Applied GIS (GEOG 489)

Week 1: Course Introduction

Slides of this class: https://git.io/vMR3X

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What is Applied GIS?

- How it is different from fundamental GIS?
- Examples of applied GIS?
- What do you want to learn from this course?

Course Topics (tentative)

- Geoprocessing using ArcGIS (2 Weeks)
- Suitability Modeling (2 Weeks)
- Land cover change modeling (2 Weeks)
- Terrain and watershed analysis (2 Weeks)
- Spatial Interpolation (2 weeks)
- Advanced spatial analysis (2 weeks, TBD)

Approaches to Lectures & Labs

- A bit of theory on certain new topics
- More focus on applications and case-studies
- Review / demonstration of particular GIS analysis or software skills on as-needed basis
- Compared to the other GIS courses, there will be much more time to work on lab assignments during scheduled class time
- Develop research ability through proposal/report writing and project presentation.

Course Material

- Slides, lab instructions and assignments can be accessed from https://github.com/qiang-yi/GEOG489
- Lab assignments, project reports should be submitted to the course site in Laulima.

Readings

- Several required readings for each topic - most are journal articles
- Text book is not necessary - but some chapters are recommended to read.
- Most of the readings are closely related to the lab assignments - we can't cover all the advanced techniques from the literature, but doing the readings will help with the lab assignments, in particular answering the questions
- Some readings use very advanced statistical methods or other non-GIS techniques - don't worry, you don't have to understand the nuts and bolts of each method - focus on the GIS elements

Expected Knowledge: ArcGIS

- Basic knowledge of ArcGIS is required
    - Support will be provided by the instructor on a as needed basis.
    - Learn to find solutions to your problems from the Internet, e.g. ESRI training/documentation, Stack Overflow and Google.
- A basic knowledge of Spatial Analyst is required -we'll do more advanced stuff throughout this course.

Expected Knowledge: Vector and Raster Analysis Tools

Vector analysis tools	Raster analysis tools
Query (spatial/attribute)	Raster calculator
Join/relate	Map algebra
Buffering	Reclassification
Dissolve	Distance functions
Merge	Zonal statisitcs
Intersect	Neighborhood
Union	Surface interpolation
…	…

Expected Knowledge: Statistics & Remote Sensing

- Hands-on Knowledge of basic statistics is required, for example, exploratory statisitc analysis or simple linear regression analysis.
- Knowledge of advanced statistics will help with readings, but is not required.
- Knowledge of remote sensing is not required but useful.

Lab Assignments

- Important part of this course
  - Learning-by-doing is essential for developing GIS skills
  - Reflect in 60% of final grade
- Assignments contain
  - Limited step-by-step software instructions
  - Questions ranging from fairly basic to very advanced
  - Some questions that are open-ended
  - Some parts that are optional
- Lab assignments broken up in many small parts - if you get stuck somewhere, you can skip ahead to another part without having to wait for instructor feedback

Suggestions for Lab Assignments

- Don't leave the assignments to the last minute.
  - You can't precisely estimate the time to finish it.
  - Doing assignment along with classes can help you better understand the classes and save your time
- Try to get work done during the scheduled class times, and ask questions.
- If you get stuck with something, contact the instructor or TA - don’t struggle too long on your own.
  - During class
  - E-mail
  - Office hours or by appointment

Project Guidelines

- The emphasis should be on using GIS as a problem solving, analytical or research tool.
- While some data collection effort is OK, most (if not all) of your data should already exist in usable form – at least 2/3 of the project time should be spent on analysis
- You are welcome to explore other spatial modeling software, so you are not limited to ArcGIS, or to even to using only GIS software.

Project Topics

- You will choose your project topics by:
  - Option 1: Select from a set of suggested projects
  - Option 2: Expand on an existing lab assignment
  - Option 3: Develop your own project

Option 1: Suggested Project Topics (1)

- Advanced suitability modeling – More advanced techniques needed.
- Least-cost path and corridor analysis for conservation – Developing a technique to determine the most appropriate linkages between existing conservation areas.
- Land cover change modeling – Deriving transition rules from a time series of images and simulating land cover change using these rules.
- Sea level rise impact and social vulnerability analysis - Estimate infrastructure or population at risk of future sea level rise and evaluate the impact.
- Advanced terrain analysis techniques - flow routing, DEM reconditioning, depression removal.

Option 2

- Expand on lab assignments
  - Expand upon the analysis in one of the lab assignments using the existing data;
  - Applying a similar analysis to another dataset;
  - Combing various analysis techniques with new and/or existing data into a new exercise.
- The key requirement here is that you truly expand upon the existing exercises, in terms of data complexity or analysis techniques.

Option 3

- You are free to develop a project of your own
  - Within the scope of GIS - but you can use GIS to solve problems in other areas
  - Mainly use methods introduced in this course - but you can combine with other methods;
  - Need explicit problem to be solved, logical methods and reasonable interpretation/conclusion.
  - Most of your data should be (almost) ready to use - don't spend most of your time on data collecting and cleaning.

Project Deliverables 1

- Project Proposal (less than 1 page)
    - Motivation for doing this project (4-5 sentences). Include any relevant citations/figures.
    - A clearly stated hypothesis (1-2 sentences).
    - An outline of the datasets you need and methods to analyze them.

Project Deliverables 2

- Project Report (Maximum 6 pages, excluding references)
  - Background (~ 0.5 page): Motivation of problem
  - Hypothesis (~ 0.5 pages): Succinct statement of problem
  - Methodology (~ 1 pages): Appropriate use of GIS
  - Results (~ 1 pages): Do results address hypothesis
  - Discussion and Conclusions (~ 1 - 2 pages): Interpretation of results, conclusions of the study
  - Future Work (~ 0.5 pages): Next steps

Project Deliverables 3 & 4

- Poster
    - A succinct and comprehensible version of project report - documenting all major components in project report.
    - Consider how to deliver information efficiently and effectively in a limited space.
    - Size proportional to 4' * 6' (landscape layout), in PDF
    - All contents visible for people standing 6' away
- Project presentation
    - <=20 mins in total (<=15 mins for presentation and <=5 mins for Q&A and transition)

Effect of different DEM Reconditioning techniques on the morphological properties of a basin.

Abstract

The extraction of Morphological properties of a basin using DEMs is widely used nowadays with the advances in computational capabilities, in particular GIS. Yet, the precision of the results is still somehow limited and different technics are used to improve these results. One concept is merging an existing stream layer with a DEM to "force" the stream and catchment delineation.

This poster represents a comparison of the results obtained from a raw DEM analysis to those obtained after reconditioning the DEM using the "Stream Burning" and "AGREE" methods. Both streams and catchment results were improved in comparison with the "true" ones.

Knowing that stream definition is more complex than just defining a threshold, a different approach of stream definition will be explored.

Data and Methods

The study are is located in the San Marcos basin – Texas

The streams and catchments of this area were delineated using a 30x30m USGS DEM. First the DEM was "filled" only. Then an NHD shapefile of the stream network of the area was overlayed with the DEM and two method of overlay were used:

Stream Burning Technique: Manual Burning.

AGREE algorithm: using the ArcHydro tool.

The way streams were defined till now is using a threshold value only based on the D8 flow direction.

Another definition based on both threshold and slope is explored in the last part, where the area and slope are obtained from the Dinfinity flow direction grid using the TauDEM extension, which allows more advanced techniques than ArcHydro.

Results

No Reconditioning:

Good for coarse representation of streams and watershed.

Modelled streams do not match with "real" ones.

Irregular Watershed boundary.

Stream burning:

Modelled streams and real ones match better.

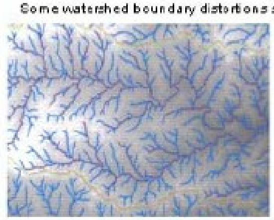
Parallel streams occur due to the local change of DEM.

Results in watershed boundary distortions.

AGREE Algorithm:

Streams match with real ones and the problem of Parallel streams is eliminated.

Some watershed boundary distortions still exists.



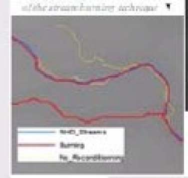
◄ No Reconditioning: For a general idea, the modelled stream network (Blue) can be considered as a good representation of the real network (Red). The catchment (Green) is also pretty close to the real one. The accuracy of these results depends on the DEM accuracy.

No Reconditioning ► Irregularities in watershed boundary

◄ No Reconditioning: Modelled stream network do not match with real one, especially if we have a stream divergence due to the D8 flow direction

Distortions in the watershed boundary caused by stream burning ►

Parallel streams is a common error of the stream burning technique ▼



Sub catchment delineation problems resulting from the stream burning ▼

Delineated Streams (Blue) match well with the real network (Red), yet some major terrain changes can't be corrected. ▼

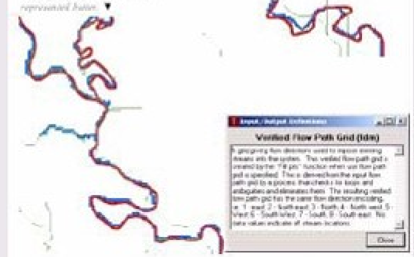
Using the AGREE algorithm, the delineated streams match the real network and we won't have the parallel stream problem if the parameters are chosen adequately (buffer, smooth and sharp edge) ►

Different Approaches.

In this part the AGREE DEM is used but with a different approach of flow accumulation and stream definition.

In general Dinfinity and using slope in addition to threshold (Blue) yielded to better results than the D8 and threshold only (Green) in comparison to the NHD layer (Red). ►

Natural shape of the streams is represented better. ▼



Another important technique that could have been explored is to use a grid to force flow direction for the known streams cells instead of modifying the DEM. But this grid preparation is harder than just using AGREE. ▲

Conclusion

The AGREE algorithm gave results more reliable than stream burning. And it's an automated process while stream burning needs to be done manually.

The D8 flow direction is a constraint for the mimic of the streams natural behaviour.

Other hydrological properties than upstream drainage area (threshold) should be used for streams definition, which yields to better results.

Even after burning streams into DEM, the flow direction can be different from the reality; so forcing the flow direction can be a better option and it avoids the topographic changes of the DEM.

Project Timeline

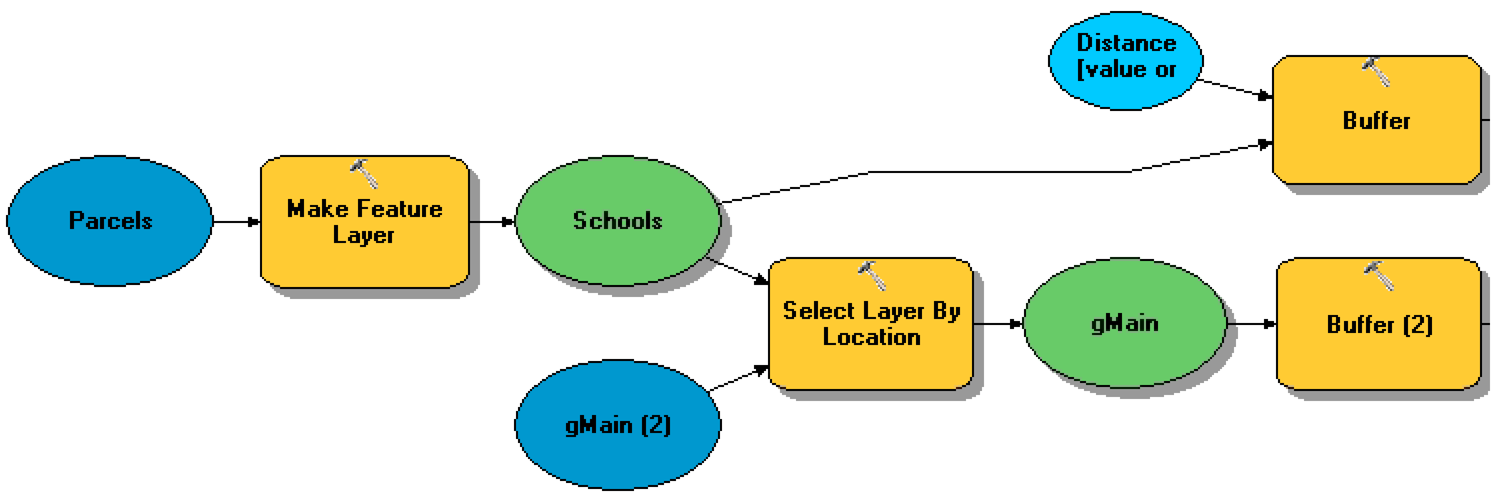
- Project proposal due: Week 7
  - Submit Word/pdf file to laulima
  - Feebacks will be given before spring break
- Report submission: Week 15
  - Submit word/pdf file using laulima
- Poster submission: Week 15
  - Submit word/ppt/pdf file using laulima
- Project presentation: Weeks 16-17
  - Submit ppt/pdf file using laulima

Course Grading

Items	% grade
Project proposal	10%
Project report	40%
Poster	20%
Project presentation	30%

Geoprocessing Model and ModelBuilder in ArcGIS

- Geoprocessing model:
  - a workflow consists of one or more multiple geoprocessing tools
  - The geoprocessing tools are connected by their interfaces (input and output variables)
  - represent a meaningful spatial analysis in a logical order



A geoprocessing model

ModelBuilder

- Visual programming language/platform that enables you to create a program without writing code.
- You create a program by adding data and tools and connecting them into a workflow.
- Models created by ModelBuilder is explicit, automated, re-usable and sharable.

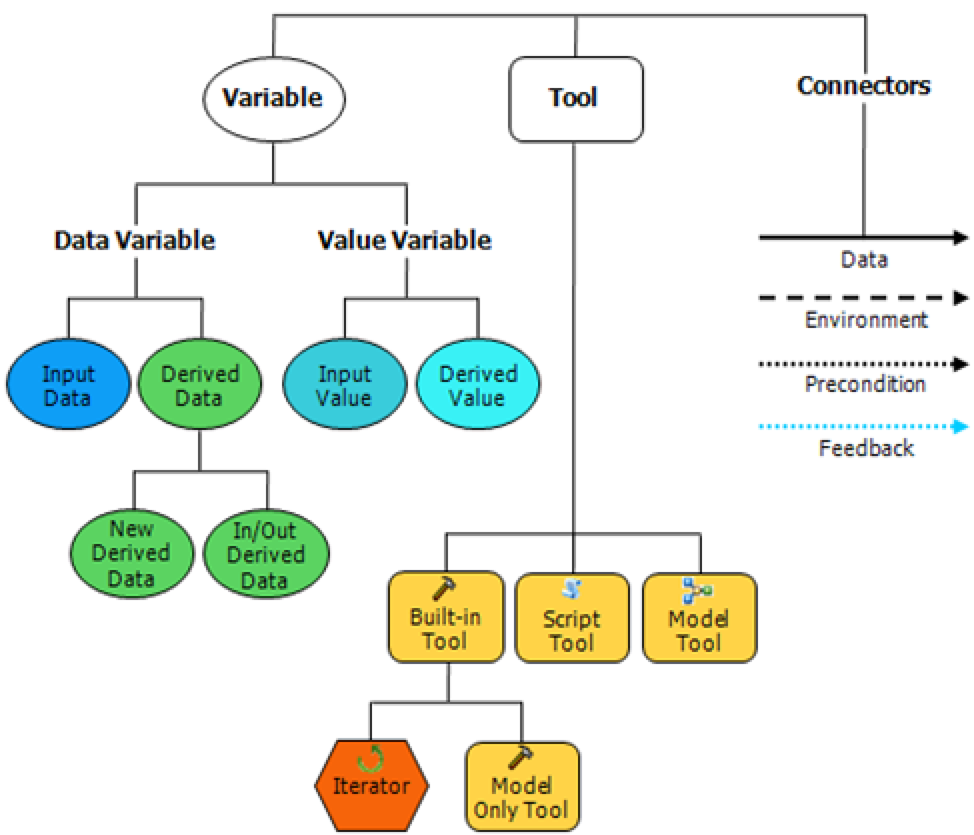
Elements in ModelBuilder

Variable: Input and output of tools

Tool: a wrapped program that operate a certain analysis task

Connector: Connecting **data, environment, precondition and feedback** with tools

Iterators: ***for*** and ***while do*** loops



Lab Computer Account

- Your account name is **the initial of your first name plus your last name, all in lower case.**
- The temporary passowrd is **change**
- In the drop list of Log on to, please select **Cartography**. If this is the first time for you to use your account, you will be prompted to **change your password**. Make a note of your password so that you can access it in the future with the same account.
- After logged on, you will see your personal drive on My Computer. (U:\ )

Account Management

- Do NOT save your work on the desktop!!!
- Do NOT save your work on the C drive !!!
- Save your work on a continuous basis to your personal folder (U drive), which is essentially a network folder.
- Use different folders to store different labs in your personal drive to easy track your work.

Using Relative Path for Your ArcGIS Projects !!!

- If you move data between computers, you will have to use relative path names for your ArcMap documents
- For ArcGIS 10.X, you can change the path setting by click File->Map Document. Check Store relative pathnames to data sources.

Lab 1 (part 1): Building Models for GIS Analysis Using ArcGIS

Please complete the lab exercises following the instruction and finish the lab assignment.

- Lab instruction: https://git.io/vMR3W
- Lab assignment: https://git.io/vMR5c

The assignment should be submitted to Laulima by Fri. Jan. 27.