University of Isfahan

Geospatial Information System (GIS) Engineering Graduate Program

Curriculum

Department of Geomatics Engineering

Faculty of Civil and Transportation Engineering

University of Isfahan

January 8, 2024

Introduction to GIS

Geospatial information system (GIS) is a vital component of the scientific and technological landscape, encompassing the collection, management, display, and analysis of geospatial data. This field is crucial for addressing various challenges in urban and regional management, environmental conservation, land use planning, and other related areas.

Government agencies are significant producers of diverse geospatial information, which is utilized by various organizations and ministries, such as power, road, urban development, agricultural Jihad, municipalities, and others, to address their specific needs, make informed decisions, and perform daily tasks. GIS graduates can contribute to these organizations by enhancing the process of information production and ensuring the effective acquisition, updating, management, and utilization of geospatial information. Additionally, they can leverage their skills to improve the services and problem-solving capabilities of these organizations.

The private sector, who is responsible for numerous construction and development projects in the country, also offers a suitable employment opportunity for GIS graduates. These projects often rely heavily on GIS and geospatial information, making it an attractive career path for individuals with expertise in this field.

The main **objectives** of the revised program are the followings:

1. Teach fundamental and applied knowledge aligned with current global issues
2. Provide novel insights for systematic investigation to solve spatial problems
3. Educate required specialist human resources for scientific centers and universities
4. Educate required specialist human resources for organizations and centers related to spatial data to involve in the country's execute projects in the collection, production and management of spatial data and information
5. Contribute to publicity of spatial information usage through provision of a required infrastructure to raise citizens usage of spatial data for their daily and specialized activities
6. Help to improve knowledge production through effective contribution in international communities related to spatial data management

Importance

With respect to the advancements in the production of mass spatial data from various views including volume, variety, structure, content, quality and speed over the last decades, application of efficient and effective methods for management and usage of the data is indispensable. In addition, this large volume of data, has created new fields for spatial data usage, where this has increased these data users. As a proof, maps and related spatial and aspatial data on the mobile devices and their use by regular users for daily analysis like routing, finding nearest public service locations, and show current location on a map. Thus, development of new methods for the management of this information including storage, retrieval, analysis and visualisation is necessary.

A GIS employs technologies in various domains like hardware, software and network and is grounded on computer science, math, geographical sciences and information technologies and communications (ITC). GISs provide a suitable infrastructure for the management and efficient interaction of users with spatial data at various levels. Development of efficient methods for spatial data entry, quantitative and qualitative analyses of spatial data, development of products derived from spatial data, and finally enhancement of visualization and presentation methods to technical as well as public users.

Role, abilities and capabilities of graduates

The principal capability of this major graduates is in efficient interaction with spatial data and effective employment of spatial information in various decision making processes which may be applied to the following application areas:

- Management and optimization of map production and other spatial information processes using available maps, terrestrial and aerial imageries, and other remotely sensed data, land surveying, and other novel digital spatial data collection methods
- employment of spatial data in design, implementation and management of civil engineering, environmental and military projects
- optimization of design and implementation of civil engineering, environmental, military, ... projects accounting for effective spatial factors as well as time and human resource requirements
- Development and employment of spatial databases of organizations and public municipal services centers for their effective use in future decission makings and improved interactions with citizens
- modeling and simulation of real world spatial processes using spatial and aspatial data stored in spatial databases to predict future state for enhanced decision making in a minimum time and with minimum budgets
- Efficient management of municipal, rural, agricultural, forest, and pasture cadastral data through storage, retrieval, analysis and visualization of spatial data and legal ownerships at various scales

Table 1: Master of engineering courses

Row	Type of course units	Number of units	Comments
1	Core	14	See table 3
2	Elective	12	See table 4
3	Thesis	6	

	Sum	32	

Table 2: PhD courses

Row	Type of course units	Number of units	Comments
1	Core	-	-
2	Elective	18	Table 3 and 4
3	Thesis	18	
	Sum	36	

Required core courses

1. It is mandatory for master students to pass the courses in Table 3
2. Phd Students are not required to pass any core course

Table 3: core courses

Row	Course	Units		Hours		Prerequisite
		Theory	Hands-on	Theory	Hands-on	
1	Advanced GIS	3	0	48	0	-
2	Spatial Data Analysis	3	0	48	0	Advanced GIS
3	Computational Intelligence in GIS	3	0	48	0	-
4	Geospatial Web and Database Systems	3	0	48	0	-
5	Research methods in Earth Sciences	2	0	32	0	-

Elective courses

1. Master students must select and pass 12 units (4 elective courses) from Table 4
2. PhD students must select and pass 18 units (a mix of 6 elective or core courses) from Table 3 and Table 4

Table 4: Graduate level elective courses

Row	Course	Units		Hours		Prerequisite
		Theory	Hands-on	Theory	Hands-on	
1	Computational geometry	3	-	48	-	-
2	Spatial Multi criteria decission making	3	-	48	-	-
3	Spatial Quality control and uncertainty modeling	3	-	48	-	-
4	Spatio-temporal data mining	3	-	48	-	-

Row	Course	Units		Hours		Prerequisite
		Theory	Hands-on	Theory	Hands-on	
5	Geographcal information systems and environmental modeling	3	-	48	-	-
6	Spatial optimization with meta-heuristic methods	3	-	48	-	-
7	Spatial planning and land use planning	3	-	48	-	-
8	3D visualization and augmented reality	3	-	48	-	-
9	Spatial Data structure and algorithms	3	-	48	-	-
10	Spatial analysis of remotely sensed data	3	-	48	-	-
11	Computational movement analysis and modeling	3	-	48	-	-
12	Spatial data fusion	3	-	48	-	-
13	Land administration systems and spatial data infrastructure	3	-	48	-	-
14	Algebraic principles of geographical information systems (GIS)	3	-	48	-	-
15	Design and implementation of a GIS	3	-	48	-	-
16	Temporal GIS	3	-	48	-	-
17	Remote sensing for GIS	3	-	48	-	-
18	Decentralized spatial computing	3	-	48	-	-

List of Core and Elective Courses

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Spatial Optimization Using Metaheuristic Methods.... 19
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Spatial Data Fusion.... 25
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Core Courses

Advanced GIS

BASIC INFORMATION

Place in curriculum, title and semester: core, Advanced GIS, S1
Number of credits: 3

COURSE PREREQUISITES

COURSE CO-REQUISITES

TEACHERS

The person in charge: Dr. Farid Cheraghi
Office location: Department of Geomatics Engineering, Faculty of Civil Engineering & Transportation, University of Isfahan, Isfahan, 81746-73441, Iran
Phone number: +983137935278
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Other instructors: ---

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	---	---	---

COURSE OBJECTIVES

Introduce spatial data theoritical foundations, spatial data infrastructure (SDI) and the steps toward the design and implementation of an enterprise GIS and spatial database

REQUIRED STUDENT RESOURCES

References:

1. Worboys, M. and Duckham, M. (2004). GIS: A Computing Perspective (2nd Edition), CRC Press.
2. Burrough, P.A., MacDonnell, R.A., Lloyd, C.D. (2015). Principles of Geographical Information Systems: (3rd Edition), Oxford University Press.
3. Longley P.A., Goodchild M.F., Maguire D.J. and D.W. Rhind. (2005). Geographic Information Systems and Science. John Wiley (Second Edition).
4. Harmon, J.E., and SJ. Anderson (2003). The Design and Implementation of Geographic Information System. John Wiley.
5. Abdul- Rahman A, Pilouk M., 2008, Spatial data modeling for 3D GIS, Springer.

Web linkes: ---
Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	A review of the principles of project management
2	Design and implementation models (Waterfall, Spiral, UML, RUP)
3	Needs assessment in GIS projects
4	Spatial and attribute data collection, entry and editing
5	Software development (design environment, software architecture, customization and test)
6	Communication, education, culture building; support and recurring development of a GIS system
7	Principles, concepts, components and pillars of an SDI
8	Models and collaboration theories of voluntary participation in an SDI
9	A review of SDI's standards, Metadata standards; Catalog server and geoportal
10	Critical challenges in the development of an SDI
11	Design of a spatial database (conceptual, logical and physical models)
12	Database normalization, Query languages, Indexing and storage, Spatial queries
13	Multi-dimensional GIS; 3D data models and their applications; Temporal data models and their applications
14	A review of visualization fundamentals including map, image-map, 3D visualization, novel developments in visualizations (e.g. virtual reality, augmented reality, etc.)
15	Tools and elements of cartography (color, darkness, texture, size, shape and direction)
16	Cartography of nominal, ordinal, interval, temporal, etc. data; Visualization as an integral part of spatial data analysis

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2 points
Comprehensive Assignment	3 points (at max)
Mid-Term Exam	7 points
Final Exam	8 points
Total Points	20 points

Advanced Spatial Analysis in GIS

Basic Information

Place in curriculum, title and semester: core, advanced spatial analysis in GIS, S2
Number of credits: 3

Course prerequisites

Advanced GIS

Course co-requisites

Teachers

The person in charge: Dr. Farid Cheraghi
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Other instructors: ---

Weekly Hours

Theory	Problem Solving	Laboratory	Guided learning
3 h	yes	---	---

Course Objectives

Introduce to various spatial data peculiarities, spatial modeling, spatial data analysis, design and implementation of various spatial and spatio-temporal data analyses

Required Student Resources

References:

1. Smith, MJ de, Goodchild, M.F. and Longley, P. A. 2007. Geospatial Analysis, A comprehensive Guide to Principles, Techniques and Software Tools, Matador, Leicester, UK.
2. Oyana, Tony J. and Margai, Florence M. 2016. Spatial Computational Methods, CRC Press Taylor & Francis Group.
3. O'Sullivan, D. and Unwin, D. 2010, Geographic Information Analysis, J Wiley, New Jersey.

Optional:

1. Haining, R. 2003, Spatial data analysis, theory and practice. Cambridge University Press, Cambridge, UK.
2. Miller, H. and Han, J. (eds.), 2005. Geographic Data Mining and Knowledge Discovery. CRC Press.
3. Fotheringham, A.S. Brandson, C., and M. Charlton (2003) Geographically Weighted Regression, John Wiley & Sons

Web linkes: ---
Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	A review of spatial analysis functions and operators like neighbourhood window functions, overlap distance and map algebra, vector and raster operators, and various data transformations
2	Statistics and geostatistics concepts
3	Spatial autocorrelation
4	Spatial dependency and spatial correlation
5	Processes and patterns in spatial analysis
6	Exploratory spatial data analysis
7	Hypothesis test, statistical conclusion in spatial data analysis
8	Anamoly and hotspot detection in spatial data
9	Knowledge-based and data-driven methods in spatial data modeling
10	Fuzzy logic and neural network application in spatial modeling
11	Stochastic processes modeling
12	Discrete (point, line, area) and continuous data analysis methods
13	Analysis and discovery of spatio-temporal patterns
14	Pre-processing, filtering, and dimension reduction
15	Spatial processes and knowledge, correlation, and dependency rules extraction steps
16	Classification, clustering, and prediction; data mining tools and applications in spatial problems

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2 points
Comprehensive Assignment	3 points (at max)
Mid-Term Exam	7 points
Final Exam	8 points
Total Points	20 points

Spatial Database and Web GIS

Basic Information

Number of credits: 3
Number of hours: 48

Course Prerequisites

Course Co-requisites

Teachers

The person in charge: Dr. Jamshid Maleki
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Other instructors: ---

Weekly Hours

Theory	Problem Solving	Laboratory	Guided learning
3 h	yes	---	---

Course Objectives

Providing the basics of Internet location information systems, location web services, location-based services and interactivity.

Required Student Resources

Main references:

1. Geospatial Web Services Advances in Information Interoperability. By Peisheng Zhan and Liping Di Information Science Reference, 2011.
2. Labrador M.A., Wightman P.M., Perez A.J. (2010). Location-Based Information Systems, Taylor and Francis.

Optional references:

1. Ferraro R., Aktihanoglu M. (2011). Location-Aware Applications, Manning Publications.
2. Brimicombe A., Li C. (2010). Location-Based Services and Geo-Information (Mastering GIS:. Technology, Applications & Management), Wiley and Sons.
3. Frattasi, S. and Della Rosa, F. (2017). Mobile Positioning and Tracking: From Conventional to Cooperative Techniques, 2nd Edition, John Wiley & Sons

Web linkes: ---
Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Spatial database: • Database definition, file-based approach versus database approach • Database design and implementation: modeling (conceptual, logical and physical), familiarity with UML. • Database management: database management system, familiarity with common types of DBMS such as SQL Server, Oracle and Postgre SQL. • Relational data model: types of relationships (one-to-one, one-to-many, and many-to-many), converting the conceptual model into a relationship, normalizing relationships (types of dependencies and normalization levels), • SQL language • Familiarity with Postgre SQL database and PostGIS plugin. • Types of spatial questions and answers that can be designed in the Postgre database
2	Introduction to Web GIS: • Definitions and history • Web basics (HTTP, HTML URL) • Main components of WebGIS • Applications of Web GIS and location web services
3	Standards: • OGC and ISO standards in the field of spatial data • Comparison of standards
4	Location web services: • Overview of OGC activities to achieve spatial interactivity • GML and CityGML • Web Service Catalog (CSW) • Map service (WMS, WFS, WCS and W3DS) • Processing services (WPS) • Measuring services (SOS, SPS) • Basics of chaining location web services
5	Web Mapping
6	Introducing programming languages and technologies: • Introduction to client-side programming technologies • Data exchange formats (XML, JSON, AFM) • Application server technologies (IIS, Apache) • Introducing server technologies (Map Server, Geoserver, ArcGIS Server) • Server-side languages (.NET, Java, Python)
7	Location-based services: • Definition, components and elements • Applications of location-based services • Positioning methods • Privacy standards and protocols

	• Context aware systems and different levels of context awareness

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2 points
Comprehensive Assignment	3 points (at max)
Mid-Term Exam	7 points
Final Exam	8 points
Total Points	20 points

Computational Intelligence in GIS

BASIC INFORMATION

Number of credits: 3
Number of hours: 48

COURSE PREREQUISITES

COURSE CO-REQUISITES

TEACHERS

The person in charge: Dr. Jamshid Maleki
Office location: Department of Geomatics Engineering, Faculty of Civil Engineering & Transportation, University of Isfahan, Isfahan, 81746-73441, Iran
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Other instructors: ---

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	yes	---	---

COURSE OBJECTIVES

Familiarizing students with mathematical concepts and the foundations of computational intelligence such as topology, graph theory, and logic, as well as the key components of computational intelligence including cellular automata, agent-based modeling, and neural networks.

REQUIRED STUDENT RESOURCES

Main references:

1. Engelbrecht A. P. (2007). Computational Intelligence, an Introduction, Second Edition, John Wiley & Sons Ltd, England.
2. Crooks, A., Malleson, N., Manley, E., & Heppenstall, A. (2018). Agent-based modelling and geographical information systems: a practical primer. Sage.
3. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT press.

Optional references:

1. Wang, L. X. (1996). A course in fuzzy systems and control. Prentice-Hall, Inc.
2. Liu Y, (2009). Modelling Urban Development with Geographical Information Systems and Cellular Automata, Taylor & Francis Group, LLC, USA
3. MacAl C.M., M.J. North, (2010). Tutorial on agent- based modelling and simulation. Journal of Simulation 4, 151-162

4. Geospatial Simulations". Working paper 110, Centre for Advanced Spatial Analysis, University College London.

Web linkes: ---

Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Topology: • Spatial relationships and their types • Topological relationships • Definition of connected topology, homomorphism, topological inversion and topological relations • Examples of topology application in spatial information
2	Graph: • Definition of graph, types of graphs, types of girth, passage, tour and path • Algorithms for determining the best path • Examples of graph applications in spatial information
3	Set theory and fuzzy logic: • An introduction to set theory and classical logic • Fuzzy set of membership functions and fuzzy set operators • The principle of expansion and fuzzy relations • Fuzzy inference engine and fuzzy expert systems • Examples of application of set and fuzzy logic in spatial information
4	Neural Networks: • Definitions and basics and objectives of use • The concept of learning (training) and its types • Types of deep neural networks, deep learning and their advantages and limitations in relation to spatial problems • Applications of deep neural networks, deep learning in solving spatial problems
5	Cellular automata: • Definitions of vector automata, fuzzy cellular automata • Basics and main components of cellular automata models (including cell states, types of neighborhoods and transition rules) • Applications of cellular automata in modeling spatio-temporal phenomena
6	Agent-based models and spatial information systems: • Definitions and basics and examples of dynamic spatial phenomena • Design of Agent-Based Models: Definition of agents and their characteristics, behaviors, strategies, and interactions • Implementation of calibration and validation of agent-based models • Applications of agent-based models in spatial decision-making

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2	points
Comprehensive Assignment	3	points (at max)
Mid-Term Exam	7	points
Final Exam	8	points

Total Points	20 points

Elective Courses

Spatio-temporal Data Mining

BASIC INFORMATION

Place in curriculum, title and semester: elective, spatio-temporal data mining, -
Number of credits: 3

COURSE PREREQUISITES

COURSE CO-REQUISITES

TEACHERS

The person in charge: Dr. Farid Cheraghi
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Other instructors: ---

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	yes	---	---

COURSE OBJECTIVES

Define big data, and introduce the importance of pattern and data mining and knowledge discovery, introduce common and popular methods for spatial and spatio-temporal data-mining. It requires implementation of various algorithms in a popular programming language.

REQUIRED STUDENT RESOURCES

References:

1. Cervone, G., Lin, J., Waters, N., (2014(, Data Mining for Geoinformatics, Springer, New York.
2. Li, D., & Li, D. (2015). Spatial data mining theory and application. By SpringerNature.
3. Miller, H.J. and Han, J.,)2009(, Geographic Data Mining and Knowledge Discovery, Second Edition, CRC Press

Other references:

4. Han, J., Kamber, M., Pei, J., (2011(, Data Mining: Concepts and Techniques, Third Edition, Morgan Kaufmann.
5. Mitsa, T., (2010), Temporal Data Mining, Chapman & Hall/CRC Press.
6. Maimon, O. and Rokach, L., (2005), Data Mining and Knowledge Discovery Handbook, Second Edition, Springer US.

Web linkes: ---

Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Principles of data mining; Spatio-temporal data mining; Introduce data mining applications in spatial analysis
2	Introduce statistical parameters which describe data (descriptive statistics)
3	Data similarity and disimilarity measurement methods; Data visualization methods
4	Data prepration and cleaning methods; mixed methods and data reduction methods; Data transformation and discretisaiton methods
5	Data warehouse principles; Data warehouse modeling, data cubes, and OLAP; Data warehouse implementation
6	Recurrent patterns exploration; recurrent constrained pattern recognition; high dimensional data exploration methods
7	Data classification basics; Decission tree; Bayesian classification and bayesian belief network;
8	Rule-based classification; Artificial neural network based classification; Support vector machine; Other classification methods: meta-heuristic optimization methods, rough-set and fuzzy set methods; Classification quality enhancement methods
9	Clustering basics; paritioning, hierarchical, density-based, grid-based, constrained clustering methods; graph and network clustering; clustering evaluation
10	Introduce outlier detection; probabilistic methods, neighbourhood based methods, cluster-based methods
11	Special topics: discovery of dependency rule using regression methods like GWR
12	A discovery of periodic patterns in temporal data, timeseries data and spatial trajectories Timeseries forcasting; spatial sensor network data mining; spatio-temporal mining of remote sensing data applications

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2 points
Comprehensive Assignment	3 points (at max)
Mid-Term Exam	7 points
Final Exam	8 points
Total Points	20 points

Land Administration Systems and Spatial Data Infrastructures

BASIC INFORMATION

Place in curriculum, title and semester: elective, land administration systems and spatial data infrastructure, -
Number of credits: 3

COURSE PREREQUISITES

COURSE CO-REQUISITES

TEACHERS

The person in charge: Dr. Farid Cheraghi
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Email address: f.cheraghi@cet.ui.ac.ir
Other instructors: ---

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
3 h	yes	---	---

COURSE OBJECTIVES

Teach advanced concepts in land administration systems and creation and management of a spatial data infrastructure. It involves the design and implementation of varous cadastre alogrithms.

REQUIRED STUDENT RESOURCES

References:

1. Williamson, I, S., Enemark, S., Wallace, J., & Rajabifard, A. (2010). Land Administration for Sustainable Development, ESRI Press Academic.
2. Rajabifard, A., Williamson, I., & Kalantari, M. (Eds.). (2012). A National Infrastructure for Managing Land Information, The University of Melbourne. 4. Rajabifard, A., & Coleman, D. (Eds.). (2012). Spatially Enabled Government, Industry and Citizens, Research and Development Perspectives, GSDI Association Press.
3. Rajabifard, A., & Eagleson, S. (Eds.). (2013). Spatial Data Access and Integration to Support Liveability: A Case Study in North and west Melbourne, The University of Melbourne.

Optional references

4. Nedovic-Budic, Z., Crompvoets, J., & Georgiadou, Y. (Eds.). (2011). Spatial Data Infrastructures in - Context. CRC Press.
5. Crompvoets, J., Rajabifard, A., Loenen, B.V., Fernández, T.D. (2008). A Multi-View Framework to Assess Spatial Data Infrastructures. The Melbourne University Press. Melbourne: Australia.
6. Rajabifard, A., & Feeney, M.E. (2003). Developing Spatial Data infrastructures: from Concept to Reality. London; New York: Taylor & Francis.

Web linkes: ---
Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Importance and neccessity of land administration systems (LAS)
2	Implementation and evolution of land administration systems
3	Theory and technical tools for land administration systems: surveying and cadastral mapping, land information management, land administration processes, design and implementation of land administration systems
4	Land registeration systems: land and real estate ownership, propery rights formalism
5	Land valuation and fiscal cadastre; land management and control
6	Policy making in land administration; government, society, and people reliant on spatial data
7	Relations between SDI and LAS
8	LAS evaluation methods
9	SDI concepts and components: importance and neccessity of SDI; theory of spatial hierarchical inference in SDI; strategies and development models in various levels
10	SDI: basic data, metadata, standards, data interoperability and exchange center, policy formulation and user management
11	Technical issues in design and implemenation of an SDI: SDI interoperability, SDI architecture (like service oriented architecture), SDI spatial framework, catalog service in SDI, homogeneity and uniformity in SDI
12	Conclusion on SDI and LAS integration

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2 points
Comprehensive Assignment	3 points (at max)
Mid-Term Exam	7 points
Final Exam	8 points
Total Points	20 points

Spatial Optimization Using Metaheuristic Methods

Basic Information

Number of credits: 3
Number of hours: 48

Course Prerequisites

Course Co-requisites

Teachers

The person in charge: Dr. Jamshid Maleki
Office location: Department of Geomatics Engineering, Faculty of Civil Engineering & Transportation, University of Isfahan, Isfahan, 81746-73441, Iran
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Email address: j.maleki@cet.ui.ac.ir
Other instructors: ---

Weekly Hours

Theory	Problem Solving	Laboratory	Guided learning
3 h	yes	---	---

Course Objectives

Familiarizing students with the basic concepts of meta-heuristic algorithms and collective intelligence, as well as explaining their applications in spatial information science (GIS) with the aim of solving spatial problems.

Required Student Resources

Main references:

1. Brimicombe, A.,)2010(. GIS, Environmental Modeling and Engineering. CRC Press.
2. Faiz, S., & Krichen, S. (2012). Geographical information systems and spatial optimization. CRC Press.
3. Engelbrecht A. P. (2007). Computational Intelligence, an Introduction, Second Edition, John Wiley & Sons Ltd, England.

Optional references:

1. Pourghasemi, H. R., & Gokceoglu, C. (Eds.). (2019). Spatial modeling in GIS and R for earth and environmental sciences. Elsevier.
2. Sanders, L. (editor), (2007). Models in Spatial Analysis. John Wiley.
3. Openshaw, S., and Abrahart, R. J., (2000). Geocomputation. Taylor & Francis, London, UK.

4. Demers, M. N., (2002). GIS Modeling in Raster, J Wiley, New York.
5. Guido Guerra and John Lewis, M. (2002). Spatial Optimization and GIS. Mc Gill University, Arc- User April-June

Web linkes: ---

Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	An overview of general concepts and optimization methods: • The concept of optimization and its models (complexity of problems and algorithms, multi-objective optimization, fuzzy optimization, dynamic optimization, etc.) • Solution space and objective space and their relationship • Optimization methods (mathematical and exact methods, approximate methods, heuristic methods, metaheuristic methods)
2	Single-Solution Algorithms: • Common concepts in single solution algorithms and their problems in solving spatial problems • simulated annealing • Tabu search • Variable neighborhood search • Solving examples of spatial problems using single-solution algorithms
3	Solving spatial problems with evolutionary algorithms: • Basic concepts and types of evolutionary algorithms • Genetic algorithm and its application in solving spatial problems • Solving examples of spatial problems with genetic algorithm
4	Spatial Discrete and Combinatorial Optimization and Ant Colony Algorithm: • Discrete and combinatorial spatial spaces and their characteristics • Defining the solution space in spatial problems and forming the corresponding graph • Types and versions of the ant colony algorithm and their differences • Solving examples of spatial problems with the ant colony algorithm
5	Optimization in continuous space and particle swarm algorithm: • Continuous spatial spaces and optimization in continuous space • Concept of solution (particle), neighborhood and movement in the solution space in spatial phenomena • Solving examples of spatial problems with the particle swarm algorithm
6	Bee colony algorithm: • Basic definitions and concepts • Types of bees, bee behavior in nature and its inspiration in the algorithm space • Defining and determining the parameters of the bee colony algorithm in spatial problems • Solving examples of spatial problems with the bee algorithm
7	Multi-objective spatial optimization: • Methods of combining objectives, dominance of solutions and Pareto solution front • Solving spatial problems with the NSGAII algorithm • Solving spatial problems with multi-objective ant colony algorithm • Solving spatial problems with the multi-objective bee colony algorithm

	• Solving spatial problems with the multi-objective Particle Swarm Optimization (PSO) algorithm
8	An overview of other existing algorithms and their capabilities and limitations

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2	points
Comprehensive Assignment	3	points (at max)
Mid-Term Exam	7	points
Final Exam	8	points
Total Points	20	points

Spatial Multi-Criteria Decision Making (SMCDM)

Basic Information

Number of credits: 3
Number of hours: 48

Course Prerequisites

Course Co-requisites

Teachers

The person in charge: Dr. Jamshid Maleki
Office location: Department of Geomatics Engineering, Faculty of Civil Engineering & Transportation, University of Isfahan, Isfahan, 81746-73441, Iran
Phone number: +983137935289
Homepage: https://cet.ui.ac.ir/~f.maleki
Email address: j.maleki@cet.ui.ac.ir
Other instructors: ---

Weekly Hours

Theory	Problem Solving	Laboratory	Guided learning
3 h	yes	---	---

Course Objectives

Familiarizing students with the theoretical foundations of models, tools and applications of spatial multi-criteria decision-making, group decision-making and how to use them to improve the results of spatial analysis in solving various decision-making problems.

Required Student Resources

Main references:

1. Geneletti, D. (2019). Multicriteria analysis for environmental decision-making. Anthem Press.
2. Shih, H. S., & Olson, D. L. (2022). TOPSIS and its extensions: A distance-based MCDM approach (Vol. 447). Springer Nature.
3. Branke, J., Branke, J., Deb, K., Miettinen, K., & Slowiński, R. (Eds.). (2008). Multiobjective optimization: Interactive and evolutionary approaches (Vol. 5252). Springer Science & Business Media.

Optional references:

1. Piotr Jankowski and Timothy Nyerges, (2003) Edition.3, Geographic Information Systems for Group Decision Making: Towards a participatory, geographic information science, Taylor & Francis.

2. Jie La, Guangquan Zhang, Da Ruan & Fengjie Wu, (2007), Multi- Objective Group Decision Making: Methods, Software and Applications with Fuzzy Set Techniques, Series in Electrical and Computer Engineering Vol. 6, Imperial College Press.
3. Balramand, S. and Dragievi, S. (ods), (2006), Collaborative Geographic Information Systems, Idea Group Publishing (386 pages), ISBN:1591408458.
4. Nolberto Munier, 2011. A Strategy for Using Multicriteria Analysis in Decision- Making, Springer.

Web linkes: ---

Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Spatial Multi-Criteria Evaluation: • All kinds of problems in terms of structuring and spatial decision making • Introduction to multi-criteria evaluation and decision-making (concepts, problem structuring, decision-making problem classification, decision-making model, normalization methods, weighting methods, prioritization methods) • The role of GIS in multi-criteria analysis and methods for generating criterion maps in GIS**
2	Multivariate decision making methods: • AHP and ANP methods • Outranking methods including PROMETHEE and ELECTRE • Distance based methods including TOPSIS and VIKOR • Decision making strategies and OWA method • Sensitivity analysis in the decision making process • Introducing some software and practical examples of solving spatial problems using multi-criteria analysis
3	Fuzzy multivariate decision making methods: • Fuzzy AHP • Fuzzy ANP • Fuzzy OWA • Fuzzy TOPSIS
4	Multi-objective decision making methods: • Basics of optimization and multi-objective decision making process • Multi-objective optimization methods • The concept of non-dominant solutions and the Pareto solution front • How to calculate convergence and dispersion of optimal solutions • Criteria for evaluating the results of multi-objective optimization • Practical examples of solving spatial problems using multi-objective analysis methods
5	Group Spatial Multi-Criteria Decision-Making: • An introduction to the models, processes and tools of participation in Group Spatial Decision-Making (GSDM) • Collaborative Group Spatial Decision-Making (CSDSS)** • Methods and techniques for multi-criteria group decision-making • Introducing some practical examples of group decision-making in solving spatial problems

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2 points
Comprehensive Assignment	3 points (at max)
Mid-Term Exam	7 points
Final Exam	8 points
Total Points	20 points

Spatial Data Fusion

Basic Information

Place in curriculum, title and semester: Elective, Image Fusion in Remote Sensing, S1
Number of credits: 3

Course Prerequisites

Course Co-requisites

Teachers

The person in charge: Dr. Sayyed Bagher Fatemi
Office location: Department of Geomatics Engineering, Faculty of Civil Engineering & Transportation, University of Isfahan, Isfahan, 81746-73441, Iran
Phone number: +983137935332
Homepage: https://engold.ui.ac.ir/~sb.fatemi/
Email address: https://engold.ui.ac.ir/~sb.fatemi/
Other instructors: ---

Weekly Hours

Theory	Problem Solving	Laboratory	Guided learning
3 h	----	---	---

Course Objectives

Introduce image fusion in remote sensing (concepts, levels, methods, quality control methods)

Required Student Resources

References:

1. Mitchell H.B., (2010), Image Fusion: Theories, Techniques and Applications, Springer.
2. Stathaki T., (2008), Image Fusion: Algorithms and Applications, Academic Press.
3. Chaudhuri S., K. Kotwal, (2013), Hyperspectral Image Fusion, Springer.
4. Blum R.S., Zh. Liu, (2005), Multi-Sensor Image Fusion and Its Applications (Signal Processing and Communications), CRC Press.
5. Stathaki T., (2008), Image Fusion: Algorithms and Applications, Academic Press.
6. Poh C.l, J. van Genderen, (2019), Remote Sensing Image Fusion A Practical Guide, CRC Press.

Web linkes: ----

Student's field trip: ---

Course Schedule/Outline/Calendar of Events

Week	Topic

1	Introduction: Importance of data fusion in Earth sciences, reasons for data and image fusion in remote sensing.
2	Data Preparation for Fusion: Preprocessing related to fusion (geometric and radiometric corrections).
3	Explanation of Fusion Levels with Practical Examples.
4	Image Fusion at Pixel Level: Basics, applications.
5	Transformations Required for Image Fusion based on existing categories: Wavelet transform, principal components, and other transformations.
6	Pixel Level Fusion Methods and Categorization: Substitution, etc.
7	Feature Level Fusion: Basics, methods like Feature Stacking.
8	Decision Level Image Fusion: Introduction of combined classifier systems (Combiners, Ensembling).
9	Supervised Decision Level Fusion Methods
10	Unsupervised Decision Level Fusion Methods
11	Ensembling: Basics, methods.
12	Fuzzification in Fusion: Principles of fuzzification, fuzzification at lower fusion levels, fuzzy combination rules in decision functions and probability models.
13	Evaluation of Fusion Results: Methods, levels, metrics (Spectral Quality, Spatial Quality, etc.)
14	Analysis of Remote Sensing Data in Information Systems and practical discussions on integrating remote sensing with other Earth sciences.

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	4 points
Comprehensive Assignment	4 points (at max)
Mid-Term Exam	0 points
Final Exam	12 points
Total Points	20 points