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GIS in Health Studies

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Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine

ORIGINAL RESEARCH

Open Access

(CrossMark

Unmanned aerial vehicles (drones) in outof-hospital-cardiac-arrest

A. Claesson^{1*}, D. Fredman¹, L. Svensson¹, M. Ringh¹, J. Hollenberg¹, P. Nordberg¹, M. Rosenqvist², T. Djarv¹, S. Österberg¹, J. Lennartsson³ and Y. Ban³







Geographical Information Systems

- What is GIS?
 - Maps/cartography
 - Spatial data
 - Coordinate Systems
 - Spatial analyses
- What can we use it for?
- Spatial data in Denmark
- Tips, tricks and caveats

Understand the basic concepts Get familiar with the language (also useful in everyday life!) See new possibilities for your research: Any time the environment is involved, GIS application may be

Father of modern epidemiology used GI(S)



John Snow: London cholera outbreak 1854



The Lancet, http://dx.doi.org/10.1016/S0140-6736(08)60978-2

GIS-users:

Scientists, governments, archaeology, landscape planning, real estate, police, military, fire departments, insurance/reinsurance, telecommunication, resource management, climate change, navigation (google maps!)...





https://gis.ny.gov/





On patrol: A computer-generated "heat map," left, shows predicted crime activity. This is translated into patrol instructions in the form of the red boxes on the map, right.

Danmark køber kontroversielt overvågningssystem hos NSA-leverandør

Millionordren på PET og Rigspolitiets nye efterretningsplatform er gået til virksomheden Palantir Technologies, der også har de amerikanske efterretningstjenester CIA, FBI og NSA på kundelisten. Kritiker kalder systemet for 'skræmmende'.

Lasse Ørum Klinke Fredag, 28. oktober 2016 - 8:45

DANSK POLITI ADVARER FORBRYDERE: VI ER KLAR MED ET »SUPERVÅBEN«



GIS: analytic mapping

- Geographical Information System:
 - A system that handles *spatial* data (input, storage, processing, and retrieval)
- Spatial data / geodata
 - Digital data that have a geographic dimension: location/shape

→ We let the software manage the data, make analyses (=solve a problem) and present results (e.g. on maps)

Thinking in Layers



Raster data

Represents the real world as a surface (layer) in regular grid cells



- e.g. digital photos, elevation models, air pollution data
- + regular geometry
- Predefined resolution
- only one attribute per grid cell
- network linkage ambiguities

Vector data

Represents the real world as set of points, that may be joined in a given order (lines), into rings (polygons)



- + original resolution and accuracy
- + good for network and proximity analyses
- + more pleasing to look at on maps
- + many attributes per object possible
- analyses need complex and computationintensive algorithms
- datasets may become large





Depends also on the expected resolution and what you want to do with the data! e.g. a building can be abstracted as a point or a polygon; a railroad could be a line or a polygon¹²



Coordinate systems







Figure 1.1 WGS 84 Reference Frame

Geoid height (EGM2008, nmax=500)



When working with satellite data (GPS)

• World Geodetic System of 1984 (WGS84)

- Geographic coordinate system: based on sphere (longitude/latitude) → curved grids
- Example:

56°10′01.22″N, 10°12′25.0000″E 56.16700556 N, 10.20694444 E







Universal Transverse Mercator Projection (UTM/ETRS89):

Fixed to Eurasian plate All units are in meters. Eastings always have 6 digits before decimals Northings always have 7 digits before decimals

This is a Cartesian coordinate system!
Only positive numbers!
→ Easy to calculate distances, areas, ...

Example

32U 401028.5 m east 5580267.3 m north 32N 401028.5 m E 5580267.3 m N **32N 401028.5 5580267.3** 401028.5 5580267.3

UTM

- Angles and shapes still preserved
- Scale error (distance between two points) within a zone is less than 0.1%



Distance is ... cm per km longer (-) or shorter (+) in real world compared to map

Compare this (in)accuracy to a handheld GPS accuracy of approx. 10 m



Denmark: UTM zone 32N

UTM/ETRS89 (*dansk: UTM/EUREF89*) is stretched to cover eastern part of Sjælland (actually in 33N). Only Bornholm is typically left in 33N, but sometimes translated to 32N, too!

For specific purposes - like construction - more precision is needed!

- Correction calculations (dangerous, because error prone)
- Use of other projections and coordinate systems (DKTM)



When possible, stay within one system!





Ooops! Sign error leads to a difference of 54 cm!

Not acceptable for bridge construction

Scale

Small scale 1 : 250,000,000





Large scale 1 : 15,000

Spatial analyses

Any kind of calculation/permutation of spatial data, to answer all kinds of spatial questions:

- Who lives within 500 m of a pig farm? (buffer calculations)
- What is the level of pollution (air, noise, water, ...) at a point on the map, where I don't have any data? (interpolation/kriging)
- What are the natural catchments of a hospital/pharmacy? (Thiessen polygons)
- Who lives far away from a pharmacy? (distance matrices)
- Where are hot and cold spots of a specific disease? (cluster analysis)
- How many hours of sunlight at a specific location? (3D analysis)





Nuclear reactor emergency plans

Thyroid blocker

Saturates thyroid with stable iodine, preventing accumulation of radioactive iodine after nuclear fallout

JODTABLE **ACHTEN SIE AUF DIE** HINWEISE ZUR EINNAHME WAS TUN IM NOTFALL? als Schutzmaßnahme b schweren Unfall in eine **RICHTIGE DOSIERUNG** Die Dosierung ist abhängig vom Lebensalter: Schlucken Sie die angegebene Menge oder Achten Sie auf amtliche Durchsagen im Radio und Fernsehen oder auf amtliche Lautsprecherdurchsanehmen Sie die Tablette in Flüssigkeit gelöst ein: gen Diese Jodtabletten d ürfen nur auf ausdr ückliche Aufforderung durch die Katastrophenschutzbehörde eingenommen werden. Normalerweise genügt eine einmalige Einnahme der angegebenen Dosis. In Ausnahmefällen kann jedoch eine weitere Tabletteneinnahme empfohlen werden. Der Einnahmezeitpunkt und die Einnahmemenge O his 1 Monat 1 Monat his 3 Jahr sind sehr wichtig. Vorbeugendes Einnehmen oder andere (höhere) Dosierungen erzielen keinen besseren Schutz - im Gegenteil – so könnten Sie Ihre Gesundheit gefähr den Iodtabletten schützen nur vor radioaktivem Iod und Lösen Sie die Tablette in Wasser auf. nicht vor anderen radioaktiven Stoffen Deshalb bleiben Sie zu Hause oder begeben Sie sich in geschlossene Räume. 3 bis 12 Jahre über 12 bis 45 Jahr und Schwangere über 45 Jahre Deutschland zählt zu den Jodmangelgebieten, wodurch mit steigendem Alter häufiger Stoffwechselstö-Zur leichteren Einnahme – vor allem für Säuglinge und Kinder rungen der Schilddrüse auftreten. Dies erhöht die Gelösen Sie die angegebene Menge in einem Getränk (Saft, Tee). fahr von Nebenwirkungen einer Jodblockade. Zudem nimmt mit steigendem Alter die Wahrscheinlichkeit stark ab, an durch ionisierende Strahlung verursach-Jodtabletten nur auf ausdrückliche Aufforderung Jodtabletten sind ein Arzneimittel. Zu Risiken und tem Schilddrüsenkrebs zu erkranken Nebenwirkungen lesen Sie die Packungsbeilage. durch die Katastrophenschutzbehörde einnehmen

Germany:

 Every household within 10 km to nuclear facility is supplied with potassium iodide/iodate pills on stock at all times

In case of fallout:

- Evacuation within 10 km
- Target group: everyone until age of 45 within 100 km, as well as all children until age 18 and pregnant/breastfeeding women in all of Germany
- authorities supply to every household within 25 km

Nuclear reactor emergency plans



A 'natural' experiment: Chernobyl disaster

Poland and Belarus received similar amounts of radioactive lodine

Thyroid blockade given to 11 million children (98%) in Poland

• Long time follow-up: no increase in thyroid cancer

No thyroid blockade given in Belarus

• Sharp increase in childhood thyroid cancer

Cluster-busters





FIGURE 2. Standardized mortality ratios for asthma deaths of persons 15–34 years of age by state economic areas, 1981–1985. Black areas were significantly greater than 100 (p < 0.05), and all other areas that were evaluated are gray. Areas that are blank were not evaluated because of small population size. Source: National Center for Health Statistics, National Vital Records, Compressed Mortality File.

American Journal of Epidemiology, Volume 132, Issue supp1, July 1990 Stop disease clusters. Protect people. Control toxic chemicals.

Health Alert: Disease Clusters Spotlight the Need to Protect People from Toxic Chemicals



Authors

Kathleen Navarro, Natural Resources Defense Council Sarah Janssen, M.D., Ph.D., M.P.H., Natural Resources Defense Council Terry Nordbrock, M.L.S., M.P.H., Executive Director, National Disease Clusters Alliance Gina Solomon, M.D., M.P.H., Natural Resources Defense Council







LOCATION: Wilkes-Barre, Luzerne County DISEASE: Non-Hodgkin's lymphoma and lupus

In 2004, researchers at Pennsylvania State University found health hazards associated with workplace exposure to trichloroethylene (TCE) at a Wilkes-Barre special education school in the school district's main administrative building. Twelve employees have been diagnosed with non-Hodgkin's lymphoma and lupus. The researchers found TCE exposures were 10,000 times higher than what the Environmental Protection Agency considers an acceptable cancer risk for someone working in the building for at least 10 years. TCE, a probable human carcinogen, was used by the staff to clean the two printing presses.

Clusters are difficult to explain to the public

Workington

Whitehaven

1983: TV documentation: leukemia cluster!
→ Investigation: emissions too small to account for the cluster
1988: Kinlen (Lancet 1998/BJC 2011): virus infection?

Isolated town (herd immunity to a postulated virus rarely causing leukemia below average) receives huge influx of workers

Same pattern seen in other isolated places (soldiers stationed on isolated islands)

1996-2006: no new cases, cluster disappeared

Cancer research UK (2016): Sellafield, radiation and childhood cancer – shedding light on cancer clusters near nuclear sites

Kinlen (2011): Childhood leukaemia, nuclear sites, and population mixing, BrJC 104:12-18

Kinlen (1988): EVIDENCE FOR AN INFECTIVE CAUSE OF CHILDHOOD LEUKAEMIA: COMPARISON OF A SCOTTISH NEW TOWN WITH NUCLEAR REPROCESSING SITES IN BRITAIN, Lancet 332: 1323-1327





Small-scale geographical variation in multiple sclerosis: A case-control study using Danish register data 1971–2013. Kristine Bihrmann, Nete Munk Nielsen, Melinda Magyari, Nils Koch-Henriksen, Rikke Baastrup Nordsborg, Annette Kjær Ersbøll. Multiple Sclerosis and Related Disorders, Vol. 23, p40–45. Published online: May 4, 2018

MIDT- OG VESTJYLLAND

Kortlægning: Her risikerer du især at udvikle sklerose

For første gang har forskere undersøgt, hvor i Danmark personer med sklerose er født eller vokset op.



Er man født eller opvokset i de røde områder, har man en øget risiko for at udvikle sklerose. I de blå områder er risikoen til gengæld lavere, viser en undersøgelse fra Statens Institut for Folkesundhed. Grafik: Emil Thorbjörnsson, DR.

Examples from epidemiological studies



IJ C International Journal of Cancer

Nitrate in drinking water and colorectal cancer risk: A nationwide population-based cohort study

Jörg Schullehner 1,2,3,4, Birgitte Hansen², Malene Thygesen^{3,4}, Carsten B. Pedersen^{3,4} and Torben Sigsgaard¹

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³ National Centre for Register-Based Research, Department of Economics and Business Economics, School of Business and Social University, Aarhus, Denmark

⁴ Centre for Integrated Register-based Research, CIRRAU, Aarhus University, Aarhus, Denmark

Table 1. Adjusted hazard ratios (95% CIs) associated with high levels of nitrate exposure compared with low levels (trend estimate). Incident cases and study population size (*N*)

Cancer site	N ¹	Cases ¹	Base adjustment ²	Second adjustment ³
Colorectal	1,742,093	5,944	1.16 (1.08–1.25)	1.14 (1.06–1.23)
Colon	1,742,156	3,700	1.15 (1.05–1.26)	1.14 (1.04–1.26)
Rectum	1,742,255	2,308	1.17 (1.04–1.32)	1.13 (1.00–1.27)

¹Incident cases for colon and rectal cancer are not mutually exclusive. ²Age, sex, year of birth and previous cancer diagnosis.

³Base and highest attained education.

What's the GIS part in this study?



Covariates

Health- & administrative registers Date of birth/death, sex, education, income, employment, taxation, link to parents/siblings/children, criminal offences, prescription drugs, cause of death, diagnosis/operations at hospitals, primary health care (treatment) ...



- 1) Georeferencing 2852 public water supply areas
- 2) Linking waterworks to supply areas (spatial join)



- 1) Georeferencing 2852 public water supply areas
- 2) Linking waterworks to supply areas (spatial join)
- 3) Identifying households supplied by private wells (buffer)



Supplementary Figure 1: Nitrate concentrations in the water supply areas, 1978-2013.

- 1) Georeferencing 2852 public water supply areas
- 2) Linking waterworks to supply areas (spatial join)
- 3) Identifying households supplied by private wells (buffer)
- Assigning each household a time series of nitrate concentrations in drinking water (spatial join)



Research

JAMA Psychiatry | Original Investigation

Association of Lithium in Drinking Water With the Incidence of Dementia

Lars Vedel Kessing, MD, DMSc; Thomas Alexander Gerds, MSc, PhD; Nikoline Nygård Knudsen, MSc; Lisbeth Flindt Jørgensen, MSc; Søren Munch Kristiansen, MSc, PhD; Denitza Voutchkova, MSc, PhD; Vibeke Ernstsen, MSc, PhD; Jörg Schullehner, MSc, PhD; Birgitte Hansen, MSc, PhD; Per Kragh Andersen, MSc, PhD, DMSc; Annette Kjær Ersbøll, MSc, PhD

Figure. Association Between Mean Lithium Exposure in Drinking Water on a Continuous Scale and the Overall Dementia Rate



Data are the incidence rate ratios (IRRs) in relation to the mean (4 $\mu g/L$) of the lowest group on a logarithmic scale. Shaded area indicates 95% CIs.



Article

Lithium in Drinking Water and Incidence of Suicide: A Nationwide Individual-Level Cohort Study with 22 Years of Follow-Up

Nikoline N. Knudsen ¹, Jörg Schullehner ^{2,3,4}, Birgitte Hansen ², Lisbeth F. Jørgensen ⁵, Søren M. Kristiansen ⁶, Denitza D. Voutchkova ^{2,6,7}, Thomas A. Gerds ⁸, Per K. Andersen ⁸, Kristine Bihrmann ¹, Morten Grønbæk ¹, Lars V. Kessing ^{9,†} and Annette K. Ersbøll ^{1,*,†}

Received: 19 April 2017 Accepted: 13 June 2017

DOI: 10.1111/bdi.12524

ORIGINAL ARTICLE

WILEY BIPOLAR DISORDERS

Lithium in drinking water and the incidence of bipolar disorder: A nation-wide population-based study

Lars V Kessing¹ | Thomas A Gerds² | Nikoline N Knudsen³ | Lisbeth F Jørgensen⁴ | Søren M Kristiansen⁵ | Denitza Voutchkova^{4,5} | Vibeke Ernstsen⁴ | Jörg Schullehner⁴ | Birgitte Hansen⁴ | Per K Andersen² | Annette K Ersbøll³



What's the GIS part in these studies?

- Lithium not part of national drinking water monitoring program
- Almost 3000 waterworks in DK

1) Representative selection of waterworks





Figure 1. Sampling point location. Symbols: initial waterworks selection, based only on the two selection criteria (n = 181): 1st selection criteria (red empty square), 2nd criteria (red empty circle); waterworks which sent samples to the lab (n = 144) (blue square); contacted waterworks which did not participate i.e., no answer; negative answer; answered positively, but samples were not received at the lab (red cross) (note: the arrow indicates North direction).

Tobler's First Law of Geography:

"Everything is related to everything else. But near things are more related than distant things."





Figure 1. Distribution of ultramafic rocks in California.



Figure 2. (*A*) Lowess-smoothed predicted log odds of mesothelioma versus nearest distance from naturally occurring asbestos deposits—men (adjusting for age, sex, and occupational exposure) and (*B*) lowess-smoothed predicted log odds of mesothelioma versus nearest distance from naturally occurring asbestos deposits—women (adjusting for age, sex, and occupational exposure).

Pan et al (2005): Residential Proximity to Naturally Occurring Asbestos occupational exp and Mesothelioma Risk in California, Am J Respir Crit Care Med Vol 172. pp 1019–1025 Received: 19 January 2017 DOI: 10.1111/zph.12441

ORIGINAL ARTICLE

WILEY

Distance to pig farms as risk factor for community-onset livestock-associated MRSA CC398 infection in persons without known contact to pig farms—A nationwide study

J. C. H. Anker^{1,2} | A. Koch¹ | S. Ethelberg¹ | K. Mølbak¹ | J. Larsen¹ | M. R. Jepsen²





FIGURE 3 Cumulative percentage of distance by road to nearest pig farm and livestock-onset (LO) MRSA CC398 case for human MRSA CC398 of unknown onset infection (MUO CC398) and population controls, Denmark overall, 2006–2015





GIS in malaria prediction



Research Article

Malaria Vulnerability Map Mobile System Development Using GIS-Based Decision-Making Technique

Jung-Yoon Kim^(b),¹ Sung-Jong Eun,² and Dong Kyun Park^(b)

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²Health IT Research Center, Gil Medical Center, Gachon University College of Medicine, Incheon, Republic of Korea

Mobile Information Systems



FIGURE 5: Analysis of raster overlay.



FIGURE 6: A result of raster overlay-based conversion and manning (a) Population man (b) Humidity man (c) Temperature man (d) Lake



FIGURE 7: Raster overlay analysis.



FIGURE 8: Final result of system visualization. (a) Marking of malaria generation region. (b) Summation information (tooltip) of malaria generation region. (c) Risk time-series animation of malaria generation region.

MAPS









DONALD TRUMP WON 7.5 MILLION POPULAR VOTE LANDSLIDE IN HEARTLAND

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ny MICHAEL PATRICK	LEAHY 15 Nov 2016	12,193		University of Michig

Donald Trump won an overwhelming 7.5 million popular vote victory in 3,084 of the country's 3,141 counties or county equivalents in America's heartland.



Trump won in rural America, but Clinton claimed populous urban counties

The 163 counties with the most voters have the same population as the other 2,939. These urban population centres overwhelmingly voted Clinton





Elements of a map

The map: who is your audience? What story do you want to tell? What is the important data you want to present, what is background info?

Extend: Can you show all your data? Does it make sense to divide the map in several parts (e.g. islands such as Bornholm)

Symbology: are the symbols clear and do they match the data?

- Qualitative data: use different colors (green for forest, blue for water)
- Quantitative data: use symbol size or color graduation/saturation

Elements of a map

Labels: are they necessary and can you read them?

Legend: only show necessary items

Additional information: North arrow, scale bar, data sources, date, name, projection...

Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine

ORIGINAL RESEARCH

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Unmanned aerial vehicles (drones) in outof-hospital-cardiac-arrest

A. Claesson^{1*}, D. Fredman¹, L. Svensson¹, M. Ringh¹, J. Hollenberg¹, P. Nordberg¹, M. Rosenqvist², T. Djarv¹, S. Österberg¹, J. Lennartsson³ and Y. Ban³



Data sources

https://download.kortforsyningen.dk/

Take home messages

- Maps are a great way to show (geo-) data in a visually attractive way
- Many exposures have a geographical dimension
- Spatial data are found all over the place
 - Danish geodata are often freely available
- Coordinate systems: make sure you use the correct one