Ministry of Higher Education and Scientific Research - Iraq
Al-Nahrain University
College of Science
Department of Medical Physics

MODULE DESCRIPTION FORM

نموذج وصف المادة الدراسية

Module Information معلومات المادة الدراسية					
Module Title	Image processing			**Module Delivery**	
Module Type	Core			☒ **Theory** ☒ **Lecture** ☒ **Lab** ☐ **Tutorial** ☐ **Practical** ☒ **Seminar**	
Module Code	MPHY3102				
ECTS Credits	5				
SWL (hr/sem)	125				
Module Level	5		**Semester of Delivery**	2	
Administering Department	Medical Physics Sciences Department		**College**	College of Science	
Module Leader	Dr. Salam E Hammeed		**e-mail**	Salam.dulaimi@nahrainuniv.edu.iq	
Module Leader's Acad. Title	Lecturer		**Module Leader's Qualification**	Ph.D.	
Module Tutor	Intizar Malik		**e-mail**		
Module Reviewer			**e-mail**		
Peer Reviewer Name			**e-mail**		
Scientific Committee Approval Date			**Version Number**		
Lab. Staff.					

Relation with other Modules العلاقة مع المواد الدراسية الأخرى			
Prerequisite module	None	**Semester**	
Co-requisites module	None	**Semester**	

Module Aims, Learning Outcomes and Indicative Contents

أهداف المادة الدراسية ونتائج التعلم والمحتويات الإرشادية

Module Aims

أهداف المادة الدراسية

General Aims of an Image Processing Module

The primary goal of an image processing module is to equip learners with the foundational knowledge, skills, and tools to work with digital images in practical, real-world scenarios. This field bridges theory (e.g., mathematics and signal processing) with applications (e.g., in AI, medical imaging, and computer vision). Key overarching aims include:

1. **Building Theoretical Foundations**: To provide a deep understanding of how images are represented, processed, and analyzed digitally. This helps learners grasp the "why" behind techniques, rather than just the "how."
2. **Developing Practical Skills**: To enable students to implement image processing algorithms using programming tools (e.g., Python with libraries like OpenCV or MATLAB). The aim is to foster hands-on problem-solving for tasks like image enhancement or feature extraction.
3. **Fostering Interdisciplinary Applications**: To connect image processing to real-world domains such as healthcare, robotics, entertainment, and security, encouraging learners to apply concepts innovatively.
4. **Promoting Ethical and Critical Thinking**: To discuss the societal implications of image processing (e.g., privacy concerns in facial recognition or biases in AI-driven image analysis), aiming to produce responsible practitioners.
5. **Preparing for Advanced Studies or Careers**: To lay the groundwork for related fields like computer vision, machine learning, or data science, with aims to prepare students for research, industry roles (e.g., software engineer in imaging tech), or further education.

Module Learning Outcomes

مخرجات التعلم للمادة الدراسية

Knowledge-Based Learning Outcomes

These focus on foundational concepts and theories.

- **Describe Image Representation and Acquisition**: Students will be able to explain how digital images are formed, represented (e.g., as matrices of pixels in RGB, grayscale, or other color spaces), and acquired (e.g., via sensors, cameras, or scanners), including common file formats and their properties.
- **Understand Core Processing Domains**: Students will be able to differentiate between spatial domain techniques (e.g., convolution for filtering) and frequency domain methods (e.g., Discrete Fourier Transform for spectral analysis), and articulate their advantages and limitations.
- **Explain Image Enhancement and Restoration Principles**: Students will be able to define techniques like histogram equalization, noise models (e.g., Gaussian or salt-and-pepper), and restoration methods (e.g., inverse filtering), including mathematical foundations.

Skill-Based Learning Outcomes

These emphasize hands-on implementation and technical proficiency.

- **Implement Basic Image Operations**: Students will be able to apply point processing (e.g., brightness/contrast adjustment) and neighborhood operations (e.g., edge detection using Sobel or Prewitt operators) using programming tools like Python (with OpenCV or scikit-image) or MATLAB.
- **Perform Image Analysis Tasks**: Students will be able to execute segmentation (e.g., thresholding, k-means clustering) and morphological operations (e.g., erosion, dilation, opening/closing) to extract features like

	shapes, textures, or boundaries from images. • **Evaluate Image Processing Results**: Students will be able to assess algorithm performance using quantitative metrics such as Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), or Structural Similarity Index (SSIM), and interpret qualitative outcomes (e.g., visual improvements). **Application-Based Learning Outcomes** These connect theory to real-world scenarios and problem-solving. • **Apply Techniques to Domain-Specific Problems**: Students will be able to solve practical challenges, such as enhancing low-light images for photography, compressing images for storage (e.g., using JPEG principles or wavelets), or detecting objects in medical scans (e.g., tumor segmentation in MRI images). • **Integrate with Related Technologies**: Students will be able to combine image processing with elements of computer vision or machine learning, such as using convolutional filters for feature extraction in preparation for neural network-based tasks like object recognition. • **Develop and Test Custom Solutions**: Through projects, students will be able to design, implement, and debug an end-to-end image processing pipeline (e.g., a system for license plate recognition or facial feature enhancement), demonstrating creativity and optimization for efficiency. **Professional/Ethical Learning Outcomes** These promote responsible practice and critical thinking. • **Analyze Ethical Implications**: Students will be able to discuss societal impacts of image processing, such as privacy risks in surveillance systems, biases in automated facial recognition, or ethical considerations in image manipulation (e.g., deepfakes). • **Communicate Findings Effectively**: Students will be able to present technical results (e.g., via reports, visualizations, or presentations) to both technical and non-technical audiences, including recommendations for improvements or alternatives. • **Engage in Lifelong Learning**: Students will be able to identify gaps in their knowledge and suggest resources (e.g., research papers or advanced tools) for further exploration in emerging areas like AI-driven image synthesis or 3D processing. **Assessment and Achievement** Learning outcomes are typically evaluated through a mix of methods: • **Exams/Quizzes**: Testing theoretical knowledge. • **Labs/Assignments**: Hands-on coding tasks. • **Projects**: Group or individual work, such as building an image filter app. • **Presentations**: Demonstrating applications and ethical discussions.
Indicative Contents المحتويات الإرشادية	**Overall Module Structure** • **Duration**: 10-12 weeks. • **Prerequisites**: Basic programming (e.g., Python or MATLAB), linear algebra, and calculus. • **Teaching Methods**: Lectures, tutorials, hands-on labs, group projects, and guest talks on applications. • **Assessment**: Midterm exam (20%), labs/assignments (30%), final project (30%), final exam (20%). • **Tools**: Python (with libraries like OpenCV, scikit-image, NumPy),

MATLAB, or ImageJ for practical work.

- **Textbooks/Readings**: "Digital Image Processing" by Gonzalez and Woods; "Computer Vision: Algorithms and Applications" by Szeliski; research papers from IEEE journals.

Week-by-Week Indicative Contents

I'll break this down by week, grouping related topics. Each week includes key subtopics, learning activities, and suggested readings.

Weeks 1-2: Introduction to Digital Images and Fundamentals

- **Core Topics**:
  - Image formation and acquisition: Sensors, cameras, digitization processes, and sampling/quantization (e.g., Nyquist theorem).
  - Image representation: Pixels, matrices, color models (RGB, CMYK, HSV, grayscale), bit depth, and file formats (JPEG, PNG, TIFF).
  - Basic operations: Image arithmetic (addition, subtraction), geometric transformations (scaling, rotation, warping).
- **Activities**: Lecture on image basics; lab: Load and display images using Python/OpenCV, perform simple transformations.
- **Readings**: Gonzalez & Woods, Chapters 1-2.
- **Objectives Tie-In**: Builds foundational knowledge for representation and basic manipulation.

Weeks 3-4: Image Enhancement in the Spatial Domain

- **Core Topics**:
  - Point processing: Intensity transformations (e.g., negation, logarithmic/gamma correction).
  - Histogram processing: Equalization, matching, and specification for contrast enhancement.
  - Spatial filtering: Smoothing (averaging, median filters) for noise reduction; sharpening (Laplacian, high-boost filters).
  - Noise models: Gaussian, salt-and-pepper, speckle noise, and basic denoising techniques.
- **Activities**: Tutorial on histograms; lab: Implement histogram equalization and apply filters to noisy images. Assignment: Enhance a low-contrast photo.
- **Readings**: Gonzalez & Woods, Chapters 3-4.
- **Objectives Tie-In**: Develops skills in enhancement and evaluation metrics (e.g., PSNR).

Weeks 5-6: Frequency Domain Processing and Restoration

- **Core Topics**:
  - Fourier transforms: Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), and frequency domain filtering.
  - Low-pass/high-pass filters: Ideal, Butterworth, Gaussian filters for blurring or edge enhancement.
  - Image restoration: Inverse filtering, Wiener filtering for deblurring, and handling degradation models (e.g., motion blur).
  - Wavelets: Introduction to wavelet transforms for multi-resolution analysis.
- **Activities**: Lecture with mathematical derivations; lab: Apply FFT to images and filter in frequency domain using Python (e.g., with NumPy.fft).
- **Readings**: Gonzalez & Woods, Chapters 4-5; optional: Mallat's "A Wavelet Tour of Signal Processing."
- **Objectives Tie-In**: Covers advanced analysis in frequency domains, with implementation practice.

Weeks 7-8: Image Segmentation and Morphological Processing

- **Core Topics**:
  - Segmentation techniques: Thresholding (global, adaptive, Otsu's method), edge-based (Sobel, Canny operators), region-based (growing, splitting/merging).

	○ Morphological operations: Erosion, dilation, opening, closing, and skeletonization for shape analysis. ○ Feature extraction: Contours, textures, moments (e.g., Hu moments for invariance). ○ Watershed algorithm and graph-based segmentation. • **Activities**: Case study on object detection; lab: Segment medical images (e.g., cells in microscopy) and apply morphology to binary images. • **Readings**: Gonzalez & Woods, Chapters 9-10. • **Objectives Tie-In**: Focuses on analysis tasks like isolating regions, with ethical discussions on applications (e.g., in surveillance). **Weeks 9-10: Color Image Processing and Compression** • **Core Topics**: ○ Color models and transformations: RGB to HSV/YCbCr, pseudocolor processing. ○ Color enhancement and balancing: White balance, color correction. ○ Image compression: Lossless (Huffman coding, run-length encoding) vs. lossy (JPEG pipeline, DCT-based compression); introduction to standards like JPEG2000. ○ Advanced topics: Multi-spectral imaging or basic video processing extensions. • **Activities**: Group discussion on compression trade-offs; lab: Implement a simple JPEG-like compressor and compare file sizes/quality. • **Readings**: Gonzalez & Woods, Chapters 6 and 8. • **Objectives Tie-In**: Integrates color theory with practical compression, preparing for real-world data handling. **Weeks 11-12: Applications, Integration, and Emerging Topics** • **Core Topics**: ○ Real-world applications: Medical imaging (e.g., MRI enhancement), remote sensing (satellite imagery), computer vision (object detection), biometrics (facial recognition). ○ Integration with AI/ML: Convolutional Neural Networks (CNNs) for image processing tasks; brief intro to deep learning libraries like TensorFlow. ○ Ethical considerations: Bias in algorithms, privacy issues, deepfakes, and responsible AI practices. ○ Emerging trends: 3D image processing, hyperspectral imaging, or AI-generated images (e.g., GANs). • **Activities**: Guest lecture from industry (e.g., on autonomous vehicles); final project: Develop an end-to-end application (e.g., automated defect detection in manufacturing). Review and exam prep. • **Readings**: Szeliski, Chapter 1; selected papers on ethics (e.g., from ACM or IEEE). • **Objectives Tie-In**: Encourages application-based problem-solving and professional awareness.

Learning and Teaching Strategies استراتيجيات التعلم والتعليم	
Strategies	Teaching strategies • **Hands-on and project-based learning:** ○ Provide ample opportunities for students to write code by implementing algorithms from scratch, which reinforces

concepts better than passive learning.

- Assign projects that require students to solve real-world problems, such as medical image analysis or applications in robotics.

- **Collaborative learning:**
  - Encourage pair programming where one student writes code and the other acts as a navigator, promoting problem-solving and communication skills.
  - Foster a culture of continuous improvement through peer-to-peer code reviews.
- **Practical application of theory:**
  - Demonstrate both fundamental concepts and advanced topics, from basic image filtering and compression to deep learning architectures like convolutional neural networks.
  - Use practical examples and case studies to show how the theory applies to real-world applications, such as medical imaging, video compression, or autonomous vehicles.
- **Structured curriculum:**
  - Start with foundational topics like image acquisition, filters, and compression before moving to higher-level subjects like object detection, segmentation, and deep learning.
  - Integrate mathematical skills needed to solve problems within the image processing context.
- **Clear and constructive feedback:**
  - Provide regular and constructive feedback on students' code to guide them in improving their programming skills.

Learning strategies

- **Active coding:**
  - Students should actively write code to implement and test algorithms to develop a direct understanding of how they work.
- **Problem-solving:**
  - Engage with the material by applying learned techniques to new problems and synthesizing the results.
- **Collaboration:**
  - Work with peers on assignments to discuss and solve

	problems together.
	• **Self-study:**
	  ○ Allocate time for independent study, wider reading, and practice to reinforce what is learned in lectures and labs.
	• **Effective communication:**
	  ○ Practice writing accurate lab reports and effectively communicating findings.

Student Workload (SWL) الحمل الدراسي للطالب محسوب لـ ١٥ اسبوعا			
Structured SWL (h/sem) الحمل الدراسي المنتظم للطالب خلال الفصل	62	**Structured SWL (h/w)** الحمل الدراسي المنتظم للطالب أسبوعيا	4.1
Unstructured SWL (h/sem) الحمل الدراسي غير المنتظم للطالب خلال الفصل	63	**Unstructured SWL (h/w)** الحمل الدراسي غير المنتظم للطالب أسبوعيا	4.2
Total SWL (h/sem) الحمل الدراسي الكلي للطالب خلال الفصل	125		

Module Evaluation
تقييم المادة الدراسية

		Time/Number	Weight (Marks)	Week Due	Relevant Learning Outcome
Formative assessment	**Quizzes**	2	10% (10)	Continuous	LO #1, 2, 10 and 11
	Assignments	2	10% (10)	Continuous	LO # 3, 4, 6 and 7
	Projects / Lab.	1	10% (10)	Continuous	All
	Report	1	10% (10)	Continuous	LO # 5, 8 and 10
Summative assessment	**Midterm Exam**	2 hr	10% (10)	7	LO # 1-7
	Final Exam	2hr	50% (50)	16	All
Total assessment			100% (100 Marks)		

Delivery Plan (Weekly Syllabus)
المنهاج الاسبوعي النظري

	Material Covered
Week 1	Back ground

Week 2	Digital image fundamentals An image model Uniform and non-uniform image sampling and quantization Basic relationship between pixel (neighbours of pixel) Connectivity distance measures
Week 3	Image transforms Introduction to Fourier transform The discrete Fourier transforms Some properties of two-dimensional Fourier transform Separability, Translation, Rotation, Scaling, Average, value, Convolution, Correlation, Sampling
Week 4	Translation, Rotation, Scaling, Average, value, Convolution, Correlation, Sampling
Week 5	Fast Fourier transform FFT algorithm The inverse FFT
Week 6	Walsh transform Hadamard transform Discrete cosine transform Hotelling transform
Week 7	Discrete cosine transform Hotelling transform
Week 8	**Mid exam**
Week 9	Examination
Week 10	Image enhancement Spatial domain method
Week 11	Frequency domain method
Week 12	Image smoothing Linear averaging Median filtering Low pass filtering Averaging of multiple images
Week 13	Image sharpening Sharpening by differentiation High pass filtering Butterworth high pass filter
Week 14	Gaussian high pass filter The Laplacian in frequency domain
Week 15	**final Exam**

Delivery Plan (Weekly Lab. Syllabus) المنهاج الاسبوعي للمختبر	
	Material Covered
Week 1-2	
Week 2-3	
Week 3-4	
Week 4-5	
Week 5-6	
Week 6-7	
Week 7-8	
Week 8-9	
Week 9-10	
Week 10-11	

Week 11-12	
Week 12-13	
Week 13-14	
Week 15	

Learning and Teaching Resources مصادر التعلم والتدريس		
	Text	**Available in the Library?**
Required Texts		No (Available as an e-book)
Recommended Texts		No (Available as an e-book)
Websites		

APPENDIX:

Grading Scheme مخطط الدرجات				
Group	**Grade**	التقدير	**Marks (%)**	**Definition**
Success Group (50 - 100)	**A -** Excellent	امتياز	90 - 100	Outstanding Performance
	B - Very Good	جيد جدا	80 - 89	Above average with some errors
	C – Good	جيد	70 - 79	Sound work with notable errors
	D - Satisfactory	متوسط	60 - 69	Fair but with major shortcomings
	E - Sufficient	مقبول	50 - 59	Work meets minimum criteria
Fail Group (0 – 49)	**FX –** Fail	راسب (قيد المعالجة)	(45-49)	More work required but credit awarded
	F – Fail	راسب	(0-44)	Considerable amount of work required

Note: Marks Decimal places above or below 0.5 will be rounded to the higher or lower full mark (for example a mark of 54.5 will be rounded to 55, whereas a mark of 54.4 will be rounded to 54. The University has a policy NOT to condone "near-pass fails" so the only adjustment to marks awarded by the original marker(s) will be the automatic rounding outlined above.



ملاحظة: هذا النموذج تم وضعه وتقديمه من قبل مديرية ضمان الجودة في وزارة التعليم العالي والبحث العلمي