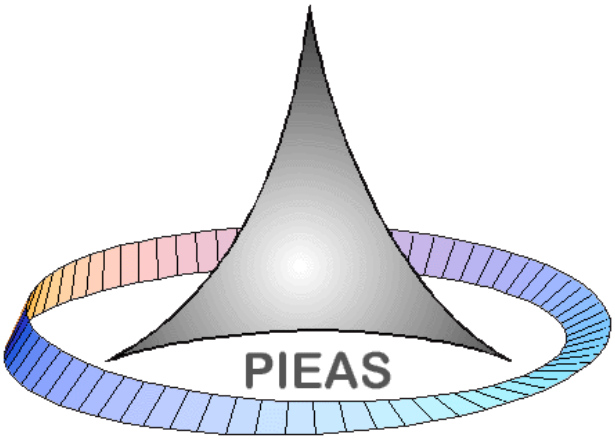
Proposal for "MS Artificial Intelligence" Degree Program at PIEAS



(Academic Committee)

August 2024

Pakistan Institute of Engineering and Applied Sciences (PIEAS)
(Dr. Asifullah Khan and Dr. Naeem Akhter)

Proposal for Launching a Master of Science Program in Artificial Intelligence (AI)

A proposal is being presented for approval, which entails launching a Master of Science (MS) program in Artificial Intelligence (AI) with a specific emphasis on industry-oriented applications at PIEAS. Recognizing the critical role of AI in the industry, we believe that establishing this program will position our university as a leading institution in AI education and research.

The proposed MS program in AI at PIEAS with an emphasis on industry-oriented applications will offer a comprehensive curriculum covering both foundational AI principles and specialized courses.

Objectives:

To effectively address critical national strategic goals in healthcare, transportation, security, energy, and education, there is a pressing need for cutting edge MS in AI curriculum. This will help interdisciplinary research in various fields of computer science and engineering. Collaboratively, it will help to develop AI solutions tailored to the specific requirements of strategic organizations. Emphasis will be placed on areas such as Target Recognition, Threat Monitoring, Drone Swarms, Cybersecurity, Reconnaissance and Surveillance, Search-and-Rescue Operations, Biomedical Informatics, Critical Infrastructure Protection, and Disaster Damage Assessment.

Eligibility:

a) BS in Computer Science, BS in Artificial Intelligence, BS in Data Science, BS in Cyber Security, BS in Information Systems, BS in Multimedia and Gaming, BS in Software Engineering, BS in Computer Engineering, BS in Electrical, BS in Electronics, and BS in Mechatronics.
b) First class academic career (2.5 CGPA out of 4 in the final degree or at least 60% in the annual system). One second division (minimum 50% marks) in the career may be allowed, however no third division is permitted.

Scheme of Studies:

The program is of 2-year duration (5 semesters including one summer session). A student will study four core and four optional courses. Fellowships are necessary to ensure the smooth operation of this MS program and to address the growing demand for young AI experts within the industry. The Fellows will be required to undertake two additional courses that are aligned with their foundational degree, potential placement, or future assignments. Following is the credit hours distribution:

Category	Credit Hours
Core	12
Institutional Requirement	1
Institutional Requirement (non-credit)	2
Fellowship Requirement	6
Optional	12
Thesis Research	12
Total Credit Hours (minimum)	**37** (43)

Semester-Wise Course Plan:

IR: Institutional Requirement, **C**: Core, **O**: Optional

S. No.	Course Code	Course Title	Cr. Hrs.	Course Status	Credit Hours
SPRING SEMESTER – YEAR 1					
1	CMS-501	Communication Skills	1	IR	**13**
2	CMS-511	Grooming and Sprucing-1	0	IR	
3	**CIS-xxx**	**Core-1**	3	C	
4	**CIS-xxx**	**Core-2**	3	C	
5	**CIS-xxx**	**Optional-1**	3	O	
6	**CIS-xxx**	**Optional-2**	3	O	
SUMMER SESSION – YEAR 1					
1	CIS-xxx	Fellowship Requirement – 1*	3	FR	**6**
2	CIS-xxx	Fellowship Requirement – 2*	3	FR	
FALL SEMESTER – YEAR 1					
1	CMS-512	Grooming and Sprucing-2	0	IR	**12**
2	**CIS-xxx**	**Core-3**	3	C	
3	**CIS-xxx**	**Core-4**	3	C	
4	**CIS-xxx**	**Optional-3**	3	O	
5	**CIS-xxx**	**Optional-4**	3	O	
SPRING SEMESTER - YEAR 2					
1	CIS-698	Thesis Research	6	C	**6**
SUMMER SEMESTER - YEAR 2					
1	CIS-698	Thesis Research	6	C	**6**

* Fellowship requirement refer to any specialized course based on basic degree, probable placement, future assignment, etc.

Note: Registered students of this program may register in courses offered by MS programs in other disciplines at PIEAS, if allowed by the Head, DCIS. MS thesis will be graded as Excellent, Very Good, Good, Fair or Unsatisfactory.

Total Credit Hours = 37 (43*)

List of Courses:

The courses listed below are intended to provide students with a strong theoretical foundation and practical skills necessary for addressing the unique challenges faced in national needs. The proposed curriculum is designed to strike a balance between theoretical knowledge, practical skills, and specialized applications of AI. By offering these courses, we aim to produce graduates, who are well-prepared to contribute to industry-related AI research, development, and strategic decision-making.

We believe that this comprehensive and specialized course list, combined with the distinguished faculty and industry collaborations at PIEAS, will position our MS program in AI with an emphasis on industry-oriented applications as a premier educational offering in this rapidly evolving field.

SR.	COURSE	STATUS
1	CIS-501 Statistical and Mathematical Methods for AI	Core
2	**CIS-504 Algorithms Design**	Core
3	**CIS-530 Artificial Intelligence**	Core
4	**CIS-621 Machine Learning**	Core
5	**CIS-522 Human Computer Interaction**	Optional
6	**CIS-523 Evolutionary Computing**	Optional
7	**CIS-524 Information Retrieval and Data Mining**	Optional
8	**CIS-527 Natural Language Processing**	Optional
9	**CIS-624 Machine Vision**	Optional
10	**CIS-627 Deep Neural Networks**	Optional
11	**CIS-642 Virtual Reality**	Optional
12	CIS-520 AI Ethics and Public Policy	Optional
13	CIS-533 Knowledge Based Systems	Optional
14	CIS-535 Autonomous Systems	Optional
15	CIS-640 Target Recognition and Tracking	Optional
16	CIS-644 Swarm Intelligence	Optional
17	CIS-647 Social Network Analytics	Optional
18	CIS-648 Intelligent Surveillance and Threat Detection	Optional

Course Contents

CMS-501: Communication Skills

Status	Institutional Requirement
Credits	1
Prerequisites	Nil

Writing module: Preparation of a project proposal or technical report, writing letters, mission statements, office memos etc; Speaking module: Presentation of the project proposal or technical report; Listening module: Simulations of interviews, lectures and question-answer sessions; Reading module: Reading of a suitable fiction novel (approximately 30-50 pages a week) with the use of vocabulary support, completion of assigned tasks and discussions.

References

1. Eric H. G., and Glendinning N., *English for Electrical and Mechanical Engineering*, Oxford University Press, 1995.
2. Huckin T. N., and Oslen L.A., *Technical Writing and Professional Communication for Nonnative Speakers of English*, 2nd Edition, McGraw Hill, 1991.
3. Swales J. M., and Feak C. B., *Academic Writing for Graduate Students, A Course for Nonnative Speakers of English*, 3rd Edition, Uni. of Michigan Press, 1994.

CIS-501: Statistical and Mathematical Methods for AI

Status	Optional
Credits	3
Prerequisites	Nil

Linear Algebra: linear mappings, orthogonal projections, matrix norms, singular values decomposition, eigenvalues and eigenvectors; Multivariate Analysis: Gradient, Jacobian, Hessian, Taylor theorem; Multivariate Optimization: linear least squares, gradient type methods and Newton type methods, regularization; Probability and Statistics: probability and Bayes theorem, distributions of random variables, covariance and correlation, Estimates: Maximum Likelihood and Maximum a Posteriori estimates, Cross entropy and Kullback-Leibler divergence.

References

1. Gareth J., Daniela W., Trevor H., and Robert T., *An Introduction to Statistical Learning with Applications in R*, Springer, New York, 2021.
2. Deisenroth M., Faisal A., *Mathematics for Machine Learning*, Cambridge University Press, 2020.
3. Thomas G., The Math of Machine Learning, Berkley University Press, 2020.

CIS-504: Algorithms Design

Status	Core
Credits	3
Prerequisites	Nil

Review of algorithmic basics; Brute force and divide & Conquer approaches; Dynamic programming: Optimization, Matrix chain multiplication, Assembly-line scheduling, Knapsack problem, Longest common subsequence, Optimal binary search trees; Greedy algorithms: Activity selection, Fractional Knapsack, Huffman coding problem; Graph algorithms: Review of basic graph algorithms, All-pairs shortest paths, Floyd-Warshall algorithm, Johnson's algorithm; Network flow: Bipartite matching, Hopcroft-Karp paths, Ford-Fulkerson algorithm, Edmonds-Karp algorithm, String algorithms: Rabin-Karp algorithm, Finite automaton algorithm, Knuth-Moris-Pratt algorithm; Polynomials and Fast Fourier Transform: Matrix multiplication on polynomials, The Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT); NP completeness:

Circuit satisfiability, 3-CNF, Cliques; Approximation algorithms: Vertex-cover and TSP, 1.5-approximation set-cover; Randomized algorithms: Randomized max 3-SAT, Probabilistic Maxcut, Derandomization of MST, Randomized median; Geometric algorithms: convex hull, segment intersection, closest-pair, voronoi, flip algorithm.

References

1. Kleinberg J., and Tardos É., *Algorithm Design*, Pearson, 2006.
2. Sedgewick R., and Wayne K., *Algorithms*, 4th ed., Addison-Wesley, 2012.
3. Cormen T. H., Leiserson C. E., Rivest R. L., and Stein C., *Introduction to Algorithms*, 3rd ed., MIT Press, 2009.
4. Skiena S., *The Algorithms Design Manual*, 2nd ed., Springer, 2008.

CMS 511: Grooming and Sprucing-1: Self Discipline

Status	Institutional Requirement
Credits	0 (One contact hour per week)
Prerequisites	Nil

Student's home town; Family set-up; School education; Performance in school; College education; Performance in college, University education; Performance in university; Religious education; Extra-curricular activities; Favorite subjects; Something special done for family; Brief description of family life; Personal impressions about studying at PIEAS; Politeness and courtesy, Some observations and/or suggestions about PIEAS, university dress code, Responsible behavior on social media, non-verbal communication, Tolerance and emotional control in discussions, Social etiquette comprising of dress code, eating manners.

CMS 512: Grooming and Sprucing-2: Personal & Professional Development

Status	Institutional Requirement
Credits	0 (One contact hour per week)
Prerequisites	Nil

Difficulties/problems faced by students; Any observations and/or suggestions; Ethical behavior and stress management; Habits of effective people: be proactive, begin with the end in mind, put first things first, think win-win, seek first to understand then be understood, synergize, and keep improving; Power point presentation on topic of choice; Job/placement interview; employment and higher education; General knowledge about the world; Global treaties and organizations; Participation in any physical activity certified by the Incharge Sports and verified by the Head Students Affair Division.

References

1. Covey S., *The 7 Habits of Highly Effective People: Powerful Lessons in Personal Change*, Simon and Schuster, 2004.
2. Covey S., *The 7 Habits of Highly Effective Teens: Workbook*, Mango Media Inc., 2015.
3. Peale N.V., *Power of Positive Thinking*, Vermilion (2012).

CIS-520: AI Ethics and Public Policy

Status	Optional
Credits	3
Prerequisites	Nil

Overview of ethics in AI; Ethics of AI in government, health, education, transportation, media, finance, and warfare; Ethics of data and AI; Ethics of AI prediction, classification, manipulation, and surveillance of humans; Ethics of social robots, self-driving cars and interactive machines; Ethics of AI on the Web and in Web based applications; The Asilomar principles

for AI; Justice, bias and human rights in AI decision-systems; AI safety, reliability and existential risks; Moral harms of AI; Disruptive regulation.

References

1. Liao, M., *Ethics of Artificial Intelligence*, Oxford University Press, 2020.
2. Dubber, M.D., Pasquale, F. and Das, S., *The Oxford Handbook of Ethics of AI*, Oxford University Press, 2020.
3. Lin, P., Abney, K. and Jenkins, R., *Robot Ethics 2.0*, Oxford University Press, 2019.
4. Saswat S., Pankaj S., Artificial Intelligence Evolution, Ethics and Public Policy, Routledge, 2019.
5. Wallach, W., Allen, C. *Moral Machines*, Oxford University Press, 2009.

CIS-522: Human Computer Interaction

Status	Optional
Credits	3
Prerequisites	Nil

Overview of Human Computer Interaction (HCI); Human capabilities: Perception, Memory, Cognition; Human diversity; Input devices and interaction techniques; Decision making; HCI tasks and metrics; Models of design: Goals Operators Methods Selection rules (GOMS), Keystroke Level, and Norman's 7 Stages; Principles and rules for interface verification, testing, and evaluation; Designing and building visual interfaces, multimodal interfaces, and perceptual interfaces.

References

1. Becker C. R., *Learn Human-Computer Interaction*, Packet Publishing, 2020.
2. Ozseven T., *Human-Computer Interaction*, Nova Science, 2020.
3. Rogers Y., Sharp H., and Preece J., *Interaction Design: Beyond Human - Computer Interaction*, 3rd ed., Wiley, 2011.
4. Shneiderman B., and Plaisant C., *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, 5th ed., Addison Wesley, 2009.Dix A. J., Finlay J. E., Abowd G. D., and Beale R., *Human-Computer Interaction*, 3rd ed., Prentice Hall, 2004.

CIS-523: Evolutionary Computing

Status	Optional
Credits	3
Prerequisites	Nil

Issues in classical optimization techniques; Introduction to evolutionary computation: Principles of evolutionary processes, Genetic algorithms, Genetic Programming, Evolutionary programming, Evolutionary strategies; Representation of data; Selection methods; Search operators; Fitness evaluation; Constraint handling techniques; Population structure; Meta evolutionary approaches; Self-adaptation; Implementation issues.

References

1. Lanham M., *Evolutionary Deep Learning*, Manning, 2023.
2. Gridin I., Learning Genetic Algorithms with Python, bpb, 2021.
3. Eiben E. A. and Smith, E. J., *Introduction to Evolutionary Computing*, Natural Computing Series, Springer, 2010.
4. Poli R., Langdon B. W. and McPhee F. N, *A Field Guide to Genetic Programming*, Lulu Enterprises, UK Ltd, 2008.
5. Adrieas P. E., *Computational Intelligence: An Introduction*, 2nd ed., John Wiley & Sons, 2007.

CIS-524: Information Retrieval and Data Mining

Status	Optional
Credits	3
Prerequisites	Nil

Overview of structure of data systems, Basics of Information Retrieval (IR) and Data Mining; Ranking principles: Boolean IR, TF-IDF (Term frequency-Inverted document frequency), IR evaluation, Probabilistic IR, BM25, Statistical language models, latent topic models, Relevance feedback, novelty & diversity; Indexing and searching: Inverted lists, Merging vs. hashing, Index compression, Top-k query processing; Kernel methods for information retrieval; Information extraction (IE): Rule- and learning-based extraction, HMMs, Entity reconciliation, Knowledge-base construction, Open-IE; Graph Mining: Centrality, random graphs, and frequent subgraph mining; Two matrix factorization methods.

References

1. Tan P., Steinbach M., Kumar V., *Introduction to Data Mining*, Pearson, 2019.
2. Buttcher S., Clarke C., Cormack G., *Information Retrieval: Implementing and Evaluating Search Engines*, The MIT Press, 2016.
3. Zaki M. J. and Meira Jr. W., *Data Mining and Analysis: Fundamental Concepts and Algorithms*, Cambridge University Press, 2014.
4. Han J. and Kamber M., *Data Mining: Concepts and Techniques*, 3rd Edition. Morgan Kaufmann, 2012.
5. Croft W. B., Metzler D., Strohman T., *Search Engines: Information Retrieval in Practice*, Addison-Wesley, 2009.

CIS-527: Natural Language Processing

Status	Optional
Credits	3
Prerequisites	Nil

Introduction to various fields of NLP; Challenges in NLP; Language characteristics and ambiguities; Linguistic NLP; Language modeling: Morphology, Syntax, Phonology, Phonetics, Semantics; Statistical NLP: Zipf's Law, N-gram models, Parameter estimation, Lexicon - word classes and tagging, Parsing: Deterministic parsing, Statistical methods of parsing; Combined linguistic and statistical approaches for NLP; Evaluation of NLP applications; Advanced topics in NLP: self-Attention and Transformers, prompting, seq2seq, question answering, machine translation, etc.

References

1. Tunstall L., Werra L., Wolf T., *Natural Language Processing with Transformers*, O'Reilly Media, 2022.
2. Majumder B., Gupta A., *Practical Natural Language Processing*, O'Reilly Media, 2020.
3. Kamath U., Liu J., Whitaker J., *Deep Learning for NLP and Speech Recognition*, Springer, 2020.
4. Jurafsky D., and Martin J. H., *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*, Prentice Hall**,** 2009.
5. Jackson P., and Moulinier I., *Natural Language Processing for Online Applications: Text Retrieval, Extraction, and Categorization,* 5th ed., John Benjamins Publishing Company, 2002.

CIS-530: Artificial Intelligence

Status	Optional
Credits	3
Prerequisites	Nil

Fundamentals of AI; Uninformed, heuristic and local search; Constraint satisfaction problems; Intelligent game programming; Propositional and first order logic agents; Probabilistic reasoning; Automatic Planning and scheduling; Learning from data; Machine learning phases; Supervised and un-supervised learning; ANNs; Adversarial learning; Reinforcement learning; Meta learning.

References

1. Bathgate A., *The Artificial Intelligence Revolution*, Andrew Bathgate, 2023.
2. Russell S. J. and Norvig P., *Artificial Intelligence: A Modern Approach*. Prentice Hall, 2020.
3. Heaton J., *Artificial Intelligence for Humans*, Volume 1: Fundamental Algorithms, CreateSpace Independent Publishing Platform, 2013.
4. Bratko, *Prolog Programming for Artificial Intelligence*, 4th edition, Pearson Education Canada, 2011.

5. Millington and Funge J., *Artificial Intelligence for Games*, 2nd edition. Burlington, MA: CRC Press, 2009.

CIS-533: Knowledge based Systems

Status	Optional
Credits	3
Prerequisites	Nil

Introduction to Knowledge Based System (KBS): Lexical KBS, Encyclopedic KBS, Common-sense KBS; KBS architecture; KBS software lifecycles; Knowledge representation; Knowledge acquisition; Knowledge engineering; Knowledge reasoning; Types of KBS: Intelligent tutoring systems, Expert systems, Hypertext manipulation systems, Case-based systems, Rule-based systems; Uncertainty and vagueness; Applications of KBS: combat management, mission planning, training aids, maintenance and troubleshooting, etc.

References

1. Merritt D., *Expert Systems in Prolog*, Independently published, 2019.
2. Joachim W., Thanos C., *Foundations of Knowledge Base Management: Contributions from Logic, Databases, and Artificial Intelligence Applications*, Springer, 2012.
3. Puppe F., *Systematic Introduction to Expert Systems: Knowledge Representations and Problem-Solving Methods*, Springer, 2011.
4. Durkin J., *Expert Systems: Design and Development*, Prentice Hall, 1994.
5. Gonzalez A. J., Dankel D. D., *The Engineering of Knowledge-based Systems*, Prentice Hall, 1993.

CIS-535: Autonomous Systems

Status	Optional
Credits	3
Prerequisites	Nil

Introduction to autonomous systems; Perception: sensors, sensing, extraction and sensor fusion; Orientation: reference frame, position and localization of autonomous systems; Modelling: forward and inverse kinematics for autonomous systems; Dynamics of wheeled, air, space and underwater autonomous systems; Control: motion control of autonomous systems; Learning and decision: Multi-agent Markov decision process, Q-learning, deep reinforcement learning, and Braitenberg vehicle.

References

1. Louise A. D., *Verifiable Autonomous Systems*, Cambridge University Press, 2023.
2. Sutton R.S., Barto A. G., *Reinforcement Learning: An Introduction*, MIT Press, 2018.
3. Corke P., *Robotics, Vision and Control*, Springer, 2017.
4. Alain C., Mhamed I., *New Autonomous Systems*, Wiley, 2016.
5. Siegwart R., Nourbakhsh I. R., Scaramuzza D., Arkin R. C., *Introduction to Autonomous Mobile Robots*, MIT Press, 2011.

CIS-621: Machine Learning

Status	Optional
Credits	3
Prerequisites	Nil

Introduction to Machine Learning: Examples, Supervised and Unsupervised Learning, Discriminative vs. Generative Learning, Regression; Bayesian Decision Theory; Parametric and Non Parametric Methods; Dimensionality Reduction; Clustering Approaches; Classification Techniques: Artificial Neural Networks, Competitive Learning, Support Vector Machines, Decision Trees and Random Forests, Combining Multiple Classifiers: Bagging, Boosting, Stacked

Generalization; Reinforcement Learning; Transfer Learning; Adversarial Learning; Deep Learning: CNN, AE, GAN, Transformer; Design and Analysis of Machine Learning Experiments; Lab Assignments.

References

1. Maini V., Sabri S., *Machine Learning For Humans*, Alanna Maldonado, 2023.
2. Witten, Ian H., *Data Mining: Practical Machine Learning Tools and Techniques*, Morgan Kaufmann, 2016.
3. Alpaydin, Ethem, *Introduction to Machine Learning*, MIT press, 2014.
4. Duda, R. O., Peter E. H. and David G. S., *Pattern Classification*, John Wiley & Sons, 2012.
5. Sergios T., Konstantinos K., *Pattern Recognition*, 4rth Ed., 2008.

CIS-624: Machine Vision

Status	Optional
Credits	3
Prerequisites	Nil

Overview of a machine vision system; Image formation; Feature extraction and matching; Transformations; Projective geometry; Camera calibration; Stereo vision; Shape from X; Scene modeling and 3D reconstruction; Pose estimation; Image classification and retrieval; Video classification and retrieval; Semantic segmentation; Image captioning; Visual question answering; Content creation; Cross-modal vision.

References

1. Elgendy M., *Deep Learning for Vision Systems*, Manning, 2020.
2. Holden S., Computer Vision: Advanced Techniques and Applications, Clanrye Intl., 2019.
3. Forsyth D. A. and Ponce J., *Computer Vision: A Modern Approach*, Prentice Hall, 2011.
4. Szeliski R., *Computer Vision: Algorithms and Applications*, Springer, 2010.
5. Hartley R, and Zisserman A., *Multiple View Geometry in Computer Vision*, 2nd Ed., Cambridge University Press, 2004.

CIS-627: Deep Neural Networks

Status	Optional
Credits	3
Prerequisites	CIS-530 or equivalent

Artificial Neural Networks: Biological and Artificial Neurons; Types of Neural Networks: Supervised, Unsupervised and Competitive Learning paradigms, Adaline, Perceptron, and Multilayer Perceptron, Back Propagation; Deep NNs and their Architectures; Training Deep Models: Gradient-Based Optimization, SGD, Momentum, Adaptive Learning Rate, Parameter Initialization Strategies; Deep Convolutional Neural Networks (CNNs): Convolution & Pooling, Variants of Convolution, Recent Architectures of Deep CNNs, Fine Tuning of already Trained CNN; Deep Autoencoders: Regularized Autoencoders, Denoising Autoencoders, Contractive Autoencoders; Practical Methodology: Performance Metrics, Baseline Models, Gathering more Data, Selecting Hyper parameters and Debugging Strategies; Transfer Learning; Generative Adversarial Learning (GAN); Deep Reinforcement Learning; Transformer; Vision Transformers; Large Language Models; Neural Evolution Search (NAS); Labs: MLP, CNN, GAN, ViT, and MaxVit-UNet.

References

1. Khan A., Sohail A., Zahoora U., Qureshi A. S., *A survey of the recent architectures of deep convolutional neural networks*, Artificial Intelligence Review, 53(8), 2020.
2. Aggarwal C., *Neural Networks and Deep Learning*, Springer, 2018.
3. Bengio Y., Goodfellow I. J., and Courville A., *Deep Learning*, MIT Press, 2016.
4. Haykin S., *Neural Networks: A comprehensive Foundation*, 3rd Edition Pearson Education Press, 2008.
5. Engelbrecht A. P., *Computational Intelligence: An Introduction*, 2nd Edition, Wiley, New York, 2007.

CIS-640: Target Recognition and Tracking

Status	Optional
Credits	3
Prerequisites	Nil

Target initialization; Appearance modelling; Target segmentation, detection, localization, and recognition; Feature extraction and matching; Motion estimation; Trajectory estimation and prediction; Tracking by detection: one-stage detection, two-stage detection; Resource-constrained tracking; Multi-target tracking; Multi-camera tracking; Multimodal tracking; 3D Tracking and pose estimation; Synchronous Localization and Mapping (SLAM); Parallel Tracking and Mapping (PTAM).

References

1. Bruce J. S., *Automatic Target Recognition*, SPIE, 2020.
2. Schachter B. J., *Automatic Target Recognition*, SPIE, 2018.
3. Szeliski R., Computer Vision: Algorithms and Applications, Springer, 2010.
4. NG W., *Intelligent Systems: Fusion, Tracking and Control*, Inst of Physics, 2003.

CIS-642: Virtual Reality

Status	Optional
Credits	3
Prerequisites	Nil

Overview of immersive technologies: augmented, virtual, mixed, and extended Reality; 3D transforms; Projective geometry; Camera calibration; Real-time tracking and pose estimation; Human factors and human perception; Characterization of virtual environments; Scene graphs; Rendering; Modelling and creating virtual environments; Immersive technology devices; Virtual characters; Interaction and collaboration with virtual environments; Immersive application development.

References

1. Pierre R., *Immersive Technologies: Virtual Reality, Augmented Reality, Mixed Reality and the Immersive Ecosystem*, Blurb, 2023
2. Steven M. L., *Virtual Reality*, Cambridge University Press, 2017.
3. Joseph L. Jr., Kruijff E., Bowman D., *3D User Interfaces: Theory and Practice*, Addison Wesley, 2017.
4. Schmalstieg D., Höllerer T., *Augmented Reality: Principles and Practice*, Addison-Wesley, 2016.
5. Fuchs P., Moreau G., and Guitton P., *Virtual Reality: Concepts and Technologies*, CRC Press, 2011.

CIS-644: Swarm Intelligence

Status	Optional
Credits	3
Prerequisites	Nil

Introduction to swarm intelligence: definition and overview, historical background, characteristics and principle; Swarm intelligence algorithms: Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), Bacterial Foraging Optimization (BFO), and Firefly Algorithm (FA); Collective behaviour in natural systems: social insects and their behaviour, flocking and schooling behaviours; Self-Organization and emergence: concepts of self-organization, emergent behaviours in swarms, local interactions and global patterns; Swarm intelligence applications: optimization problems and swarm approaches, routing and scheduling problems, swarm robotics and autonomous systems, data clustering and classification; Multi-objective optimization with swarm intelligence.

References

1. Chakraborty A., Kar A., *Swarm intelligence: A review of algorithms*, Nature-inspired Computing and Optimization: Theory and Applications, 2017.
2. Englebrecht A., *Computational Intelligence: An Introduction*, John Wiley & Sons, 2007.
3. James K., *Handbook of Nature-inspired and Innovative Computing: Integrating Classical Models with Emerging Technologies*, Springer, 2006.
4. Andries P. E., *Fundamentals of Computational Swarm Intelligence*, Wiley, 2005.

CIS-647: Social Network Analytics

Status	Optional
Credits	3
Prerequisites	Nil

Introduction to networks and graph data structure; Network data representation and analysis; Basic Network measures; Random network models; Network centrality; Community detection; Small world network models; Network theories: Theories of self-interest (control of information flow), Theories of mutual self-interest and collective action (Inducement to contribute), Contagion theories (social influence); Cognitive theories (knowledge structure / semantic network); Strategic network and information search; Contagion, opinion formation, coordination and cooperation.

References

1. Coscia M., *The Atlas for the Aspiring Network Scientist*, Michele Coscia, 2021.
2. Scott J., *Social Network Analysis*, SAGE, 2017.
3. Easley D., Kleinberg J., *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*, Cambridge University Press, 2010.
4. Brandes U., Erlebach T., *Network Analysis*, Springer, 2005.

CIS-648: Intelligent Surveillance and Threat Detection

Status	Optional
Credits	3
Prerequisites	Nil

Access control and intrusion detection; Object detection, localization, recognition, re-identification, counting, and tracking; Behaviour monitoring; Crowd monitoring; Traffic monitoring; Media monitoring; Video summarization; Video forensics and demographic analytics; Multimodality analytics; Large scale analytics; Threat actors; Threat intelligence; Threat intelligence types; Threat intelligence lifecycle; Threat intelligence tools; Threat intelligence use-cases.

References

1. El-Alfy E. M., Bebis G., and Zhou M., *Intelligent Image and Video Analytics*, CRC Press, 2023.
2. Roccia T., *Visual Threat Intelligence: An Illustrated Guide For Threat Researchers*, Independently published, 2023.
3. Rathore A., Rahamatkar S., Ali I., *Video Data Analytics for Smart City Applications: Methods and Trends*, Bentham Science, 2023.
4. Olatunji I. E., Cheng C., *Video Analytics for Visual Surveillance and Applications: An Overview and Survey*, Springer, 2019.
5. Liska A., *Threat Intelligence in Practice*, O'Reilly Media, 2017.

MS THESIS RESEARCH IN SPRING and SUMMER SEMESTER

CIS-698: MS Thesis Research

Status	C
Credits	6+6
Prerequisites	Relevant courses in previous semester

Under this title, student will conduct a project on some AI related problem. He/She may take part in the on-going research or may introduce a novel approach in a specific field in consultation with his/her supervisor. The nature of the project may be research, development or design and may involve experimental or computational work or combination of both. Student performance in these activities will also be counted towards the overall evaluation.