GE/ES 340 GEOGRAPHIC INFORMATION SYSTEMS (GIS)
IES Abroad Freiburg

DESCRIPTION: This course introduces the fundamental concepts of Geographic Information Systems (GIS) and the major functionality of the ArcGIS Desktop software package. After presenting various definitions of GIS, the basic principles of modelling the infinitely complex real world in a computer system with limited resources are portrayed. Different data models, such as vector and raster data, and their respective (dis-)advantages are discussed and the relational data model is introduced. The essentials of geographic reference systems and transformations are shown and possible problems related to working with data from different data sources are discussed. Basic vector as well as raster data analyses are conducted and the most commonly used tools for data analyses are presented. Wherever possible, data from original research projects or the students’ hometowns is used.

This course has an extensive practical component. Typically, afternoon sessions take place in the computer lab where students learn solving spatial problems using GIS software. Sample data is either provided by the instructor or students research datasets for their respective hometowns online. The students work on specific tasks individually or in small groups in order to deepen the understanding of basic concepts of GIS. The results are presented and are evaluated as part of the class participation grade. Through the course, the students should acquire a knowledge base that enables them to conduct their own GIS projects (e.g. in the course of their Master thesis), including data collection, preparation, analyses and presentation in form of maps. Furthermore, the students learn how to work with the software ArcGIS that is widely used in public administration, private enterprises, and non-profit organizations.

CREDITS: 3

CONTACT HOURS: 46

LANGUAGE OF INSTRUCTION: English

PREREQUISITES: Basic knowledge of geographic reference systems as well as data formats, computer literacy.

METHOD OF PRESENTATION:
- Lectures
- E-Learning
- Student presentations
- Tutoring/practical exercises
- Group work
- Application of Moodle

Additional material comes from Moodle. This platform is also the place to share assignments and to follow recent developments in the field. Participation is part of the student’s grade, therefore it is expected that all students contribute during classes.

REQUIRED WORK AND FORM OF ASSESSMENT:
- Written Assignment – 20%
- Midterm Evaluation – 20%
- Final Exam – 50%
- Class Participation – 10%

Written assignment
The assignment takes the form of a project report (around ten pages); a number of topics for data analyses are named by the instructor. Based on the lectures (theoretical input) and E-Learning modules (practical knowledge), each student works on a small GIS project from data search to data presentation.

Mid-term evaluation
The mid-term assessment is an in-class oral presentation of selected journal papers. Each student summarizes one or two papers selected by the instructor. The presentations will be held during the sections that the topic belongs to, respectively.

Final exam
The final assessment is a written exam and tests the students’ overall knowledge and ability to analyze and apply the concepts presented during the course.

Class participation
As the students are expected to come to class having completed required readings, work sheets, E-Learning modules and join the seminar discussions, participation in the seminar discussions based upon the compulsory readings and teaching introductions given by the instructors will be evaluated.

LEARNING OUTCOMES:
By the end of the course students will be able to:

- Implement the principles of GIS as a digital representation of complex spatial interactions in the real world.
- Search for possible spatial data sources and critically review their quality, comprehensiveness, and suitability for the respective task.
- Visualize spatial data and the respective attributes.
- Conduct basic analyses using vector data as well as raster datasets.
- Produce maps showing the results of spatial analyses in an easy-to-understand manner.
- Analyze and discuss the potential as well as the constraints of GIS for spatial analyses on different scales.
- Manage complex spatial problems and a complex and powerful software package.

ATTENDANCE POLICY: IES Abroad courses are designed to take advantage of the unique contribution of the instructor and the lecture/discussion format is regarded as the primary mode of instruction, regular class attendance is mandatory. Every unexcused absence will lower your grade by 5%.
Tests/presentations missed during unexcused absences cannot be made up.
If you miss a class it is your responsibility to make up on everything that was covered in class.
If you can’t attend class because you are sick please go and see a doctor. S/he will issue a doctor’s note.
Without that your absence will count as unexcused absence.

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<th>Session</th>
<th>Content</th>
<th>Assignments</th>
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<tr>
<td>1</td>
<td>General Introduction, Introduction of ArcGIS Software</td>
<td>This session gives a presentation of the course content followed by an overview of the different proprietary as well as open-source software packages that can be used for spatial analysis. The ArcGIS software package is introduced.</td>
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<td></td>
<td>Definition of GIS, Basic Data Models</td>
<td>Required Readings:</td>
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| 2 | Several definitions of GIS used by different actors are presented and discussed. Fundamental data models (vector data vs. raster data) are introduced and ways of systematically representing the complex real world in computer software are shown. Furthermore, the georelational data model as the foundation for spatial analysis is portrayed. | *ESRI (2014): What is ArcGIS? Online: [http://bit.ly/1qs8VWR](http://bit.ly/1qs8VWR)*  
*ESRI (2014): Introduction to ArcGIS. Online: [http://bit.ly/1kO5oC1](http://bit.ly/1kO5oC1)*  

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<th>3</th>
<th>Georelational Data Model</th>
<th>Required Readings:</th>
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| 3 | The students gain understanding of the principles of referencing geodata, based on varying reference systems. Furthermore, they learn how to transform datasets having different coordinate reference systems. As spatial data – even for small GIS projects – often is provided in different reference systems, understanding the differences is essential. | *ESRI (2014): Databases and ArcGIS. Online: [http://bit.ly/1Ajyxuh](http://bit.ly/1Ajyxuh)*  

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<th>Databases, Data Formats, Value Ranges</th>
<th>Required Readings:</th>
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| 4 | During this session, an overview is given on the different ways of storing spatial data. Particular attention is given to data bases in general, and geodatabases in particular. The importance of database normalization is emphasized and the three basic Normal Forms are introduced. Different data types are mentioned and their respective (dis-)advantages are discussed. Eventually, data ranges are explained and their application is shown. | *ESRI (2014): Databases and ArcGIS. Online: [http://bit.ly/1Ajyxuh](http://bit.ly/1Ajyxuh)*  

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<th>5</th>
<th>Relational Database Management Systems (RDBMS)</th>
<th>Required Readings:</th>
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<td>5</td>
<td>Relational data base management systems (RDBMS) as the most common way of storing spatial data is explained extensively. In the second part of this session, the Structured Query Language (SQL) is introduced and students learn how to apply basic SQL terms. Furthermore, they learn to link different datasets using ‘join’ and ‘relate’.</td>
<td><em>Huisman, O. and de By, R.A. (2009): Principles of Geographic Information Systems. An introductory</em></td>
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<th>6</th>
<th>Topology and Data Consistency</th>
<th>Required Readings:</th>
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<td>6</td>
<td>In this session, an overview is given of data topology in general and topology of spatial data in particular. Students learn why data consistency is important and how to make sure that data is captured, edited, and</td>
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7 Geometric and Topologic Queries, Toolboxes

- The students learn what the differences are between geometric and topologic queries, how to design these queries and how to execute them in ArcGIS. As a basic principle they get to know the Egenhofer-Matrix as well as the Clementinis-Matrix. An overview is given about the most commonly used Toolboxes and Tools within the software environment and examples are provided when the respective tools can be used.

8 Modifiable Area Unit Problem (MAUP), Ecological Fallacy, and GIS

- The Modifiable Area Unit Problem (MAUP) as one of the challenges in spatial analyses is introduced and ways of solving this issue are presented. Furthermore, the ecological fallacy as an additional potential trap in geodata analyses is discussed. Students will get to know a standardized way of translating real world problems into a smooth GIS workflow. Therefore, complex problems are disaggregated into smaller problems that can be solved using individual GIS tools.

9 How to Search and Find Geodata, Geodata Infrastructures, Selected Examples

- This session concentrates on finding suitable geodata for different kinds of research questions. Several online databases as potential data sources are introduced and students practice data import into GIS. Standardized geodata infrastructures, such as the GDI-DE, INSPIRE, and an online database of the Food and Agriculture Organization of the United Nations are portrayed. The students learn to critically evaluate the suitability of datasets for their respective research project.

10 Raster Data Analysis

- While the main focus of this course is on vector data analysis, this session focusses on the analysis of raster data. A wide range of possible analyses are

**Required Readings:**
11 Georeferencing Raster Data

In the course of spatial analysis projects, unreferenced raster data, such as scanned maps and survey plans, often form the foundation of the analysis. Therefore, the students learn how to georeference raster data based on ground control points. The importance of referenced data is emphasized using the example of multi-temporal satellite images of the Amazonian pioneer front. Polynomial transformations are introduced and the implementation of the process in GIS is shown.

Required Readings:

12 Capturing Data

Different ways of capturing data are presented and evaluated. Students get to know the basic principles of GPS usage in the field as well as more sophisticated devices, such as ArcPad and ArcMobile. Limitations and potentials of using these devices in the field are discussed and students gain an understanding of which tools should be used in which environments.

REQUsted READINGS:
- ESRI (2014): Introduction to ArcGIS. Online: http://bit.ly/1kO5oC1

• Tripathi, R. et al. (2014): Climate change, urban development, and community perception of an extreme flood: A case study of Vernonia, Oregon, USA. In: Applied Geography 46: 137-146


RECOMMENDED READINGS:
• Longley, P. (2011): Geographic information systems & science. Hoboken