Concepts in Spatial Data Science

Acknowledge

- Dr. Elisabetta Pietrostefani &
- Dr. Carmen Cabrera-Arnau

A course in Geographic Data Science

SCTIMST, Trivandrum

- Sree Chitra Tirunal Institute for Medical Sciences & Technology, Trivandrum
- An Institution of National Importance established by the Act of the Indian Parliament (Act No.52, 1980)
- Dept. of Science & Technology
- Three major focus areas
  - Bio-Medical Technology Wing
  - Super specialty Hospital
  - Public Health (AMCHSS)
- Healthcare Technology development
- inter-disciplinary initiatives
- Running MPH program since 1997, PhD programs since 2003

Super Speciality Hospital

Bio-Medical Technology Wing

Achutha Menon Centre

Introduction

- Public Health - Science *vs.* Advocacy
- The need for participatory decision making in public health
- The transparency of open data science approach
- The beauty of computational reports, presentations, etc.

Work plan

Lectures

- Essential concepts
- Mainly to get the big picture
- Enthusing interest rather than teaching
- Welcome to the open data science initiative!

Lab work

- Do it yourself
- Get skilled in the process
- Come out of your comfort zones and collaborate!

- Use data for dialogue!

What information does GIS use?

- Data that defines geographical features like roads, rivers
- Soil types, land use, elevation
- Demographics, socioeconomic attributes
- Environmental, climate, air-quality
- Annotations that label features and places

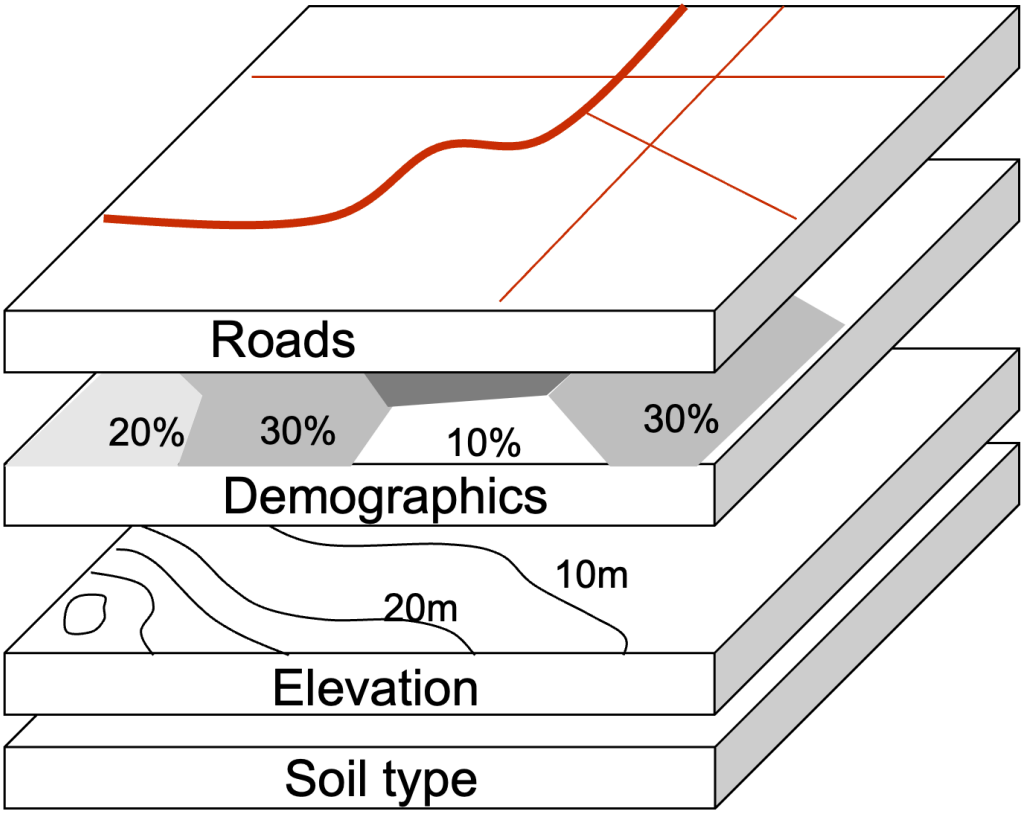
What is Spatial Data Science?

Spatial Data Science

- **Analyse** and **extract** insights from geospatial data
- Work with **real-world data** on a number of domains and problems
- Acquire key **data science skills** and important tools to answer spatial questions

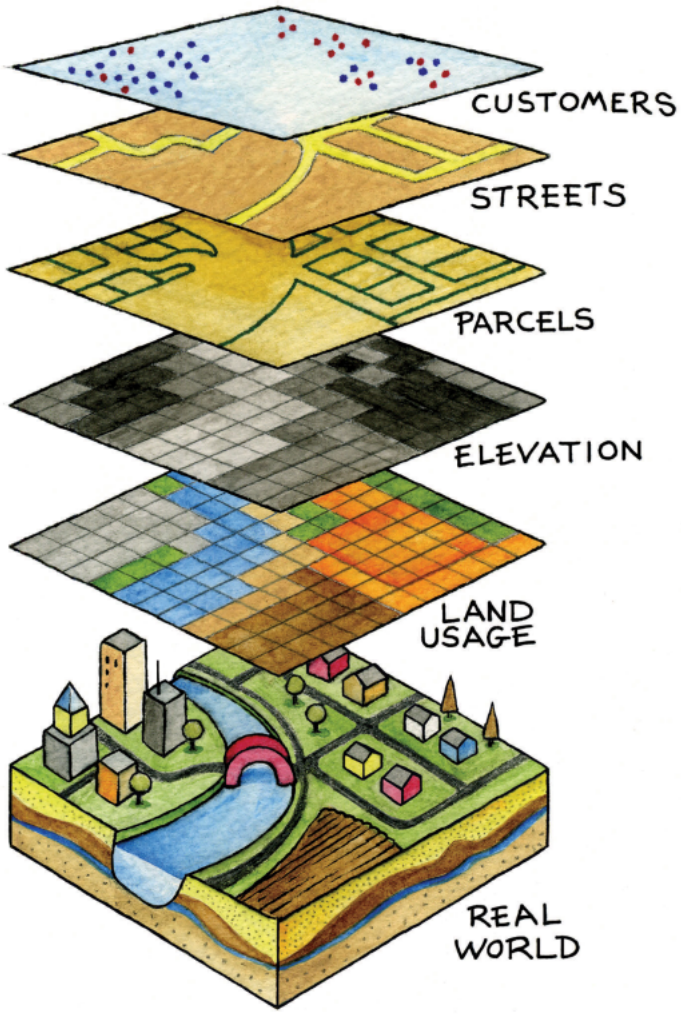
It is especially true in public health

GIS



Layers - Image - Data

GIS world vs. Real World



Skills for public health data science

Hard Skills - Programming Language - Transparency and Reproducibility - Version control

Soft Skills - Communication - Storytelling - Geospatial analytics acumen - Ethical skills

R software for Spatial Data Science (SDS)

Graphical User Interfaces (GUIs)

- QGIS and GRASS has revolutionized Open source Spatial Information Systems (GIS).
- However, the reproducibility aspect has many challenges

Command Line Interfaces (CLIs)

Command Line Interface (CLIs) of R software is a good way to bring in reproducible algorithms for GIS/SDS

The Spatial Data 'Revolution'

Advanced Hardware: High-performance computer hardware and efficient algorithms allow us to process vast data sets quickly.

Scalable Software: Scalable solutions with the R environment help us to sift through the data deluge, and extract valuable insights from the noise.

Spatial Databases: The advent of spatial databases empowers us to store and manipulate manageable subsets within the vast ocean of spatial data.

SDS in Public Health

- **Data Science**:"gathering data messaging it into a tractable form, making it tell its story and presenting that story to others"

Loukides (2011) What is Data Science?

Traditional datasets in healthcare

- Collected for the purpose (carefully designed)
- Detailed and informative ("rich profile and portraits of the country")
- High quality

Traditional health and allied sector data

- Massive enterprises (very costly)
- Coarse in resolution (to preserve privacy they need to be aggregated)
- Slow - the more detailed, the less frequent they are available

Examples

- Decennial census (census geographies)
- Longitudinal surveys
- Custom collected surveys, interviews etc.
- Economic or well-being indicators

New Forms of spatial data

Tied into the geo-data revolution

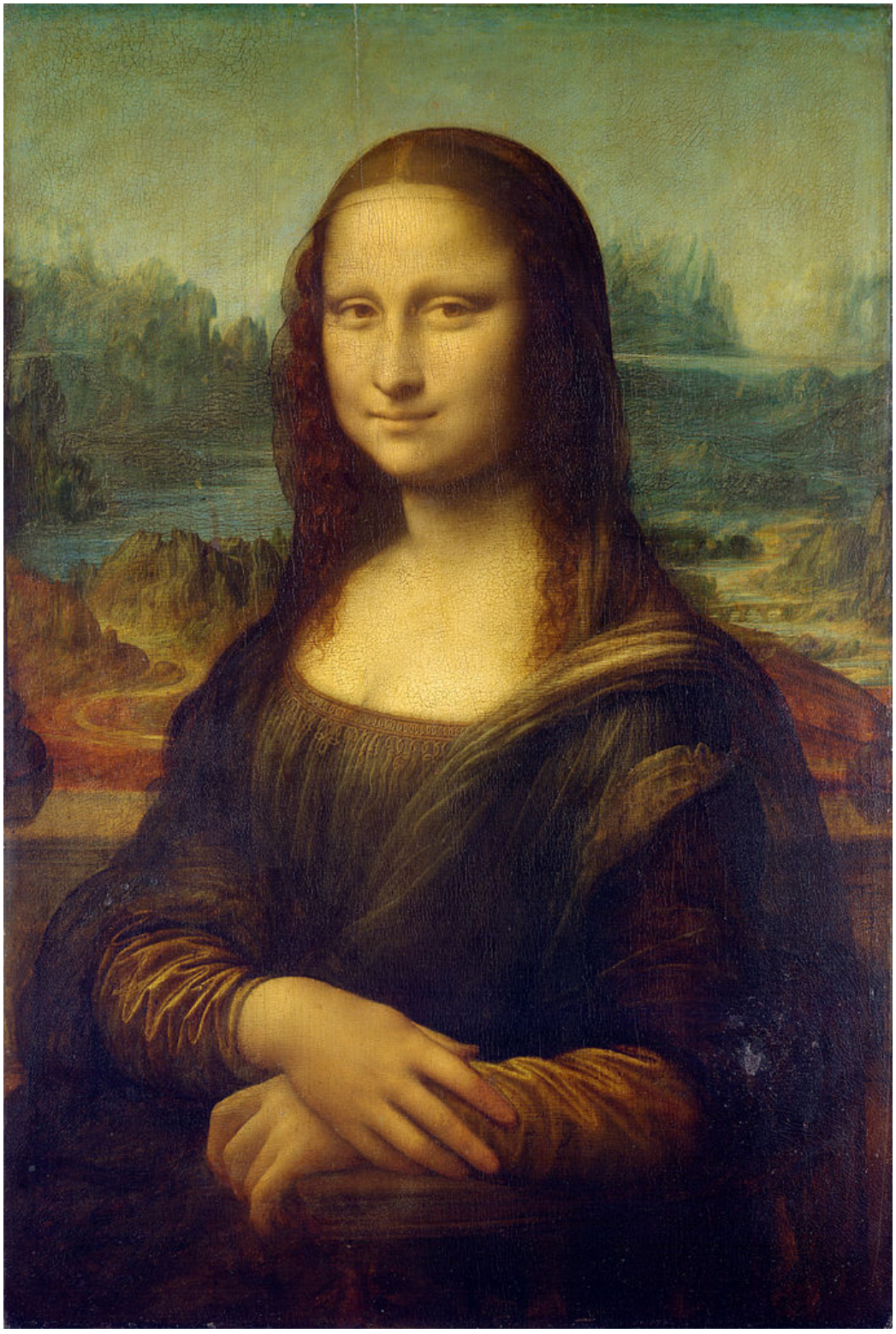
- Accidental : created for different purposes but available for analysis as a side effect
- Very diverse in nature: resolution and quality but, potentially much more detailed in both space and time

Challenges (Arribas-Bel, 2014)

- Bias
- Technical barriers
- Methodological "mismatch"

Part 2

(Geo)visualisation



By encoding information visually, they allow to present large amounts of numbers in a meaningful way.

A map for everyone

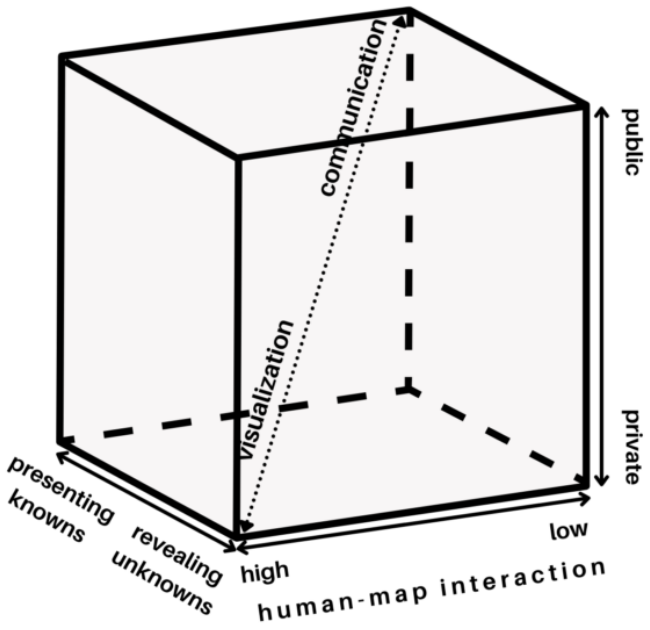
A real public health tool

Maps can fulfill several needs, looking very different depending on the end-goal.

MacEachren & Kraak (1997) identify three main dimensions:

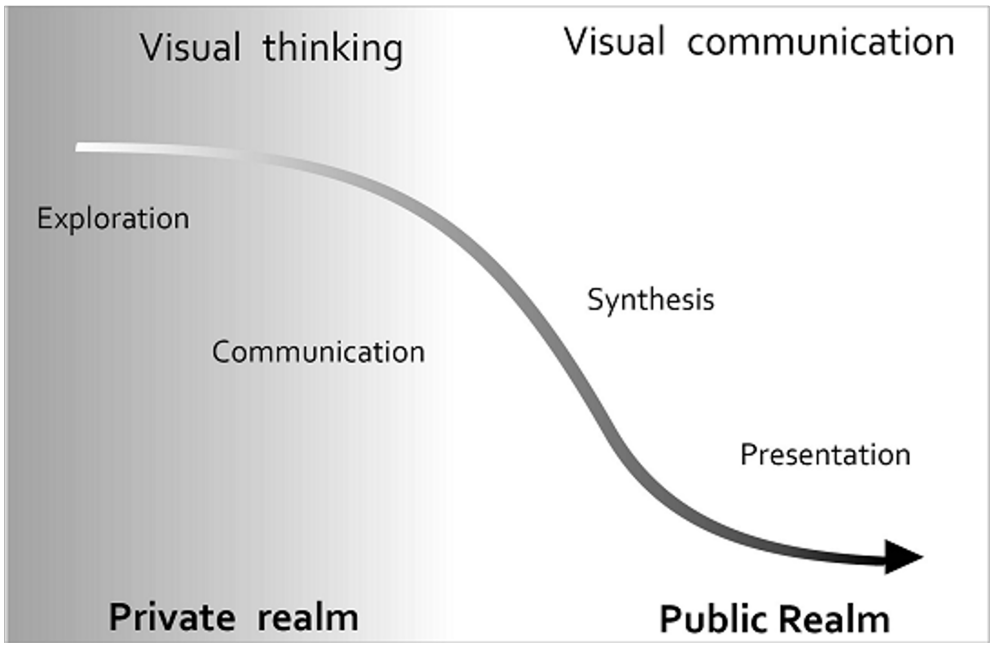
- Knowledge of what is being plotted
- Target audience
- Degree of interactivity

MacEachren & Kraak (1997)



DiBiase's (1990) "Swoopy"

Translating numbers into a (visual) language that the human brain "speaks better"



Exploratory Visualization

"forces us to notice what we never expected to see" (Tukey 1977: vi)

- Mostly for ourselves in the course of the research process.
- Many, quick and dirty, and rather unattractive graphs.

Explanatory Visualization

"forces readers to see the information the designer wanted to convey" (Kosslyn 1994: 271)

- Mostly for others after the research is completed.
- Few, carefully crafted, and attractive graphs.

Choropleths

Thematic map in which values of a variable are encoded using a color gradient of some sort

- Counterpart of the histogram

  Both allows us to gage the distribution of a variable

Part 3

Spatial Weights

For a statistical method to be explicitly spatial, it needs to contain some representation of the geography, or spatial context. One of the most common ways is through **Spatial Weights Matrices**

- (Geo)Visualization: translating numbers into a (visual) language (colors) that the human brain can interpret.
- Spatial Weights Matrices: translating geography into a (numerical) language that a computer can interpret.

Spatial Weight Matrices

Spatial Weights Matrices are building block for spatial analysis and statistics.

They are used to assign a weighted average or sum of neighbouring data values to an observation, or other point in space.

- Relates to concepts of spatial 'smoothing' and interpolating data
- They can be used to see how one's characteristics or outcomes is correlated with their neighbours: e.g. education, criminality, disease risk factors,…

Core element in several spatial analysis techniques

- Spatial autocorrelation
- Spatial clustering/geo-demographics
- Spatial regression

Spatial Weights

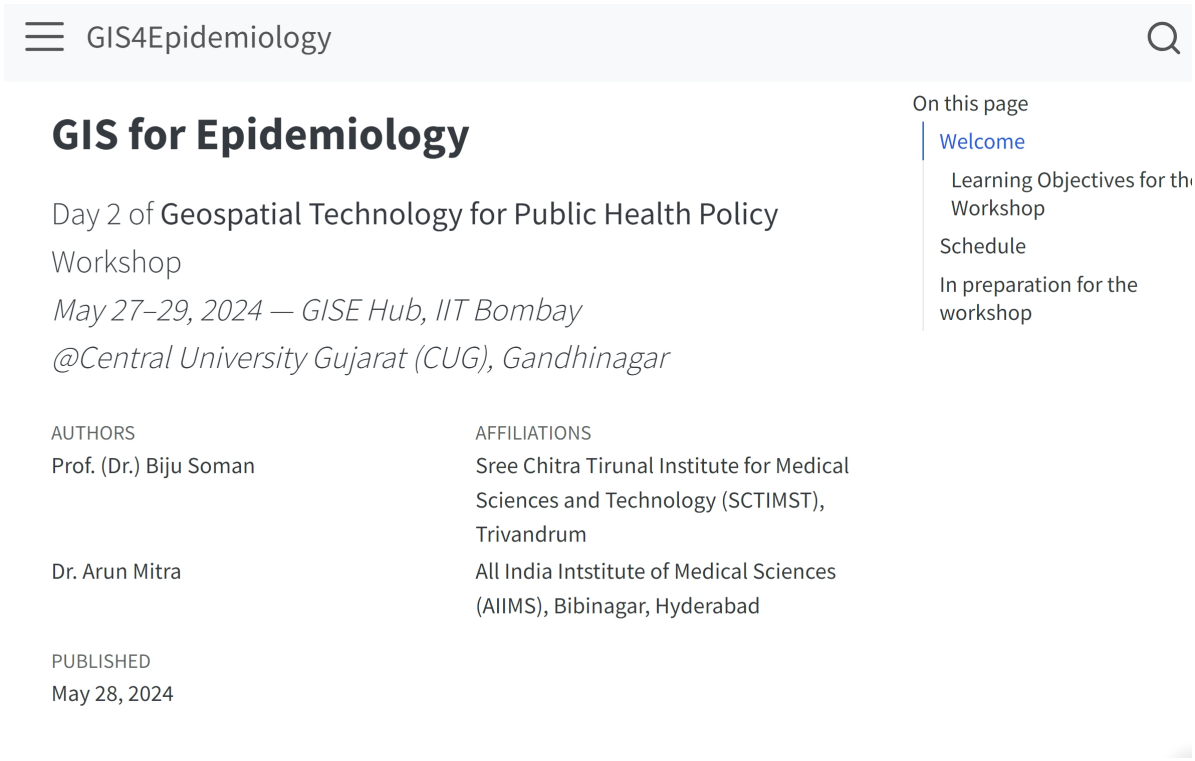
Spatial Weights represented by

$$W$$

N x N positive matrix that contains spatial relations that are translated into values

- If you are not a neighbour, $value = 0$
- If you are a neighbour, $value < 0$

Website



https://drarunmitra.github.io/GIS4Epidemiology/