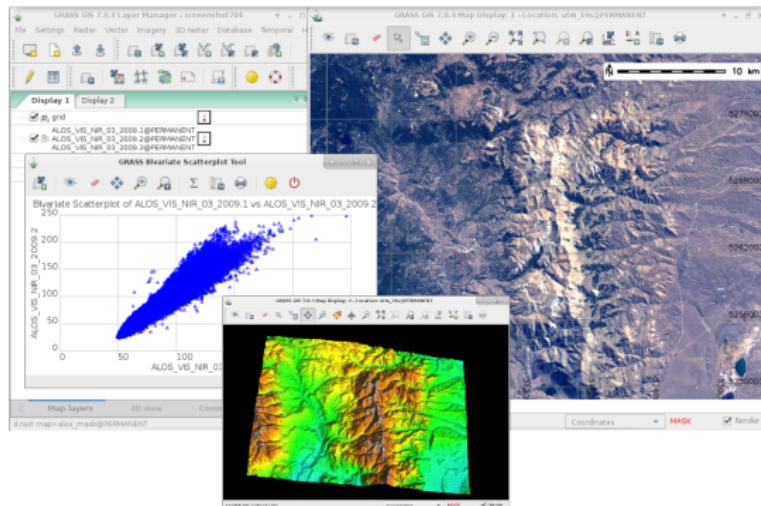
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- ⇒ Time to try something different

Can I overcome disadvantages?

Free Point-and-click solutions

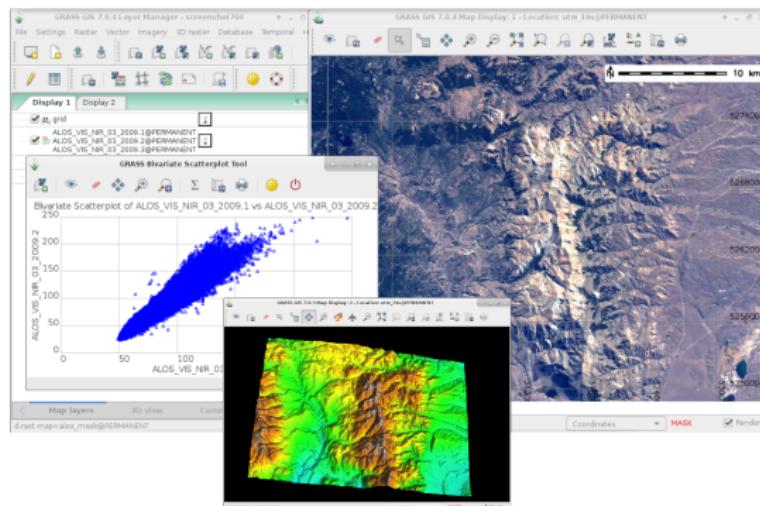
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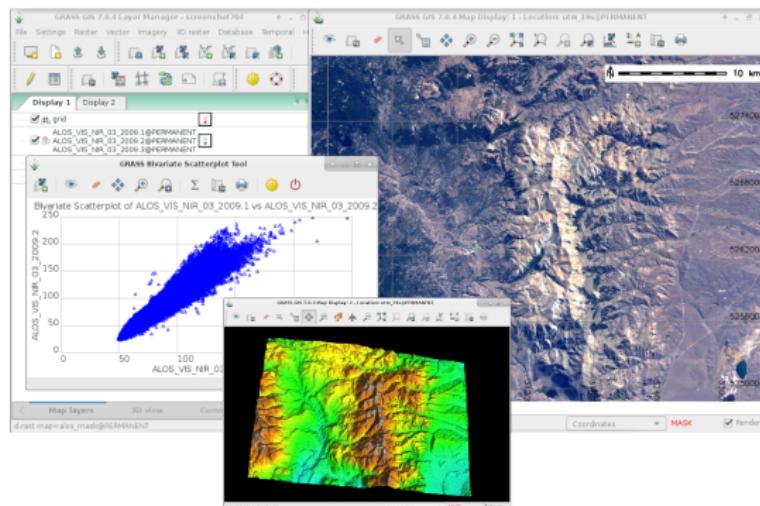


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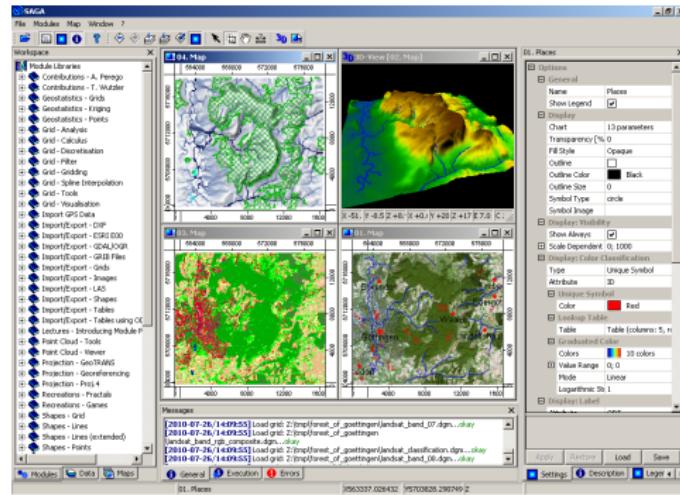
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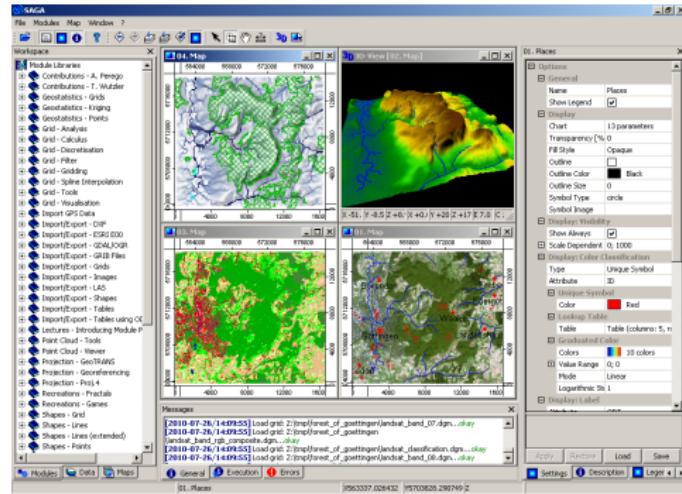
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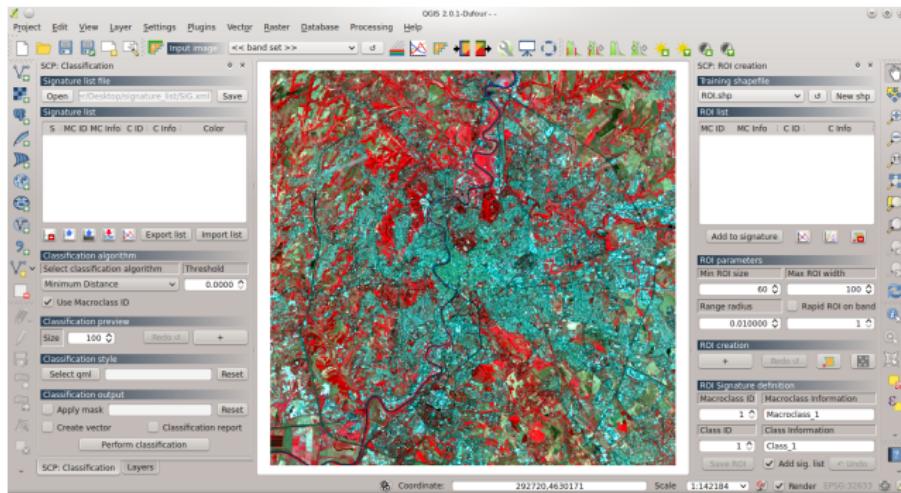
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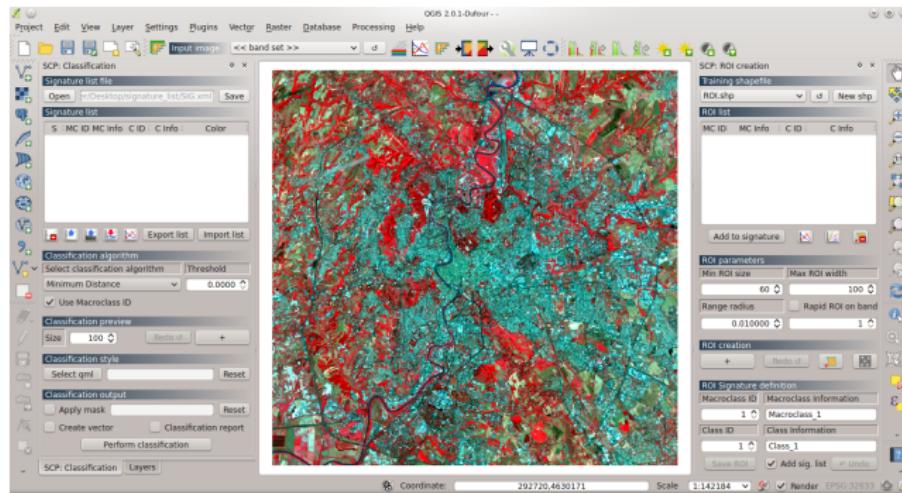
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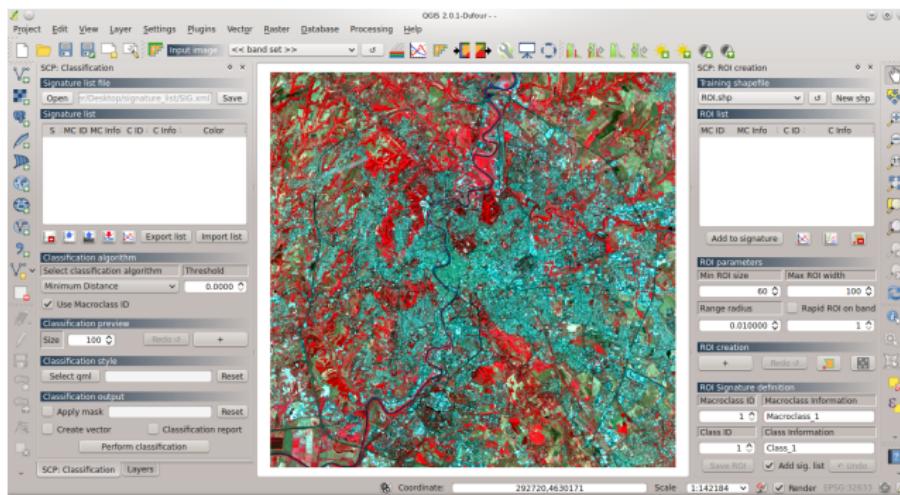
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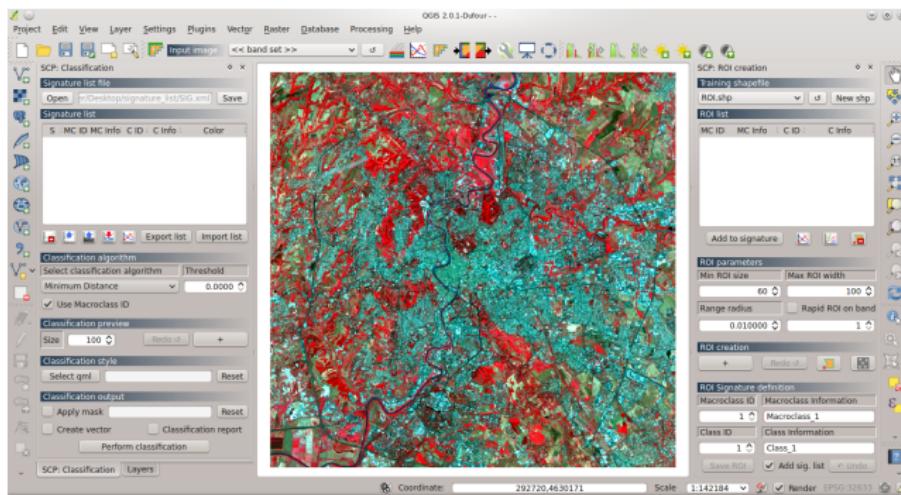
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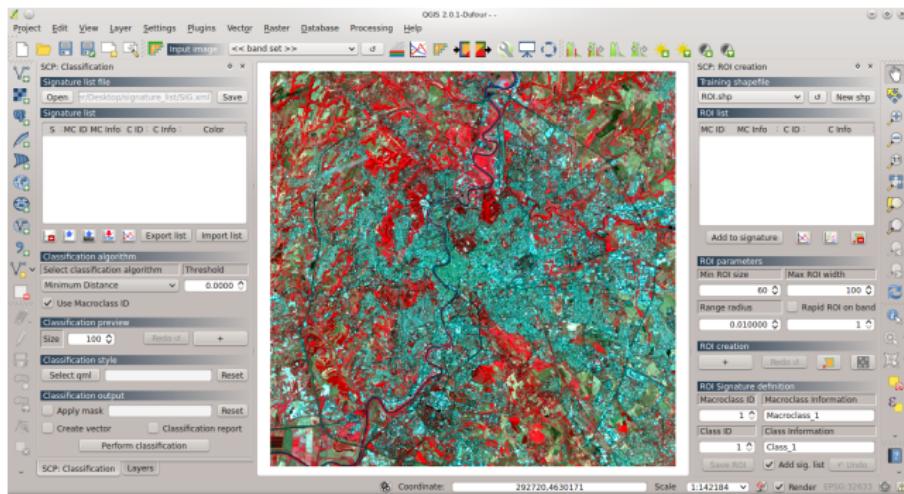
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- Ömer's Basic QGIS Tutorial

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 - Propose plug-ins, features, etc.

How I Learned to Stop Clicking and Love the Code

Finally started using





- General Purpose Programming Language



- General Purpose Programming Language
 - Open source



- General Purpose Programming Language
 - Open source
 - Easy to learn and code



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- Versatile
- Lots of packages to get things done
- Large community (Stackoverflow, Github, Bitbucket)
- Used in ArcGIS, QGIS, Google, Yahoo!, LANL, Netflix, National Weather Service, NASA, etc.

IP[y]: IPython

Interactive Computing

- Interactive Python

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 - GUI/Kernel for Python/Jupyter

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IP[y]: IPython

Interactive Computing

- Terminal/Command Line

```
Python 2.7.3 (default, Jul 10 2012, 18:48:25)
Type "copyright", "credits" or "license" for more information.

IPython 0.13.1 -- An enhanced Interactive Python.
?          --> Introduction and overview of IPython's features.
%quickref --> Quick reference.
help       --> Python's own help system.
object?   --> Details about 'object', use 'object??' for extra details.

In [1]: import numpy as np

In [2]: N = 3000

In [3]: a = np.random.rand(N,N)

In [4]: b = np.random.rand(N,N)

In [5]: np.dot
np.dot      np.double

In [5]: np.dot(a, b)
Out[5]:
array([[ 65.45670109,   64.96918252, -120.2955101 , ...,   46.52919413,
         1.62384273, -117.27453077],
       [ 103.8332094 , -63.19741333,  25.638050851, ...,   10.43730591,
        -98.22728902, -9.16795735],
       [-36.45095805,  44.32128353, -17.58969917, ..., -125.12907291,
        -70.58206964, -32.85757429],
       ...,
       [-42.46168724,  36.45522834,  28.8765628 , ...,   39.40943867,
        -16.43199427, -63.08194364],
       [-84.46717927,  28.06738804,  32.00026395, ...,  -42.127647 ,
        -116.20291034,  32.02266909],
       [ 56.79843374,  23.60837948,  52.24793136, ...,  -35.53881726,
        -21.19119431, -151.71414646]]))

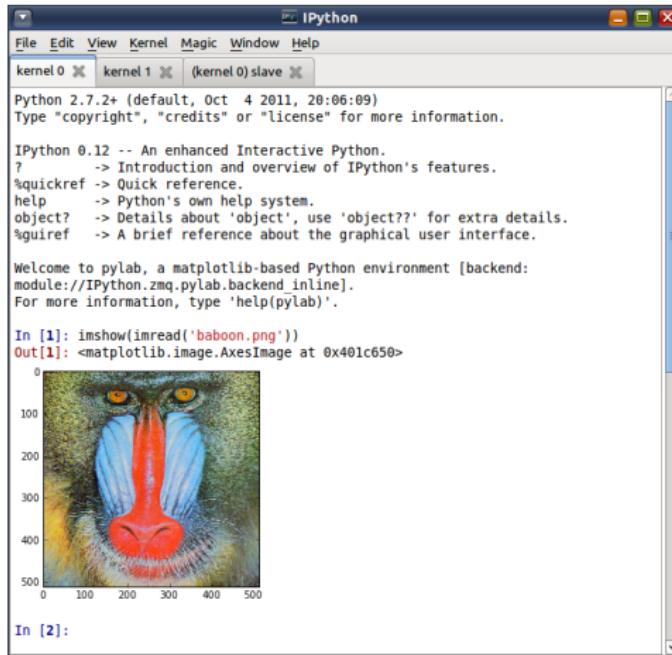
In [6]: %timeit np.dot(a,b)
1 loops, best of 3: 2.17 s per loop

In [7]: np.
Display all 551 possibilities? (y or n)
np.ALLOW_THREADS          np.convolve           np.iscomplex        np.ravel
np.BUFSIZE                 np.copy                np.iscomplexobj    np.ravel_multi_index
```

IP[y]: IPython

Interactive Computing

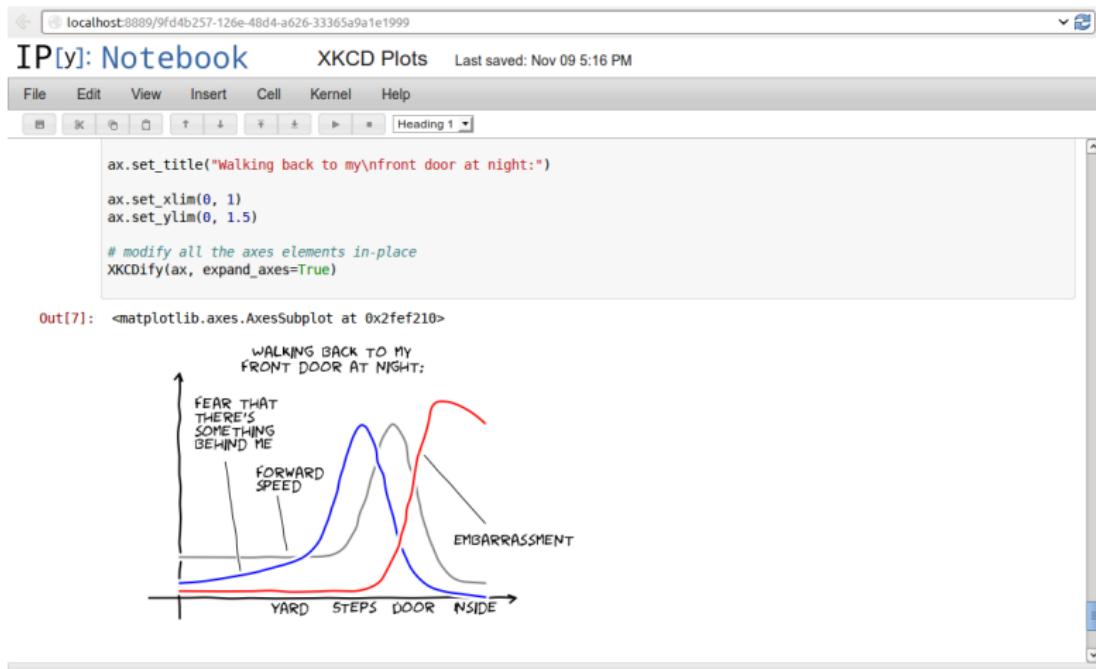
- QtConsole



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Interactive Computing

- Notebook (Web Application)





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- Share notebooks (Web, L^AT_EX)
- Use multiple language simultaneously (e.g. Python & R)

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⇒ Scary!

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 - Suggestions

My Main Workhorses

Main GIS Packages I use:

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- Write paper in L^AT_EX

Examples

- Ömer's intro to GIS with IPython

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- CSI

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- Google Location History

Example: Compute Zonal Stats I

Example: HMI Distances with MP I

Example: Extension of Original Project

New Project...similar to original one but using city data

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- Using 149 cores on server
- Less than 1 day for full results (data, networks, MST, etc.)

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The Voyage of Homo-œconomicus into GIS

Ömer Özak

Dept. Economics, SMU

Here's How I Do GIS

August 22, 2019