GEO 345/445: Programming in Python for GIS

Spring 2017 (3/25/17-6/9/17) | Department of Geography | DePaul University

The class meets on Tuesday and Thursday at 4:20-5:50 pm in SAC 224 (SAC GIS Lab)
Instructor: Sungsoon (Julie) Hwang (shwang9@depaul.edu, 773-325-8668, 990 W Fullerton #3133)
Instructor's office hours: Tue, Wed, Thurs 2-3 pm in her office and by appointment
Teaching Assistant: Emily Flock (flock.emily@gmail.com; Lab hours: TBA)

1. Course Description: Knowledge of a scripting language is a valuable skill for GIS analysts. Students will learn the basics of Python (a programming language), including script writing and implementation. By completing this course, students should be able to manipulate GIS data, automate GIS work flows, and develop customized GIS tools by writing script in Python with ArcGIS. The class is largely conducted through hands-on activities in a GIS laboratory. Formerly GEO 342.
Prerequisites: GEO 242 for GEO 345; GEO 440 or GEO 441 for GEO 445.

2. Course Topics: Python is in high demand in GIS industry and beyond. Through GEO 345/445, you will learn Python as a scripting language and ArcGIS site package ArcPy. With Python you can manipulate various data and control workflow, and can call and execute geoprocessing functions (eg. buffering, query) in ArcPy. US Department of Labor's Geospatial Technology Competency Model identifies design and development of geospatial applications (tools) as one of three industry-sector technical competencies along with data acquisition and analysis. In this course you will be introduced to logics of programming language. Through the course you will learn to write a Python script to (a) automate routine tasks; (b) customize data processing; and (c) create a simple tool with GIS applications in mind. More specifically, you will

- Build a model using the ModelBuilder, and convert the model to a Python script
- Learn syntax, data types and operations in Python
- Learn conditional statement and loop structure in Python
- Get an overview of ArcPy, and access properties of datasets
- Retrieve and update rows in geospatial data using ArcPy Cursors along with SQL
- Read and write a text file using a file object with a Python script
- Access map document elements and create a map series using ArcPy mapping module

3. Learning Outcomes – with the completion of this course you should be able to

- Write Python scripts for a given problem using various data types and operations
- Write Python scripts for a given problem using conditional statement and loop structure
- Perform geoprocessing tasks using ArcPy geoprocessing tools and classes
- Explore and manipulate geospatial data using ArcPy Cursors
- Create a map series using ArcPay mapping module

4. Required Text: *Python Scripting for ArcGIS* (2013) by Paul A. Zandbergen, ESRI Press (ISBN: 9781589482821). In case you run into the 2014 edition, the 2014 edition is same as the 2013 edition content-wise. Although the text is written for ArcGIS 10.1, it works as well with ArcGIS 10.4 and Python 2.7.10 that are currently installed in selected labs at DePaul University.

The text is available at college bookstore in Lincoln Park Campus. **The college bookstore price matches through the first week of classes. Click here for more details.**

5. Outlines of Topics and Tentative Schedules

Wk.	Date	Topic	Reading	In-class lab activities	Assignments
1 T	3/28	Course overview. Entry survey	Ch1		
R	3/30	**1. Python script editor & ModelBuilder**	Ch2,3	**1.** IDLE and a Python script from ModelBuilder	
2 T	4/4	**2. Python fundamentals I: data types and operations**	Ch4 ~ p. 81	**2A.** Work with data types and operations in Python	
R	4/6	Label features using Python string operations in ArcGIS		**2B.** Use Python in the ArcGIS Label Expression dialog box	
3 T	4/11	Help for Lab2A, Lab2B, HW1			
R	4/13	**3. Python fundamentals II: conditional statement and loop structure**	Ch4 p. 81 ~	**3A.** Control workflow using if, while, and for in Python	**HW1** due 4/14 F
4 T	4/18	Calculate field using conditional statement in ArcGIS		**3B.** Use if statement in the ArcGIS Field Calculator	
R	4/20	Help for Lab3A, Lab3B, HW2 & ILGISA			
5 T	4/25	**4. Introduction to ArcPy**	Ch5,6	**4A.** Use environmental settings and describe data	
R	4/27	Batch geoprocessing using List objects in ArcGIS		**4B.** Perform query and field calculation in batch	**HW2** due 4/28 F
6 T	5/2	**Midterm**			
R	5/4	Help for Lab4A, Lab4B & HW3			
7 T	5/9	**5. Manipulate geospatial data with Cursors**	Ch7 ~ p. 149	**5A.** Use Cursors to read and write rows in the table	
R	5/11	Write a text file by looping through a table	Ch7 p. 149 ~	**5B.** Write a report that summarizes text files	**HW3** due 5/12 F
8 T	5/16	Help for Lab5A, Lab5B, HW4			
R	5/18	**6. Map scripting (ArcPy mapping module)**	Ch10	**6A.** Access map document elements	
9 T	5/23	GEO Year of End Event			
R	5/25	Create a PDF map book consisting of multiple maps if time allows		**6B.** Make a map series by looping through features	**HW4** due 5/26 F
10 T	5/30	Help for Lab6A, Lab6B			
R	6/1	7. Error handling if time allows Exit survey	Ch11	7. Debugging and error handling	
11 R	6/8	**Final exam** 4:20-5:50 pm in SAC 224			

6. Grading Components

Components	Points	Notes
Participation	10	See below for rubric
11 labs	33	Each exercise accounts for 3 points
4 homework	36	Each homework accounts for 9 points
Exam	9	Midterm on May 2nd (week 6 T)
	12	Final on June 8th (during an exam week 11 R)
Extra credit	3-5	Enter Poster Competition at ILGISA Chicago Regional Meeting on 4/28. Submit a poster by 4/14 (week 3). Max 5 points. or

		Enter 2017 ILGISA Map Competition "Most Interesting Map!". Submit a map and 1-page report by 6/1 (week 10). Max 3 points.

6.1 Participation: score is assigned according to the criteria below.
- A (9-10) = Student is present in all or nearly class meetings, and prepared, at all times, to respond to questions. Student is an active participant in and out of class, and stays on task in class-time activities.
- B (8-9) = Student participates as above, 75% of the time.
- C (6.5-8) = Student does not volunteer comments; responses demonstrate vague familiarity with course readings. Student is a passive participant in and out of class, and/or does not stay on task during class-time activities.
- D (5-6.5) = Student never volunteers, cannot respond to direct questions, keeps silent during class discussions and is unable to summarize readings if asked.
- F (0-5) = Student misses many class sessions and/or sits silently in classes when present, or is disruptive and non-participatory in the classroom.

6.2 Labs: complete labs after lectures in the class when instructors are present. If you can't complete the lab in time, make arrangement with a TA. Labs are due 11:59 pm one week after handouts are distributed in the class unless noted otherwise. See the table above for the content of each lab.

6.3 Homework: write and submit a Python script.
- HW1: this covers module 1 (ModelBuilder) and module 2 (data and operations) testing the following: (a) export a model to a Python script; (b) calculate distance between two points using functions and methods for numeric data; (c) custom-label features using string methods in the Label expression dialog box
- HW2: this covers module 3 (conditionals and loop) testing the following: (a) calculate descriptive statistics using list methods; (b) custom-label features & calculate fields using conditional statements in the Label expression dialog box; (c) calculate fields using conditional statements
- HW3: this covers module 4 (ArcPy) testing the following: (a) visualize data distribution using list methods; (b) retrieve properties of geospatial data with ArcPy functions and classes; (c) perform batch processing with ArcPy
- HW4: this covers module 5 (cursor and text file handling) testing the following: (a) check data quality by looping through the geodatabase table with ArcPy Cursor and SQL; (b) generate a summary statistics by looping through multiple text files
- HW5: this covers module 6 (ArcPy mapping module) testing whether you can create a map book showing the list of features by neighborhoods.

6.4 Exam: Midterm will be held on May 2nd (week 6 Tuesday), and final exam will be held on June 8th (week 11 Thursday) during an exam week. Midterm covers module 1, 2, and 3. The midterm exam consists of multiple choice, and short answer which is designed to test your understanding of Python fundamentals in general. The final exam is comprehensive (covers all modules that are taught by the end of the quarter). The final exam includes a lab test for which you write a script that performs the set task. For example, you need to write a code to perform a task such as 'print the string "Hello World" 20 times'. Given limited time allowed for the final exam, fairly simple tasks will be given. You're allowed to refer to Python help, and ArcPy help during the final exam. You are also allowed to bring a cheat sheet (A4 size in both side) to the final exam. In the cheat sheet, you can write down syntax for Python operations and ArcPy geoprocessing functions.

6.5 Extra credit: you can do one of the following that counts toward extra credit.

A. ILGISA Poster Competition: enter the Poster Competition in the 2017 ILGISA Chicago Regional Meeting held at DePaul Center (1 E Jackson Blvd) on 4/28 (Friday of Week 5). Posters will be displayed during lunch, and attendees will vote on their favorite. The winning poster will be announced at the closing of the Regional Meeting, and will win a $25 gift certificate. This is a good chance to meet GIS professionals from IL and beyond. Two GEO seniors and one alum got awards last year.

The poster format is best when your material can be most effectively communicated in visual form, so it would be good to limit text to brief statement. Poster should be clearly legible from a distance of four feet. Poster will be displayed on a 4' by 8' (landscape-oriented only) poster board supplied by the host. Posters will be graded based on organization, visual presentation clarity, content, and significance.

To be considered for extra credit, you should do the following:
1. By April 7 (Week 2 Fri): submit a draft poster in ppt file on D2L dropbox ExtraCredit. Feedback will be provided if submitted in time.
2. By April 14 (Week 3 Fri): submit a revised poster file in ppt file on D2L dropbox ExtraCredit and email the poster to contact@ilgisa.org.
3. On April 28 (Week 5 Fri): stand by your submission during lunch to answer any attendee questions in DePaul Center 8th Floor Conference Center.

Extra credit A is graded as follows:
- 5 points: do all of three tasks above and good effort in revision and good quality poster
- 4 points: do all of three tasks above and good effort in revision
- 3 points: do all of three tasks above but minimal revision was made
- 2 points: do some of three tasks above

B. ILGISA Map Competition: enter the 2017 ILGISA Map Competition – Traditional Map Category. The theme this year will be "Most Interesting Map!". There are two categories in this Map Competition: traditional map category and web mapping category. Topic/theme is open, and no data is being provided.

Submissions for the traditional map category shall include a 24 x 36 inch PDF map and a brief report (1 page) containing executive summary (brief abstract in 1 paragraph), methodology (description of any analysis techniques and considered factors), and results. Entries will be ranked with a 1 through 5 based on cartographic quality, analytical techniques (if applicable), and overall clarity.

Student and professional entries will be scored separately. It is requested that the top three finalists from each category give a 20 minute presentation at the 2017 Conference explaining their entries. Winner (student and professional) from each category will receive a $50 gift card.

To be considered for extra credit, you should do the following:
- By May 25 (Week 9 Thur): submit a draft map and report on D2L dropbox ExtraCredit. Feedback will be provided if submitted in time.
- By June 1 (Week 10 Thur): submit a revised map and report on D2L dropbox ExtraCredit and email the submission to contact@ilgisa.org.

Extra credit B is graded as follows.

- 3 points: do all of two tasks above and good effort in revision and good quality poster
- 2 points: do all of two tasks above and good effort in revision
- 1 points: do some of two tasks above

6.6 Project: <u>if you are a graduate student</u>, you need to propose and complete a final project that uses Python to perform a geoprocessing task in the area of your interest. You should submit a tool written in Python as a final product along with the documentation of the tool you created. The proposed project should meet the following minimum requirements:

The minimum requirements of a proposed project	# required
# Python data types {strings, numbers, lists, tuples, dictionary, date & time}	3
# Python operations, such as operators, and built-in functions and methods • Generic operators (eg. ==,!=, =, +=, and, or, not, in, not in) • Strings (eg. +, [], in, len(),upper(), find(), strip(), split(), replace()) • Numbers (eg. +, -, /, *, **, int(), float(), abs()) • Lists (eg. len(), max(), min(), append(), count(), insert(), remove())	6
# Python conditional statement and loop structure (if, while, for)	2
# ArcPy geoprocessing tools, functions and classes • Tools/functions (eg. Buffer, SelectLayerByAttribute, CalculateField, GetCount, SearchCursor, UpdateCursor, GeocodeAddresses) • Classes (eg. SpatialReference, Extent, Cursor, Field) • Functions (eg. Describe, Exists, ListFeatureClasses, ListFields)	6
Others—for example, • Text file reading & writing • User keyboard input (eg. raw_input(), ArcPy GetParameter()) • ArcPy modules (eg. Data Access, Mapping, Spatial Analyst) • ArcGIS Python script tools (eg. Python toolboxes, Python add-ins) • Python modules & functions (eg. math, random, datetime, csv)	1

A tool defined by the project proposal will usually perform tasks that cannot be accomplished effectively through manual processes. A well-conceived tool will make a good use of Python fundamentals like conditionals, iterations, and taking a user input, and ArcPy geoprocessing tools. For example, a tool you propose to create can accomplish a task such as the following:

Python as a calculator
- Calculate descriptive statistics from data (e.g., calculate average from the list of numbers)
- Calculate the distance or heading between POIs using Pythagorean theorem
- Count the number of place names in historical records

Python as a data processing tool
- Process existing data to create new variables (e.g., convert lat/long in DMS to decimal degree)
- Geocode POIs stored in a csv file in batch
- Check whether data values are missing or unusual, and correct the data value if needed

Python as a data analysis tool
- Summarize characteristics of population near facilities in many metropolitan areas
- Monitor changes in precipitation by watersheds over time in the US
- Identify activity patterns from GPS trace data or detect outliers (or noises) from data

Python as an application development tool
- Identify suitable sites based on a user input (eg. what is the best city to live?)
- Build a tool that is designed to increase situation awareness given a POI
- Create a series of thematic maps by different neighborhoods in a city

If you're a graduate student, project is required to pass the course. Maximum 15 points are assigned to project. Total 115 points will be calculated as 100% of the total grade when a grade is submitted. A proposal is due on 5/28 (week 9 Sun), and final product (that contains Python script, data and documentation) is due on 6/9 (week 11 Fri). Guidelines will be provided.

Grading scale: A = 93-100%; A- = 90-92.99%; B+ = 87-89.99%; B = 83-86.99%; B- = 80-82.99%; C+ = 77-79.99%; C = 73-76.99%; C- = 70-72.99%; D+ = 60-69.99%; D = 50-59.99%; F = 0-49.99%

Late Work Policy: Late work will be accepted with 20% of the total grade deducted for each day being late. Extensions can be requested if needed, but will be only granted if excused. This policy applies to exercises only. Although I will accommodate to ongoing progress in the class, if group exercises are not completed in class, it is expected that your group will complete exercises in time through collaboration outside of the class.

Makeup Exam/Incomplete Grade Policy: A makeup exam or an incomplete grade can be arranged or granted only when credible dire and documented medical or family situations arise and these circumstances are communicated in a timely fashion.

7. Learning Objectives by Modules

Module 1: Script Editors and Model Builders
- Get familiar with script editors
- Build a model using ArcGIS ModelBuilder
- Create scripts from ArcGIS tools

Module 2A: Python fundamental I – data types and operations
- Get familiar with Python's standard (or built-in) data types: numbers, strings, and lists
- Describe how an index positioning system works in strings and lists
- Distinguish functions, methods, and modules

Module 2B: use Python parser for labeling in ArcGIS
- Use methods for manipulating strings
- Define your own function
- Custom-label features using a Python parser in ArcGIS

Module 3A: Python fundamental II – workflow control
- Write conditional statements
- Use while loop structure
- Use for loop structure

Module 3B: use conditional statements for labeling and field calculator in ArcGIS
- Get familiar with list methods
- Use conditional statements for labeling in ArcGIS
- Use conditional statements for field calculator in ArcGIS

Module 4A: Introduction to ArcPy
- Understand how ArcPy is organized

- Differentiate ArcPy functions, clasess, and modules
- Use environment settings
- Describe the data

Module 4B: Batch processing with ArcPy

- Get familiar with List Object functions
- Perform batch geoprocessing
- Perform multiple geoprocessing tasks

Module 5A: manipulate geospatial data using Cursors

- Work with SearchCursor
- Work with UpdateCursor

Module 5B: work with text files

- Read a text file
- Write a text file

Module 6A: access map document elements (if time allows)

- Reference map document
- Work with data frames and map layers
- Work with page layout elements

Module 6B: create a map series (if time allows)

- Add and update a map layer using a layer file
- Create a map series using Cursor

8. Miscellaneous

Attendance/Absentee Policy: Consistent with university's policy, all students are expected to attend class meetings. Unless absence is explained on medical or compassionate grounds (documentation is required), absence from any classes is grounds for a grade adjustment.

Academic Honesty and Plagiarism: Academic honesty and integrity are expected at all times. Academic dishonesty, such as cheating or copying during exams, will be punished severely. Plagiarism – using someone else's work without acknowledgment and, therefore, presenting their ideas or quotations as your own work – is strictly forbidden. DePaul University officials will be informed of any instance of academic dishonesty and notification will be placed in your file. Please read the DePaul Academic Integrity Resources page (http://academicintegrity.depaul.edu/Resources/index.html) for definitions and explanations of plagiarism and the University's Academic Integrity expectations for students. Cutting and pasting text taken directly from a web-site without appropriate referencing and quotation marks is plagiarism and is forbidden. Submitting work that has any part cut and pasted directly from the internet is grounds for an automatic grade of zero.

Accommodations: Any student who requires assistance is asked to contact the University's Center for Students with Disabilities (CSD) (Phone 773/325-1677, TTY 773/325-7296, Fax 773/325-7396, http://studentaffairs.depaul.edu/studentswithdisabilities).They will be able to assist both student and faculty. If you have a condition that requires accommodation from the Productive Learning Strategies program (PLuS Program) please contact them at the Student Center room 370 (Phone 773/3251677 or online: http://studentaffairs.depaul.edu/plus/

University Center for Writing-Based Learning: Collaborates with writers from all disciplines, backgrounds, levels of expertise, and roles within the University community. Their goal is to help

develop better writers along with better writing and reflection through continual revision. If you need assistance with writing assignments, they can be contacted at: 773.325.4272 (LPC) or wcenter@depaul.edu

GIS lab open hours
- Geography GIS Lab: http://las.depaul.edu/academics/geography/Pages/Geographical-Information-Systems.aspx
- GIS lab in SAC: http://qrc.depaul.edu/hours.htm or the GIS lab door.

Labs with ArcGIS: SAC GIS lab (SAC 224), Geography GIS lab (3135 W 990 Fullerton), SAC 268, Richardson Library, Loop Library, and Daley 1327.

To install ArcGIS in your computer: ArcGIS for Desktop 10.5 free trial that is good for 60 days can be downloaded from http://www.arcgis.com/features/free-trial.html?origin=arcgiscom-Desktop. You can purchase a 1 year ArcGIS for Desktop Advanced for $ 100 with free ArcGIS online subscription at http://www.esri.com/software/arcgis/arcgis-for-home.

To access ArcGIS in both PC and Mac remotely: go to DePaul Virtual Lab http://vlab.depaul.edu

Department of Geography Learning Goals—GEO 345/445 addresses 1), 5), 6), and 7).

Courses in the Department of Geography teach students:

1) Understand spatial patterns and processes of modification of the Earth's physical and cultural landscapes
   a. As social constructions.
   b. As systems that link the Earth with human society in interdependent, dialectical relationships, and
   c. Through mapping and visualization.
2) Understand the concept of scale as a spatial phenomenon that ties the local, the regional, the national, the transnational, and the global in a system of interaction.
3) Understand the phenomenology of the discipline of Geography—most importantly, "space", "place", "landscape," "region," and "location".
4) Distinguish that spaces, places, and so on, may have both objective and subjective/symbolic dimensions.
5) Develop research and writing competences that would allow you to:
   a. Formulate a cogent research question about the spatial character of a physical, socio-cultural, or environment-societal phenomenon,
   b. Write about it in ways that reflect analytical and critical thinking, and
   c. Ethical concern over social and environmental justice, consistent with the University's social mission.
6) Engage competently in qualitative and quantitative spatial analysis, and with exercises that are concerned with explaining spatial regularities (for example, the spatial calculus behind the location of retail commerce in Chicago, or transnational flows of capital).
7) Learn the basic utility and use competently one or more of the information technologies that are now redefining the logistical limits of spatial analysis: geographic information systems (GIS) and remote sensing.
8) Achieve greater general knowledge of the world, its regions, its physical systems, its cultures, and political-territorial divisions.