University of Isfahan

Remote Sensing Engineering Graduate Program

Curriculum

Department of Geomatics Engineering

Faculty of Civil and Transportation Engineering

University of Isfahan

December 1, 2024

1. Introduction

The general characteristics and the curriculum of the courses of the supplementary education course in civil engineering mapping-remote sensing based on the records of several years of the educational department of mapping engineering and based on:

1. The title of Master's Degree in Remote Sensing Engineering, University of Isfahan (Revised in Isfahan University, 2014)
2. Master's degree in Remote Sensing Engineering, University of Isfahan
3. General specifications, program and chapter headings of the Civil Engineering Doctoral course (approved by the 589th meeting of the High Council for Planning and Development of Higher Education, approved on 1385/4/31 Jalali calendar)

It is reviewed and presented. In this review, great attention has been paid to the experiences of University of Isfahan, domestic universities that administer the field (University of Tehran and Khaje Nasir Toosi University) and prestigious international universities.

2- The purpose and importance of remote sensing engineering

Remote sensing engineering is a theoretical and practical set of theories, methodologies, algorithms and methods that have the ability to prepare up-to-date maps in various fields of earth sciences based on satellite, aerial and ground data. These maps are prepared along with very diverse side information, and in addition, the frequency of providing these information and maps can be even on a daily basis or less. With the increasing need for such information, especially in regional and national planning, the need for remote sensing engineering specialists has increased significantly. Remote sensing engineering has caused a fundamental change in earth sciences in the past years. Before the emergence of common methods in remote sensing, the information that was available to earth science experts was limited to small scale maps; Moreover, these maps were prepared only for very limited areas of the earth's surface. The wide applications of this field in various scientific and engineering fields, including mapping, geology, atmospheric physics, geography and other earth sciences, have made this important academic field in prestigious universities of the world and in developed and developing countries with an increasing speed be noticed.

The purpose of this field is to train qualified specialists who have the ability to carry out research and applied projects in remote sensing engineering based on satellite, aerial and ground data, in various fields of earth sciences and in sync with the scientific developments of the day (considering the rapid growth of this field in the world).

3- The skills of graduates of the field

A) Conducting research and applied projects of remote sensing and geospatial information systems in earth sciences such as mapping, geology, atmospheric sciences, oceanography and hydrography, agriculture, urban and regional planning and geography
B) Carrying out all types of monitoring in all aspects of construction-spatial development and geosciences through remote sensing
C) The ability to carry out satellite photogrammetry and radar altimetry projects
D) The ability to perform two and three-dimensional graphic types of spatial information and

data

E) Ability to process satellite images and extract information and data mining
F) Digital Earth Modeling (DTM)
G) Design and development of spatial management system (GIS/LIS) and advanced geospatial information system (object-based and time-based)
H) Acquiring skills in carrying out specialized projects in the following fields:
    1. Identification and selection of satellite images and information for various applications, multi-band and multi-temporal image processing and extraction of earth's environmental information and determination of environmental changes, expertise in earth data archives and structuring of this type of information, creation of reference earth sites for control and verification of accuracy Image processing
    2. Basic information in agriculture, estimation of cultivated area, amount of crop, assessment of pests, erosion, temperature and humidity.
    3. Basic information on the environment and natural resources such as assessment of forests and pastures, air, land and sea pollution, environmental impact of industrial projects, creation of a warning system and assessment of natural disasters such as floods, fires, earthquakes
    4. Basic information about mines and resources such as gender, soil moisture and temperature, reflection and spectral emission coefficient.
    5. Providing information in the fields of urban and regional planning and design

4- Educational and research program

This educational and research program is a set of lessons (theoretical, seminar and thesis) which is planned in order to strengthen the scientific ability of students to carry out research activities and to master the new concepts of remote sensing engineering. A set of main courses and supplementary education courses for master's degree and doctorate level are organized according to table 2 and 3 and clauses 1-4 to 4-4 below.

Note 1: In addition to the supplementary education courses stated in table number 3, according to the opinion of his supervisor and the approval of the department council, the student can take three credit courses from the supplementary education courses of other fields-trends of the mapping engineering department or other educational fields such as physics, electronics , telecommunications, statistics and mathematics, geospatial information systems, geology, and meteorology, so that the total number of credits in his degree is respected.

4-1- Master's degree

Master's degree students in Civil Engineering Mapping-Remote Sensing are required to pass 32 credits including five main courses (table no. 2) equivalent to 14 credits and four courses with the recommendation of the supervisor and the approval of the department council, from among the supplementary education courses (table no. 3) They are equivalent to 12 credits and the master's thesis is 6 credits.

Note 2: It is not recommended to enroll a master's degree student in the education-oriented method for this field, but in case of registration of this type of student, taking other courses from the supplementary education courses (Table No. 3 and Note 1) equivalent to 6 credits will replace the thesis.

4-2- Doctoral degree

PhD students in Civil Engineering, Mapping and Remote Sensing complete a total of 36 credits. This number of credits for the students of the educational-research method includes six courses (equivalent to 18 credits) from the supplementary education courses (Table No. 3) and the doctoral thesis course, equivalent to 18 credits (and in addition, 3 separate credits for thesis advisors).

Note 3: For doctoral degree students in the field of civil mapping-remote sensing engineering, in the research method, with the proposal of the supervisor and the approval of the department council, a maximum of two courses (equivalent to a maximum of six credits) from among the courses of supplementary education (Table No. 3) and also the doctoral thesis credit (equivalent to 30 to 33 credits) is required.

4-3- Compensatory lessons

At the master's level, for students whose undergraduate field of study was not mapping engineering, with the decision of the department council, compensatory courses (maximum 12 credits) from the undergraduate courses of mapping engineering are determined for the student. At the doctoral level, the student must take a maximum of 3 courses (with a total of 8 credits) from the main courses table (Table No. 2) as a compensatory course with the suggestion of the supervisor and the approval of the department council. In both stages, compensatory courses must be passed successfully, while no credit is assigned to these courses.

4-4- Table of educational and research programs

The summary of the educational and research program for each of the educational levels and methods in this field according to the approvals of the Ministry of Science, Research and Technology and the approvals of the University of Isfahan, in this field, is described in Table 1.

5-4- Scope and method of work in thesis/dissertation credit

The scope of theses/dissertations in this field includes the issues raised in the graduates' skills section. Each thesis or thesis, relying on the theoretical foundations and reviewing the latest developments in the topics raised in that section, based on the acquisition and pre-processing of satellite and aerial data and the collection of field data, processes these data and obtains results and information, and during this research It deals with the development of theoretical topics and the presentation of operational and regional-local algorithms and the quality confirmation of the results of the methods.

Table 1 - The number of credits required for each of the courses and educational methods of the field of civil engineering, mapping and remote sensing

	Master's degree	Educational and research doctorate	Research doctorate
Compensatory courses	Up to 12 credits of Bachelor courses from Surveying Engineering	Up to 3 courses from Table of main courses	Up to 2 courses from Table of main courses
Main courses	14 credits	-	-
Graduate education courses	12 credits (18 for education-based)	18 credits	6 credits
Thesis/dissertation credit	6 credits (0 for education-based)	18 credits	30 credits
Total credits	32 credits	36 credits	36 credits

Table 2 - The main courses of the field of civil engineering, mapping and remote sensing engineering

Number	Course name	Credit		House		Prerequisite
		Theoretical	Practical	Theoretical	Practical	
1	Remote sensing digital image processing	3	-	48	-	-
2	Physics in remote sensing	3	-	48	-	-
3	Pattern recognition	3	-	48	-	-
4	Remote sensing applications	3	-	48	-	-
5	Research method in geoscience	3	-	48	-	-
Total		14 credits				

Table 3 - Courses of supplementary education in the field of civil engineering, mapping and remote sensing engineering

Number	Course name	Credit		House		Prerequisite
		Theoretical	Practical	Theoretical	Practical	
1	Remote sensing data management	3	-	48	-	-
2	Advanced geospatial information systems	3	-	48	-	-
3	Advanced statistics	3	-	48	-	-
4	Space-born photogrammetry	3	-	48	-	-
5	Applications of GNSS in remote sensing	3	-	48	-	-
6	Radar altimetry and Interferometry	3	-	48	-	-
7	Digital train modeling	3	-	48	-	-
8	Microwave remote sensing	3	-	48	-	-
9	Remote sensing images fusion	3	-	48	-	-
10	Stochastic processes	3	-	48	-	-
11	Neural networks	3	-	48	-	-
12	Image processing using computational intelligence	3	-	48	-	-
13	Hyperspectral image processing	3	-	48	-	-
14	Change detection using remote sensing	3	-	48	-	-
15	Advanced optimization algorithms	3	-	48	-	-
16	Special studies in remote sensing	3	-	48	-	-
17	According to note 1	3	-	48	-	-

Explanation: Table 3 is a group of elective or optional courses that are taken according to the level of study and the method of study.

List of Core and Elective Courses

Core Courses

Physics in Remote Sensing

BASIC INFORMATION

Place in curriculum, title and semester: core, Physics in Remote Sensing, S1
Number of credits: 3

COURSE PREREQUISITES

COURSE CO-REQUISITES

TEACHERS

The person in charge: Dr. Mehdi Momeni
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Other instructors: ---

WEEKLY HOURS

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

COURSE OBJECTIVES

Completing students' knowledge of physical principles in Remote sensing. The students learn the main physical concepts of Remote sensing including emission, absorption and reflection of radiative energy, atmospheric transmission, and It goes far to satellites orbits and missions

REQUIRED STUDENT RESOURCES

References:

1. Mahan J.R., (2002), Radiation Heat Transfer: A Statistical Approach, Wiley-Interscience.
2. Capderou M., (2005), Satellites Orbits and Missions, Springer.
3. Elachi Ch., J. van Zyl, (2021), Introduction to the Physics and Techniques of Remote Sensing, Third Edition, Wiley.
4. Lillesand T.M., R.W. Kiefer, J.W. Chipman, (2015), Remote Sensing and Image Interpretation, 7th Edition, Wiley.
5. Richards J.A., X. Jia, (2005), Remote Sensing Digital Image Analysis: An Introduction, 4th Edition, Springer.
6. Chapman R., R. Gasparovic, (2022), Remote Sensing Physics: An Introduction to Observing Earth from Space, American Geophysical Union.

Web linkes: ---

Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Principles of Remote sensing: Remote sensing steps, energy sources and transfer, electromagnetic radiation properties
2	Radiation terminology (radiation, flow, radiance), measurements units in radiation
3	Radiation physical principles: historical aspects and Stefan-Boltzmann's law, Planck's law, Wein's law, atomic-molecular structure and the source of radiation
4	Radiation-Surface interaction: emission, absorption, reflection, transmission, Kirchhoff's Law
5	Directional coefficients, hemispherical and spherical, spectral and total coefficients, theoretical and applied physics in Remote sensing
6	Radiation in participating media of atmosphere: extinction, emission, and scattering in participating media and atmosphere
7	Layer structure of atmosphere in Remote sensing, Radiative transfer equation and problem of analytical solution, numerical solution, Remote sensing Radiative transfer
8	Remote sensing sensors: types and features, common features(swath, effective resolutions, spectral response, spectral diffraction)
9	A review on some optical, thermal, microwave and radar and altimeter sensors, onboard calibration (hardware and calibration data) and periodic calibration
10	Platforms: types and features, satellite and airborne systems
11	Satellite orbits: Keplerian orbits and perturbations, coordinate systems,
12	Geosynchronous and sun synchronous orbits and missions
13	Earth resource satellite, weather satellite,
14	A comparison between satellite systems

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2-4 points
Comprehensive Assignment	12 points (at max)
Mid-Term Exam	- points
Final Exam	6 points
Total Points	20 points

Remote Sensing Applications

Basic Information

Place in curriculum, title and semester: Core, Remote Sensing Applications, S1
Number of credits: 3

Course Prerequisites

Course Co-requisites

Teachers

The person in charge: Dr. Mina Moradizadeh
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Other instructors: ---

Weekly Hours

Theory	Problem Solving	Laboratory	Guided learning
3 h	---	---	1h

Course Objectives

The purpose of this course is to acquire extensive technical knowledge and skills to provide different services, including remote sensing engineering methods and algorithms, to other scientific and executive specialties of earth sciences and related fields.

Required Student Resources

Textbooks:

1. Liang Sh., Wang, J., "Advanced Remote Sensing Terrestrial Information Extraction and Applications", Academic Press, 2019.
2. Gupta R.P., "Remote Sensing Geology", Springer, 2018.
3. Lillesand T.M., Kiefer, R.W., Chipman, J.W., "Remote Sensing and Image Interpretation", 7th Edition, Wiley, 2015.

References:

4. Liang Sh., "Quantitative Remote Sensing of Land Surfaces", Wiley, 2014.
5. Richards J.A., Jia, X., "Remote Sensing Digital Image Analysis: An Introduction", 4th Edition, Springer, 2005.
6. Elachi Ch., van Zyl, J., "Introduction to the Physics and Techniques of Remote Sensing", Third Edition, Wiley, 2021.

Web linkes: ---

Student's field trip: -----

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Introduction and overview of data and analysis methods in remote sensing
2	The importance, applications and necessity of using remote sensing
3	Plant applications: reflection and emission of radiant energy from plant, effective components in reflection and emission, plant indices, plant growth curve
4	Plant applications: plant classification, estimation of cultivated area and yield of agricultural products
5	Atmospheric applications: surface-air interaction, atmospheric structure and its radiation behavior, retrieving of atmospheric components (including: column and near-surface water vapor, water vapor and temperature profiles, air pollution)
6	Examples of atmospheric applications
7	Atmospheric correction of remote sensing images: histogram methods, target pixel, fixed and relative pixel, radiative transfer equation, software and LUT
8	Ground applications: estimation of surface moisture and temperature, species identification in spectral images, snow and ice estimation, natural hazards (flood, fire and earthquake, identification, evaluation and damage estimation), rapid assessment systems and warning systems
9	Examples of ground applications
10	Marine applications: salinity and water temperature, water pollution, marine currents, coastal management, examples of marine applications
11	Urban and rural applications: construction indices, regional maps and spatial resolution considerations
12	Environmental indices, the role of remote sensing data in spatial and environmental modeling
13	Environmental change detection: the concept of environmental changes, spatial resolution considerations, an example of remote sensing applications in environmental change detection
14	Visualization of results: methods of displaying and presenting remote sensing results, principles of cartography in remote sensing

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2 points
Comprehensive Assignment	8 points (at max)
Mid-Term Exam	0 points
Final Exam	10 points
Total Points	20 points

Remote Sensing Digital Image Processing

Basic Information

Place in curriculum, title and semester: Core, Remote Sensing Digital Image Processing, S2
Number of credits: 3

Course Prerequisites

Course Co-requisites

Teachers

The person in charge: Dr. Mina Moradizadeh
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Email address: m.moradizadeh@eng.ui.ac.ir
Other instructors: ---

Weekly Hours

Theory	Problem Solving	Laboratory	Guided learning
3 h	---	---	1h

Course Objectives

The purpose of this course is to acquire the basic knowledge of signal processing for all engineering fields, especially for geomatics engineering, which provides the basis for a deeper understanding of advanced topics such as ground and air data collection, navigation and others. This course is accompanied and completed with exercises.

Required Student Resources

Textbooks:

1. Gonzalez R., Woods R., "Digital Image Processing", 4th Edition, 2020.
2. Richards J.A., "Remote Sensing Digital Image Analysis", 2022.
3. Chityala R., Pudipeddi S., "Image Processing and Acquisition using Python", 2021.

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

Course Schedule/Outline/Calendar of Events

Week	Topic
1	Introduction and overview of digital images
2	Digital Image Fundamentals, Image sampling and quantization

3	Filtering in spatial space and intensity transformations
4	Filtering in the frequency domain
5	Image restoration and reconstruction
6	Wavelet transform
7	Color Image Processing
8	Image compression
9	Morphological Image Processing
10	Image Segmentation
11	Feature extraction
12	Classification based on pattern recognition
13	Representation and Description
14	Object Recognition

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2 points
Comprehensive Assignment	8 points (at max)
Mid-Term Exam	0 points
Final Exam	10 points
Total Points	20 points

Elective Courses

Image Processing Using Computational Intelligence

Basic Information

Place in curriculum, title and semester: core, Image Processing Using Computational Intelligence, S5
Number of credits: 3

Course prerequisites

Pattern recognition, Image Processing

Course co-requisites

Neural networks

Teachers

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Weekly Hours

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

Course Objectives

Review on major aspects of Numerical intelligence and applications in addition to applied concerns in Photogrammetry and Remote sensing

Required Student Resources

References:

1. Goodfellow I., Y. Bengio, A. Courville, (2016). Deep Learning. MIT Press.
2. Grana M., R.J. Duro, (2010), Computational Intelligence for Remote Sensing, Softcover Edition, Springer.
3. Witten I.H., E. Frank, (2011), Data Mining: Practical Machine Learning Tools and Techniques, 3rd Edition, Morgan Kaufmann Publisher.
4. Kulkarni A.D., (2001), Computer Vision and Fuzzy-Neural Systems, Prentice Hall.

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

Course Schedule/Outline/Calendar of Events

Week	Topic
1	Introduction to Artificial intelligence: elements of human intelligence and a glance on

	Machine learning, a review on applications
2	Turing test and criticisms
3	Image Objects detection: needs, methods and researches, numerical intelligence in object detection
4	Image features, feature vector extraction, representation, pixel-based and object-based approaches
5	Neural networks: network architecture, activation functions, and loss, learning principles and how to, back propagation
6	Convolutional networks, hyper parameters and optimization, network evaluation
7	Pattern recognition using CNN on satellite images
8	Fuzzy logic principles in AI image processing
9	Some examples: fuzzy histogram equalization, fuzzy thresholding, corner detection using fuzzy logic, geometrical feature extraction using fuzzy logic, edge detection in fuzzy approach
10	Fuzzy networks systems, pattern recognition using fuzzy logic
11	Some examples: delimitation of image objects using NN, image texture analysis, fuzzy networks image classification
12	C-means and fuzzy C-means clustering, fuzzy network clustering
13	SOM clustering, network memory gates, recurrent, attention and more
14	Case studies of numerical intelligence in Photogrammetry and Remote sensing

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2-4 points
Comprehensive Assignment	12 points (at max)
Mid-Term Exam	- points
Final Exam	6 points
Total Points	20 points

Hyperspectral Image Processing

Basic Information

Place in curriculum, title and semester: core, Image Processing Using Computational Intelligence, S5
Number of credits: 3

Course prerequisites

Linear algebra

Course co-requisites

Teachers

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Weekly Hours

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

Course Objectives

The students learn theories and applications of hyperspectral Remote sensing including physic of spectral radiation of materials, radiometers and spectrometers (satellite and ground based sensors), hyperspectral images management and processing in order to spectral decomposition (pure pixel identification), target detection, and anomaly exploration.

Required Student Resources

References:

1. Chang Ch., (2013), Hyperspectral Data Processing, Algorithm Design and Analysis, Wiley.
2. Eismann M., (2012), Hyperspectral remote sensing, SPIE.
3. Qian Sh., (2020), Hyperspectral Satellites and System Design, CRC Press.
4. Van der Meer F.D., S.M. DeJong, (2001), Imaging Spectrometry, Basic Principles and Prospective Applications, Kluwer Academic Publish.
5. Thenkabail P.S., J.G. Lyon, (2011), Hyperspectral Remote Sensing of Vegetation, CRC Press.
6. Pu R., (2017), Hyperspectral Remote Sensing, Fundamentals and Practices, CRC Press.
7. Manolakis D. G., R. B. Lockwood, Th. W. Cooley, (2016), Hyperspectral Imaging Remote Sensing, Physics, Sensors, and Algorithms, Cambridge University Press.

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

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Introduction to physic of spectral radiation: energy levels of atom-molecules, overtone spectral radiation, line by line model, band average model
2	Reflection and scattering properties of surfaces: reflective and emissive spectrum formation, reflective properties of materials (minerals, rocks, soils, vegetation covers, water bodies, man-made)
3	Spectro-radiometer systems: spectral coverage, optics, electronics, dispersion, noises (6 internal sources of noise and external ones), PSF, MTF and spectral spatial resolution, focal plane arrays, some samples of optical design, laboratory and field goniometer
4	Spectral sensors: hand-held radiometers, airborne hyperspectral systems, spaceborne hyperspectral systems, principles of hyperspectral image simulation,
5	A review on some hyperspectral systems examples
6	Pre-processing: data quality control, SNR, mixed pixels and spectral averaging, noise management, atmospheric effects, relative and absolute correction of atmospheric effects
7	Hyperspectral processing: spectral derivatives, similarity measures and spectral discrimination, orthogonal hyperspectral dimensions, hyperspectral absorption features,
8	Hyperspectral indices extraction, transformation and extraction of hyperspectral features, Some practices in real cases
9	Hyperspectral data analysis: pure pixel identification, pixel unmixing, target detection, target-background analysis, anomaly detection, hyperspectral classification, Some real cases
10	Hyperspectral data analysis: pure pixel identification, pixel unmixing, target detection, target-background analysis, anomaly detection, hyperspectral classification, Some real cases
11	Hyperspectral data analysis: pure pixel identification, pixel unmixing, target detection, target-background analysis, anomaly detection, hyperspectral classification, Some real cases
12	Thermal hyperspectral imaging: thermal radiation principles, spectral emissivity of minerals and rocks, vegetation, and water bodies, effects of geometry in emissivity, review on some thermal hyperspectral imaging
13	Case studies: geology (petrogeology, mining, erosion), vegetation (water stress, plant diseases/pests, types, phenology), civil and military applications (target detection, change/anomaly detection), hyperspectral data fusion, deep processing of hyperspectral data
14	Case studies: geology (petrogeology, mining, erosion), vegetation (water stress, plant diseases/pests, types, phenology), civil and military applications (target detection, change/anomaly detection), hyperspectral data fusion, deep processing of hyperspectral data

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2-4 points
Comprehensive Assignment	12 points (at max)
Mid-Term Exam	- points

Final Exam	6 points
Total Points	20 points

DIGITAL TERRAIN MODELING

BASIC INFORMATION

Place in curriculum, title and semester: Elective, Digital Terrain Modeling, S2
Number of credits: 3

COURSE PREREQUISITES

Principles of Photogrammetry

COURSE CO-REQUISITES

TEACHERS

The person in charge: Dr. Sayyed Bagher Fatemi
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Other instructors: ---

WEEKLY HOURS

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

COURSE OBJECTIVES

Introduce digital elevation data generation (concepts, methods...), quality control methods and production of related products

REQUIRED STUDENT RESOURCES

References:

1. Li Z., Q. Zhu, C. Gold, (2004), Digital Terrain Modeling: Principles and Methodology, CRC Publishers.
2. Zhou Q., B. Lees, G. Tang, (2010), Advances in Digital Terrain Analysis (Lecture Notes in Geoinformation and Cartography), Springer.
3. El-Sheimy N., C. Valeo, A. Habib, (2005), Digital Terrain Modeling: Acquisition, Manipulation and Applications, Artech House Publishers.
4. Linder W., (2016), Digital Photogrammetry, A Practical Course, Springer Berlin.
5. Wilson J.P., (2018), Environmental Applications Of Digital Terrain Modeling, Wiley.

Web linkes: ----

Student's field trip: ---

Course Schedule/Outline/Calendar of Events

Week	Topic
1	An overview of the basic concepts and definition of digital earth model (DTM), types of digital earth models and their differences
2	Geomorphology and morphological complications and their role in determining the skeleton of the region and classifying the land in terms of roughness
3	Elevation data sources: aerial photographs, satellite images, LIDAR data, existing DEMs, existing maps
4	Data collection methods: manual method, semi-automatic methods
5	Data collection methods: automatic methods, digital matching
6	Sampling methods, accuracy and their advantages
7	Optimal sampling: optimal sampling methods, variogram, spectrum, roughness coefficient, criteria for increasing the density of points
8	Classification Of Point Structures, Description Of Different Structures, Delaunay Triangulation Method
9	Interpolation, Filtering And Data Reduction, Comparison Of Different Interpolation Methods, Surface Fitting And Filtering
10	Dem Fusion, Principles and methods
11	Digital Elevation Model Products: Curve Of Measurements, Slope Map, Slope Direction, Elevation Lighting, 3D Perspective
12	Elevation Data Interpretation: Concepts, Parameters, Methods
13	The Accuracy Of DEM And Preliminary Analysis In Achieving The Required Accuracy
14	DEM Applications In Earth Sciences, Environment, Natural Hazards, Civil Engineering And Related Fields

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

Image Fusion in Remote Sensing

Basic Information

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

Course Prerequisites

Principles of Remote Sensing

Course Co-requisites

TEACHERS

The person in charge: Dr. Sayyed Bagher Fatemi
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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.
- Stathaki T., (2008), Image Fusion: Algorithms and Applications, Academic Press.
- Chaudhuri S., K. Kotwal, (2013), Hyperspectral Image Fusion, Springer.
- Blum R.S., Zh. Liu, (2005), Multi-Sensor Image Fusion and Its Applications (Signal Processing and Communications), CRC Press.
- Stathaki T., (2008), Image Fusion: Algorithms and Applications, Academic Press.
- 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

Remote Sensing Data Management

Basic Information

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

Course prerequisites

Principles of Remote Sensing

Course co-requisites

Teachers

The person in charge: Dr. Sayyed Bagher Fatemi
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Email address: https://engold.ui.ac.ir/~sb.fatemi/
Other instructors: ---

Weekly Hours

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

Course Objectives

Introduce remote sensing data management concepts, requirements, spatial data formats and principles of information extraction from remote sensing data

Required Student Resources

References:

1. Kochenour C., (2020), Remote Sensing with Google Earth Engine, calekochenour.github.io, last access Jan 2023.
2. Miano J., (1999), Compressed Image File Formats, Addison-Wesley.
3. Landsat Missions, (2019), LSDS-1388 Landsat Cloud Optimized GeoTIFF (COG) Data Format Control Book, usgs.gov, last access Jan 2023.
4. Klein L., A. Taaheri, (2016), HDF-EOS5 Data Model, File Format and Library, ESDS-RFC-008v1.1.
5. Arvidson T., J. Gasch, S.N. Goward, (2001), Landsat 7's Long Term Acquisition Plan - An innovative approach to building a global imagery archive, Remote Sensing of the Environment, vol. 78.

Web linkes: https://earthexplorer.usgs.gov/, last access Jan 2023

Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Digital data and information: types of ground data; Vector and Raster data.
2	Digital data and information: Geometric, spectral and temporal characteristics, Metadata,
3	Receiving remote sensing data: Organization and data receiving hardware, ground antennas and TDRSS (example of Landsat and Sentinel Constellations)
4	Raw data processing: Gain and Offset, Spectral Response Curve, Digital Number, Radiance, and Reflectance,
5	Common coordinate systems, Image Reference Systems (WRS)
6	Data management levels: Data processing levels, Data Release Policy, Free And Non-Free Data, Naming Conventions, Metadata Formats, Metadata Storage
7	Image Data Format: How To Save The Image File (BIP, BIL, BSQ), Common Formats in Image Processing: TIFF, GeoTiff, HDF, HDF-EOS, NC, JPG, GRD Formats, Common Formats In ArcGIS And ENVI.
8	Earth Science Data Archives: Volume And Storage Of Remote Sensing Data, Types Of Storage Media, Global Archives And Data Sites, How To Purchase Images, Free Data, And GEE And Bing Archives.
9	Format Conversion And Data Transfer: Applied Examples In ENVI And ArcGIS Software, Important Considerations
10	Data Selection Based On Sensor Specifications
11	Principles of Passive Defense In Remote Sensing Data Management
12	Principles of Quality Control in Remote Sensing: Subjective Quality Control (History And Perspectives), Geometric Control,
13	Confusion Matrix, Related Accuracy Measures (Kappa, ROC Curve, F1 Score), User's And Producers Accuracy, Uncertainty Cycle
14	information Extraction from remote sensing data (principles, methods, requirements,...)

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

Pattern Recognition

Basic Information

Place in curriculum, title and semester: core, Pattern Recognition, S2
Number of credits: 3

Course prerequisites

Course co-requisites

Teachers

The person in charge: Dr. Iman Khosravi
Office location: Department of Geomatics Engineering, Faculty of Civil Engineering & Transportation, University of Isfahan, Isfahan, 81746-73441, Iran
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Homepage: https://cet.ui.ac.ir/~i.khosravi
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Other instructors: ---

Weekly Hours

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

Course Objectives

Pattern recognition is one of the important topics in various engineering fields, which provides many different methods for data analysis by relying on different tools. This lesson is the basic and classified design and explanation of these tools.

Required Student Resources

References:

1. Theodoridis S., K. Koutroumbas, (2008), Pattern Recognition, 4rd Edition, Academic Press.
2. Bishop C.M., (2007), Pattern Recognition and Machine Learning, Springer.
3. Bishop C.M., (1996), Neural Networks for Pattern Recognition", Oxford University Press.
4. Ripley B.D., (2008), Pattern Recognition and Neural Networks", Cambridge University Press.
5. Witten I.H., E. Frank, (2011), Data Mining: Practical Machine Learning Tools and Techniques, 3rd Edition, Morgan Kaufmann Publisher.
6. Wu J., (2020), Essentials of Pattern Recognition, 1st edition Cambridge University Press.

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

Course Schedule/Outline/Calendar of Events

Week	Topic
1	Introduction: the importance of pattern recognition, vector space of components,

	classifiers, comparison of supervised and unsupervised methods
2	Production of components: the concept of production of components, different transformations of production of components
3	Dimensionality reduction: expressing the problem of data dimensions, dimensionality reduction methods
4	Selection of components: pre-processing, selection of components based on classical and innovative methods
5	Classification based on Bayesian decision-making theory: separation functions, density function estimation, risk concept
6	Linear classifiers: linear and plane separation functions, Perceptron algorithm, least squares algorithms
7	Nonlinear classifiers, XOR problem, two-layer Perceptron algorithm, backpropagation algorithm
8	Generalized linear classifiers, polynomial classifiers and basic radius functions, practical examples
9	Classification based on support vector machine (SVM): SVM in linear and non-linear separability mode, kernel functions
10	Multi-class classifiers: Bagging methods, Boosting methods
11	Tree-based classifiers: decision tree, random forest, XGBoost
12	Classification system evaluation: concepts of error and uncertainty, ROC curve
13	Clustering: basic concepts, clustering methods, similarity measures, different algorithms, clustering evaluation

EVALUATION PROCEDURES AND GRADING CRITERIA

Class Seminars	4 points
Class Projects	8 points
Final Exam	8 points
Total Points	20 points

Microwave Remote Sensing

Basic Information

Place in curriculum, title and semester: optional, Microwave Remote Sensing, S2
Number of credits: 3

Course prerequisites

Course co-requisites

Teachers

The person in charge: Dr. Iman Khosravi
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Email address: i.khosravi@cet.ui.ac.ir
Other instructors: ---

Weekly Hours

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

Course Objectives

- Getting to know the principles and basics of microwave remote sensing and its differences with optical remote sensing and thermal remote sensing
- Getting to know the processing of microwave remote sensing images
- Getting to know the applications and capabilities of microwave remote sensing

Required Student Resources

References:

1. F.M. Henderson and A.J. Lewis, "Imaging Radar (Manual of Remote Sensing, Volume 2)", 3rd Edition, Wiley, 1998.
2. M.I. Skolnik, "Introduction to Radar Systems", 3rd Edition, McGraw-Hill, 2002.
3. M.M. Abid, "Spacecraft Sensors", Wiley, 2005.
4. J. Lee, E. Pottier, "Polarimetric Radar Imaging: From Basics to Applications", CRC Press, 2009.
5. F. Ulaby, "Microwave Radar and Radiometric Remote Sensing", University of Michigan Press, 2013.
6. I.H. Woodhouse, "Introduction to Microwave Remote Sensing", CRC press, 2017.

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

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Introduction: principles of electromagnetic energy, electromagnetic wave parameters (wavelength, amplitude, frequency, phase, polarization), electromagnetic spectrum and its types, history of microwave remote sensing, microwave applications in remote sensing and future programs
2	Physics of microwaves: microwaves and the generation and propagation of radar waves, the principles of antennas, reflection, penetration and absorption, propagation in the atmosphere
3	Types: passive and active microwave remote sensing and their mechanisms
4	Measurement tools: radiometers, radars, artificial aperture radar (SAR), real aperture radar (RAR), polarity, radar equation, SAR imaging processes
5	Geometric principles of images (tilt angle, topography of the area, height, azimuth angle, environmental parameters), spatial separation limit and accuracy
6	Reflection and scattering of radar waves: distribution models of ground effects, the effect of humidity, polarity, topography, roughness and gender, resolving power and factors affecting it
7	Interpretation of microwave image data: principles of interpretation, difference with infrared and visible images, experimental and automatic interpretation
8	Radar errors and distortions: geometric distortions (shortening, layover, radar shadows, slant range scale distortion), radiometric distortions (speckle defects), ways to remove or reduce speckle defects (filters, multi-view operations).
9	Microwave data processing: highlighting, Doppler effect, radar interferometry, radar range equation
10	All Polarized Artificial Aperture Radar (PolSAR): referring to the representation of a PolSAR image (covariance matrix, coherence matrix), polarization simulation theory, polarization characteristics, coherent and incoherent target analyzers, compact polarization
11	Radar satellites: referring to the history of radar satellites, their types from the point of view of frequency, polarization, and spatial resolution
12	Microwave applications in remote sensing: combination of microwave data with visible and infrared data, coverage map preparation, urban area survey, land use, moisture and water detection, ice and snow components detection, plant components detection, soil studies, target detection, Application of passive microwave and differences

EVALUATION PROCEDURES AND GRADING CRITERIA

Class Seminars	5 points
Class Projects	7 points
Final Exam	8 points
Total Points	20 points

Advanced Optimization Algorithms

BASIC INFORMATION

Place in curriculum, title and semester: optional, Advanced Optimization Algorithms, S2
Number of credits: 3

COURSE PREREQUISITES

COURSE CO-REQUISITES

TEACHERS

The person in charge: Dr. Iman Khosravi
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Other instructors: ---

WEEKLY HOURS

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

COURSE OBJECTIVES

- Getting to know the concept and necessity of optimization in earth sciences
- Getting to know the optimization methods of mathematical models used in earth sciences, especially remote sensing

REQUIRED STUDENT RESOURCES

References:

1. Y. Wang and A.G. Yagola, “Optimization and Regularization for Computational Inverse Problems and Applications”, Springer, 2011.
2. J.A. Snyman, “Practical Mathematical Optimization: An Introduction to Basic Optimization Theory and Classical and New Gradient-Based Algorithms”, Springer, 2005.
3. H. Pohlheim, “Evolutionary Algorithms: Overview, Methods and Operators”, 2005.
4. T. Back, D.B. Fogel and Z. Michalewicz, “Evolutionary Computation 1: Basic Algorithms and Operators”, CRC Press, 2000.
5. T. Back, D.B. Fogel and Z. Michalewicz, “Evolutionary Computation 2: Advanced Algorithms and Operations”, CRC Press, 2000.
6. A. P. Engelbrecht, “Computational Intelligence, an Introduction, Second Edition”, John Wiley & Sons Ltd, England, 2007.

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

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Introduction: Introduction of optimization, necessity and its applications
2	Various methods of optimization, introduction and introduction
3	Optimization methods based on traditional algorithms such as the gradient descent method, the mathematical bases necessary for optimization such as the Hessian matrix, the gradient vector, standard methods for finding the minimum without constraints
4	Optimization methods based on evolutionary algorithms (genetic algorithm, birds, etc.), convergence of algorithms, problems caused by the limit of values on the merit function, incomplete convergence, terminate
5	Comparison of different optimization methods
6	Advanced concepts in optimization: multi-objective and multi-constraint optimization, knowledge-based methods, chromosomes with variable length
7	Optimization applications in solving remote sensing problems: selection of feature vector, selection of pure members in hyperspectral images, clustering of remote sensing images, finding the best parameters of kernel-based methods such as support vector machine method
8	An overview of current topics and future research fields

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	5 points
Class Projects	7 points
Final Exam	8 points
Total Points	20 points

Research Method in Geoscience

BASIC INFORMATION

Place in curriculum, title and semester: core, Research Method in Geoscience, S1
Number of credits: 1

COURSE PREREQUISITES

COURSE CO-REQUISITES

TEACHERS

The person in charge: Dr. Iman Khosravi
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Email address: i.khosravi@cet.ui.ac.ir
Other instructors: ---

WEEKLY HOURS

Theory	Problem Solving	Laboratory	Guided learning
1 h	Yes	---	---

COURSE OBJECTIVES

- Getting to know the concept, important features and types of scientific research, especially in the field of earth sciences
- Getting to know how to understand the concepts of problem statement, goals and the necessity of the subject in scientific research
- Getting to know how to write and structure scientific research (article, thesis) and its proposal

REQUIRED STUDENT RESOURCES

References:

1. A. Pourhashemi, G. E. Zaikov, A.K. Haghi, "Engineering Materials, Applied Research and Evaluation Methods", Apple Academic Press, 2015.05.22
2. G. Rugg, M. Petre, "A Gentle Guide to Research Methods", McGraw-Hill, 2007.
3. Thomson-Reuters Corporation, "Journal Citation Reports 2022", Thomson-Reuters Corporation, 2022.
4. Scopus Journal Ranking, " Scimago Journal & Country Rank", www.scimagojr.com, 2022.
5. IEEE, "IEEE Citation Reference", Institute of Electrical and Electronics Engineers, last access 2023.
6. Purdue University, "Purdue OWL: APA Formatting and Style Guide", owl.english.purdue.edu, last access 2023.
7. E. DB, B. Hosp, "Vancouver style", British Medical Journal, 3, 1980.

Web links:
https://www.scimagojr.com/
https://www.webofscience.com/wos/
https://www.bioxbio.com/
https://www.elsevier.com/
https://www.scopus.com/
https://scholar.google.com/
https://www.doi.org/
https://orcid.org/
https://www.crossref.org/
https://civilica.com/
https://www.magiran.com/
Student's field trip: ---

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	Introduction: the definition and concept of research, the characteristics of a scientific research, the importance and pillars of research, types of logic in research, types of research from the perspective of the purpose of research, the nature of data and collection methods
2	Principles of scientific research: studies, scientific criticism, search for research issues, research front, research scope of earth sciences, classification of earth sciences and study of commonalities and differences in these sciences
3	Research method in experimental sciences: the problem of research in experimental sciences, types of problems and types of research, stages of research in earth sciences, field activities and evidence collection, types of analyzes and principles of inference in earth sciences, selection of general areas and specific areas of research, Innovation in research
4	Research proposal: types of proposals in earth sciences, introduction of the proposed structure, how to write the proposal and its approval
5	Report of the results/research output: thesis and its structure and how to write it, comparison of master's thesis and doctoral dissertation, essay and its structure and types, important points of writing an essay, scientific levels of publishing essays (research, promotion, conference and conferences), types of articles (original research, case study, review, technical report, letter), comparison of the structure and method of judging thesis and article
6	Research journals: types of journals, their ranking and references, quantification of quality in research journals and their mathematical relations, geoscience journals, choosing a journal to submit an article, introduction of domestic and foreign journals, familiarization with validation sites for articles, conferences and magazines such as Web of Science, Scimagojr, bioxbio, Crossref, DOI, Google Scholar, ORCID, Scopus, Researchgate, Linkedin, Civilica, Mag Iran
7	Ethics in research: a reference to plagiarism and its prevention by relying on research methods, plagiarism prevention by relying on software and internet methods, honesty and scientific justice, principles of confidentiality in research, principles of non-conflict benefits
8	Referencing: the method of referencing in research, referring to referencing software

	such as EndNote, Mendeley and Zotero
9	Additional topics: how to prepare slides, how to present in a seminar/dissertation defense session, how to write and layout research with text processing software such as Word and LaTeX
10	A practical overview of the world's current topics in earth sciences and research fields

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	5 points
Class Seminars	5 points
Final Exam	10 points
Total Points	20 points

Special Studies in Remote Sensing

Basic Information

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

Course Prerequisites

Course Co-requisites

Teachers

The person in charge: Dr. Mina Moradizadeh
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Other instructors: ---

Weekly Hours

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

Course Objectives

The purpose of this course is to contemplation and specialized discussion of students in advanced research topics and knowledge of the growth trend of remote sensing in earth science issues.

Required Student Resources

Textbooks:

Internal and external articles and theses related to the two years leading to teaching the course, at the discretion of the course teacher.

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

Course Schedule/Outline/Calendar of Events

Week	Topic
1	Recent advances in pattern recognition topics using satellite data
2	Recent advances in optimization topics using satellite data
3	Recent advances in classification and clustering of satellite data
4	Recent advances in the field of data fusion
5	Target detection using satellite images

6	Determining environmental changes using satellite images
7	Theoretical and practical advances of remote sensing in physical modeling issues
8	Algorithms based on physical models
9	Analysis of applied quantities in earth sciences
10	Advanced topics and recent studies in the field of error and quality control
11	Advances and achievements from new satellite data
12	Comparison of new data with the results of old sources
13	Introducing the scope of remote sensing applications
14	Examining special researches in new fields

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2 points
Comprehensive Assignment	8 points (at max)
Mid-Term Exam	0 points
Final Exam	10 points
Total Points	20 points

Space-born Photogrammetry

Basic Information

Place in curriculum, title and semester: elective, Space-born Photogrammetry, -
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

An explaination of theoritical principals and the practical steps in geometrical applications of remote-sensing to land surveying using aerial and satellite imageries to obtain ample operational proficiency for the management of relevant projects

Required Student Resources

References:

- Richards J.A., X. Jia, (2005), Remote Sensing Digital Image Analysis: An Introduction, 4th Edition, Springer.
- Wolf P.R., B.A. DeWitt, (2000), Elements of Photogrammetry with Applications in GIS, 3rd Edition, McGraw-Hill.
- Mikhail E.M., J.S. Bethel, J.C. McGlone, (2001), Introduction to Modern Photogrammetry, Wiley.
- Petrou M., (2010), Image Processing: The Fundamentals, 2nd Edition, Wiley.

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

COURSE SCHEDULE/OUTLINE/CALENDAR OF EVENTS

Week	Topic
1	An assessment of 2D and 3D geometrical models of imageries from various sensors
2	Properties of apt sensors for a pictorial map production at various scales
3	Atmospheric correction of optical images
4	A review of geometric and radiometric maps' standards
5	Design of standard ground control points
6	Various methods for determination of parameters for external orientation
7	Nadir pictorial map
8	Geometric assessment images from precision, resolution and intrinsic errors
9	Geometry of Radar images and digital elevation models from interferometery or radargrammetery
10	Image processing of images in these topics: mosaicking, georeferencing, and required image reconstruction
11	An introduction to LIDAR and an evaluation of space-born LIDAR applications

EVALUATION PROCEDURES AND GRADING CRITERIA

Assignments	2-4 points
Comprehensive Assignment	3-5 points (at max)
Mid-Term Exam	3 points
Final Exam	12 points
Total Points	20 points