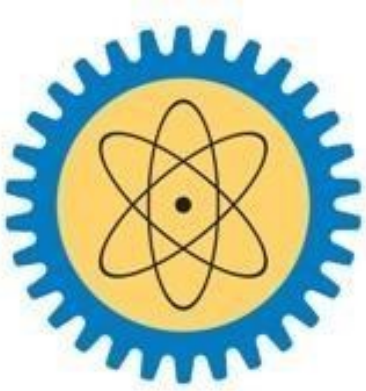

BUSITEMA UNIVERSITY

Pursuing Excellence

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF COMPUTER ENGINEERING AND INFORMATICS

Master of Science in Artificial Intelligence

March 2023

1.0 BACKGROUND

1.1 BUSITEMA UNIVERSITY

Busitema University was established as a Public University under the Universities and OtherTertiary Institutions Act 2001 Instrument No. 22 of 2007. This followed the accreditation of the University and its initial academic programs by the National Council for Higher Education in February 2007. Busitema University was established as a multi-campus model public University located in the eastern region of Uganda. The main campus is at Busitema and other campuses at Nagongera, Namasagali, Arapai, Mbale, Pallisa and Kaliro.

Vision:

A centre of academic and professional excellence in science, technology and innovation

Mission:

To provide high standard training, engage in quality research and outreach for socio-economic transformation and sustainable development.

Core Values:

Excellence, Relevance, Innovativeness, Professionalism, Ethics and Integrity, Equity, Internationalization and Respect for diversity

1.2 Department of Computer Engineering

The Department of Computer Engineering is under the Faculty of Engineering at the Busitema main campus. The department offers the following courses:-

1. Master of Computer Forensic
2. Bachelor of Computer Engineering
3. Bachelor of Electrical Engineering
4. Diploma in Computer Engineering
5. Diploma in Electrical Engineering

1.3 The Proposed Programme

1.3.1 Programme Background

The rapid evolution of computing in the last century has transformed our world. Industries in every field are becoming more and more productive and efficient. The UN highlights the critical role of science, technology and innovation in achieving the Sustainable Development Goal (SDGs)[1]. SDG goals cannot be achieved without the effective, appropriate, and inclusive application of science, technology, and innovation. Tjoa (2016) also highlights the enormous potential of ICT to accomplish the SDGs, which cover the three dimensions of economic prosperity, social equity and environmental sustainability in 2030. Adding that no other domain in the recent past had such a strong influence on the development of countries and societies than information and communication technologies (ICTs), especially in driving today's innovation, efficiency and effectiveness across all sectors. The proposed programme intends to address SDG4 (Quality education) and 9 (Generating employment and income through innovation).

Uganda's policy on science, technology and innovation (STI) requires programmes to make an effective contribution to its social and economic development[2]. For this reason, the government advocates for strengthening national innovation performance to improve the competitiveness of Ugandan firms and industries in the global economy which aligns with Busitema University Strategic Plan (2020/21 – 2024/25). Under objective 2, Increasing High Impact Research, Innovation and Technology, the University will "increase the number of graduate programmes and strengthen their relevance and quality." The proposed programme aims to equip students with the knowledge and

[1] https://unctad.org/press-material/un-highlights-critical-role-science-technology-and-innovation-achieving-sdgs

[2] https://unctad.org/system/files/official-document/dtlstict2020d4_en.pdf

technical skills in computers and IT, research and innovation, leading to the development of solutions that strengthen the sustainable development of communities and the country as a whole. Moreso, the graduates from this programme will contribute to society by translating knowledge and skills acquired to support government programs that improve incomes and welfare of all Ugandans e.g development of technologies to implement Uganda's Parish Development Model (PDM).

Despite the increasing prominence of the computer science discipline, existing computer scientists' workforce are inadequate to satisfy the demand for qualified computer professionals. Moreover, while the number and sophistication of computer systems increase, the shortfall is expected to worsen in the coming years. According to 2020 Google Developer Survey[3,4], Uganda has 11,000 developers and is ranked ninth on the African continent. However, experts say this is a very small pool compared to the country's needs. Aware of this problem, several academic institutions worldwide have defined and offered computer science programs to address the shortage.

Particularly, to address the increasing demand for computer professionals with expertise in software development, data analytics, cybersecurity and robotics, academic institutions have established several computing programmes, including Master in computer science programs. In addition, ACM has undertaken special initiatives to develop educational guidelines for developing such computer science programs at the post-secondary level.

The Masters of Science in Artificial Intelligence programme provides in depth training in computer science. Students acquire a solid foundation in advanced algorithms, computer security, artificial intelligence and Internet technologies and gain expertise through specialization tracks. The Discipline of Computer Science has changed the way we live, has propelled our economy forward through innovation and will continue to do so for the foreseeable future. Problem-solving is a core aspect of computer science, and graduates of this programme will be at the forefront of software-based technologies, which are viewed from many angles.

Recent breakthroughs in Information and Communication Technologies (ICTs) are unleashing new capabilities and fundamentally changing the nature of work. The Fourth Industrial Revolution (4IR) provides challenges and opportunities. The proposed Science in Computer Science programme is designed to strengthen linkages between industry and academia.

[3] https://www.newvision.co.ug/articledetails/111503
[4] https://www.developintelligence.com/developer-survey/

1.3.2 Justification of the Master of Science Programme

Computer science is driving our digital transformation; it is at the forefront of scientific discovery and the heart of economic growth. Utilizing society's wealth of data requires people who can blend research, technology and ingenuity. With the exponential growth of data being produced and the rise of automation in the workplace, our MSc in Artificial Intelligence Programme aims to meet the high demand for skilled data scientists, Artificial Intelligence (AI) and Systems and Robotics specialists. Graduates of our programme will be employed in a wide variety of sectors, including finance and government and well as create jobs by developing products and innovations that add value to other professional fields. This program has been designed for two major specializations: Artificial Intelligence & Data Science, Systems & Robotics. Graduates of Masters of Science in Artificial Intelligence will have strong technical expertise in their particular field and have the ability to work effectively in interdisciplinary areas and tackle problems that require both computing and technical solutions.

1.3.3 Uniqueness and Relevance of the Programme

The MSc program differs from most existing computer science programs as it concentrates on both applied research and the development of professional skills. The program focuses on the skills required for successful careers in industry, reflecting the University's goals to be market-oriented and provide high-quality professionals in the industry. Graduates from this program will build careers in industrial research and a wide variety of sectors, solving real-world problems and talking through the latest cutting-edge discoveries and innovations. The MSc in Artificial Intelligence programme of Busitema University intends to shape the digital future within the two broad knowledge areas of: Artificial Intelligence & Data Science and Robotics & Intelligent Systems. The programme will produce graduates with theoretical and practical expertise in analysis, development and execution of computer systems that solve industry and organizational challenges in health, transportation, agriculture, industrial automation, and financial systems among others.

1.4 TITLE

The title of the programme is: “Master of Science in Artificial Intelligence (MAI)”

1.4.1 Main Features in the Program

Areas of Specialisation

The MSc in Artificial Intelligence program is entirely privately sponsored. The curriculum has two areas of specialization:

i. Data Science

ii. Systems and Robotics

A student pursuing a MSc in Artificial Intelligence shall be required to specialize in one of the two areas in the second semester of year one. The choice of the areas of specialization was dictated by the current trends and needs in the computing field in the region and internationally.

i. Data Science

The Data Science option aims at producing graduates equipped with skills to process, analyze and extract insight from huge amounts of data. It draws upon our world-leading expertise in machine learning, computer vision and image processing, visual analytics, high-performance computing, data mining and information retrieval. There is a growing demand for professionals with this skill set because individuals and organizations continuously produce vast amounts of real-time heterogeneous data (known as Big Data). The application of Big Data can be seen in health, business, security, intelligent transport, energy efficiency, education, retail and the creative industries, among others. The AI and data science option will equip students with advanced knowledge and hands-on experience in algorithms, tools, and techniques for managing and processing big data.

ii. Systems and Robotics

The Systems and Robotics option combines instructions in the underlying theoretical basis for modern robotics and autonomous systems with machine learning and hands-on experience in industry or research. This option bridges cutting-edge technologies and industrial research in the 4^{th} industrial revolution. It is designed for students from any engineering or computer science bachelor’s degree program and teaches them to synthesize engineering with machine learning. Students will gain hands-on experience to integrate knowledge in programming, machine learning, and control systems among others to develop industrial robots, medical/surgical robots, assistive robots, etc.

1.4.2 Programme Objectives and Outcomes

Main Objective

The Master of Science in Artificial Intelligence aims to equip students with advanced computing skills to solve real-world problems.

The Objectives of the Program are:

1. To equip students with technical expertise in computer science and skills, along with wider professional skills such as critical thinking and communication to satisfy the technological needs in the private and public sectors.
2. To provide students with advanced knowledge in data science, AI, and systems security access to cross-cutting edge technologies, including IoT.
3. To provide students with competence in applying modern computing tools and technologies to solve real-world challenges.
4. To equip students with the knowledge and skills required to design and build robotic/automated industrial systems.
5. To provide students with research skills.

Learning Outcomes of the Programme

On successful completion of this programme, each student can:

1. Demonstrate knowledge and skills needed to tackle real-world problems requiring computing and technical solutions.
2. Apply technical expertise in computer science and skills, along with wider professional skills such as critical thinking and communication, to satisfy the technological needs in the private and public sectors.
3. Demonstrate advanced knowledge in data science, AI, and systems security access to cross-cutting edge technologies, including IoT.
4. Show competence in applying modern computing tools and technologies to solve real-world challenges.
5. Apply knowledge and skills required to design and build robotic/automated industrial systems in this growing 4th industrial and robotic revolution.
6. Exhibit research skills that show they can grow with the technological advancements and help them participate in developing new technologies.

Opportunities for the Graduates of the Programme

This programme intends to strengthen graduates in academia, research field, industries, government, private and business organizations. Graduates of the programme have the following possible career options:

- Computer/Cyber Security professionals
- Software Development Engineers
- Data Scientists
- Data Analysts
- ICT Project Consultants
- Systems Security Analysts
- Researchers
- Systems Analysts
- Business Intelligence Analysts
- Robotic Developers
- Innovators and Job Creators

2.0 RESOURCES

2.1 Human Resources

The University (both Faculty of Engineering and Faculty of Science Education) has well-qualified full-time academic staff who teach core computer science courses in the programme curriculum. Available human resources include seven (08) PhD holders and five (05) PhD students and three (3) Visiting experts. The qualifications of the academic staff for teaching the programme are presented in Table in Appendix 2. Staff in the department usually receive specialized skills enhancement training on how to handle the practical aspects of the course

2.2 Technical and Infrastructure Resources

2.2.1 Lecture Rooms

The department has five lecture rooms for conducting the MSCS classes. In addition, there is a dedicated Research and discussion room for use by graduate students at Busitema Faculty of Engineering.

2.2.2 Laboratories

There are adequate laboratory facilities for carrying out practical sessions. The Faculty of Engineering has two well-equipped computer laboratories with over 150 computers. Another computer laboratory is situated in the university library, which is also well-equipped for students' research. Furthermore, the University procures software required for carrying out practical sessions in the computer science course. In addition, there is a dedicated E-learning Laboratory, a dedicated laboratory for graduate students.

2.2.3 Office Space

The department has an office and a common room for teaching staff; the need for additional office space has been addressed through the ongoing construction of the new faculty building complex that will have an office space for all the departments in the faculty.

2.2.4 Tools, Equipment and Materials

The following tools, equipment and materials will be used in the teaching: LCD projectors, computers, chalkboards, whiteboards, markers and chalk, software and intelligent devices.

2.2.5 Modern library and ICT facilities

Under the Higher Education Science Technology project, the African Development Bank set up a three-storied library with offices. Furthermore, the ADB support set up a state-of-the-art ICT-based library with E-learning facilities, linking together all campuses of the University. Additionally, a wide range of E-resources is available in the library. Internet access with 64Mbps is also available for accessing these e-resources; the university library has subscribed to several journal databases as listed in Table in Appendix 3.

2.2.6 E-Learning Platforms

Busitema University has an eLearning platform called "https://lms.busitema.ac.ug/" and it is expected that courses will be developed as interactive online modules on lms. Students in the Department of Computer Science have adequate access to computers. Each student will be expected to have a personal computer. This creates a good environment for e-learning blended teaching. All courses in the new curriculum will be taught in a blended way. All course materials will be put on lms. Staff will, as much as possible, make use of e-learning facilities like discussion forum and drop boxes for assignments. This will increase student activity/participation and reduce staff effort (e.g. staff will not need to dictate notes). This in turn will increase the material covered and taken in by the students.

2.3 Programme funding

Busitema University is a public-funded University that receives most of its financial resources from the Government of Uganda. However, the primary source of funding for the programme shall be through tuition fees (self or private institutional student sponsorships), investments by the University, development partners, consultancy services, and private sector partnerships. For this programme, privately sponsored students - both Ugandan and non-Ugandan - are required to pay their tuition fees on a semester basis for four (4) semesters over the two (2) years of study. See Appendix 1. Various resources shall also be generated by faculty staff under the programme through bankable research and outreach projects, consultancies and donor support, some of which resources will be used to strengthen programme facilities and activities.

3.0 PROGRAMME REGULATION

3.1 Program Duration

The Masters of Science in Artificial Intelligence will be a two-year (four-semester) programme by Taught Courses and Dissertation.

During the training:

- A student must complete an approved program of courses totalling to 40 Credit Units in year one and 20 Credit Units in year two of the programme.
- A student must submit a Dissertation on an approved topic that carries a minimum of 10 Credit Units in year two. Joint internal and external examination of the Dissertation is mandatory.
- The Minimum Graduation load for the programme is, therefore 60 CUs.

3.2 Admission Requirements

To be eligible to apply for the Master of Science in Artificial Intelligence , the candidate must hold any of the following:

1. A Bachelor's degree in Computer Science of second-class lower division and above from a recognised university, or
2. A Bachelor's degree of second-class lower division and above in Computer Engineering, or
3. A Bachelor's degree of second-class lower division and above in Software Engineering, or
4. A Bachelor's degree of second-class lower division and above in an Engineering field or Information Technology with a strong foundation in programming, data structures, algorithms, and mathematics, or any other field of Science with a Computer Science option.

3.3 Upgrading from Postgraduate Diploma

If a candidate holds a Postgraduate Diploma in Computer Science of Busitema University of at least a Lower Second class, he/she may apply to join in the second year of the Master of Science in Artificial Intelligence provided they have followed equivalent courses in the post graduate Diploma. In such a case, the applicant is expected to undertake research in the second year and any remaining course units to meet the minimum requirement for the award of the M.Sc. in Computer Science Degree.

The upgrade of the PGD Computer Science to the M.Sc. Computer Science described above must be supported by relevant academic documents obtained for the PGD Computer Science of Busitema University. This must be done for purposes of analyzing the relevant academic courses that must have been attempted as per the current M.Sc. in Computer Science curriculum. Any courses that were not attempted by the applicant as per the first years course load of the current M.Sc. in Computer Science

curriculum must be taken. When a student graduates with a Postgraduate Diploma of Computer Science of Busitema University with a classification of Pass, s/he can apply for the Master of Science in Artificial Intelligence but is admitted to the first year of the M.Sc. in Computer Science program.

3.4 Target Group

The Master of Science in Artificial Intelligence is aimed at telecom engineers, computer scientists, software developers, researchers, developers of robotic and industrial automation systems, etc., who wish to expand their knowledge in computer science.

3.5 Projected Student numbers

It is proposed that the programme starts with 25 students in the 2022/2023 academic year and the same numbers (25 students) admitted each year for the next four years (see Table below). The increase in student number will consider both infrastructures and human and financial resource capacity to handle the programme.

Activity/Year	2022/2023	2023/2024	2024/2025	2025/2026	2026/2027
No. of Students Admitted	25	25	25	25	25
Commutative No. per year	25	50	50	50	50

3.6 Aspects of Gender and Equality

Uganda actively promotes gender and equality because it's a precondition for sustainable development; Busitema University has a strong affirmative policy. The current female enrollment at the graduate level at the Faculty of Engineering is about 10% compared to about 30% and increasing at undergraduate levels. The programme will specifically target female candidates to increase the percentage to 25%.

4.0 EXAMINATION REGULATIONS

4.1 General Regulations

The general Master's degree regulations of Busitema University, as stipulated in the Graduate Studies Handbook, shall apply.

4.2 Method of Assessment

Assessment will be done through coursework, including home assignments, classroom and take-home tests, field study trips with trip reports, project work and presentations, and written examinations. Course work will carry 40%, and written examination will carry 60%. The overall pass mark is 60%.

4.3 Grading of Courses

Each course shall be graded out of 100% marks and assigned an appropriate letter grade as shown in the Table below: To record a pass mark in a course unit, a student must achieve a minimum mark of 60%. The student must also have attended at least 70% of all scheduled classes, practicals, and presentations.

Marks % Point	Letter Grade	Grade	Remarks
80 - 100	A	5.0	Excellent
75 -59	B+	4.5	Very Good
70 - 74	B	4.0	Good
65 -69	C+	3.5	Fairly Good
60 -64	C	3.0	Satisfactory
0 - 59	D	0.0 - 2.5	Fail

4.4 Calculation of Cumulative Grade Point Average (CGPA)

The programme shall be conducted on a credit unit basis. One credit unit shall be equivalent to one contact hour per week per semester or 15 contact hours. And one contact hour shall be equivalent to one hour of lecture/ tutorial or two hours of laboratory/ practical work. The Grade Point Average (GPA) shall be calculated using the following formula:

Where [redacted] is the Grade Point score in the course[redacted]; [redacted] is the number of Credit Units of course[redacted]; and [redacted] is the number of courses taken in that semester or recess term. CGPA is calculated using a formula similar to the one above, but [redacted] is the number of courses taken from the beginning of the program up to the time when the CGPA is being calculated.

4.5 Course Retaking

i. A student shall retake a Course or Courses when next offered again in order to obtain at least the Pass Mark (60%) if he/she had failed during the first assessment in the course or courses.
ii. A student who has not done coursework will not be allowed to sit for final examinations
iii. A student who has failed to obtain at least the Pass Mark (60%) during the Second Assessment in the same Course or Courses retaken shall receive a warning.
iv. A student may retake a Course or Courses when next offered again in order to improve his/her Pass Grade(s) if the Pass Grade(s) got at the first Assessment in the Course or Courses were low. However, for a student who fails to attain higher marks after retaking to improve, the examination results of the first sitting are recorded on the transcript and shall not be recorded as Retake.
v. Where a student misses to sit examinations for justified reasons, his/her results shall not be recorded as Retake when the examination(s) is/are next offered.
vi. Attend all the prescribed lectures/ tutorials/ practicals/fieldwork in the Course or Courses;
vii. Satisfy all the requirements for the coursework component in the Course or Courses; and
viii. Shall sit for the University Examinations in the course or courses.
ix. A student who accumulates more than four (4) Retake Courses will be requested to stay put.
x. Students are required to register for retake course(s) first before registering for new courses offered in that semester. The retake courses should fit into the approved normal load to avoid timetable clashes.
xi. A final year student whose final Examination Results have already been approved by the Graduate Board and has qualified for the Award of the MSc. in Computer Science Degree shall not be permitted to retake any Course(s).

When a student has retaken a course, the better of the two Grades he/she has obtained in that course shall be used in the computation of his/her cumulative Grade Average (CGPA). The Academic Transcript shall indicate so whenever a course or courses has/have been retaken.

xii. Students shall pay for a retake(s) registered for.

4.6 Academic Progress

At the end of every semester and recess term, students' progress shall be classified into Normal Progress, Probationary Progress, and Discontinuation.

4.6.1 Normal progress

This occurs when a student has passed (Grade point of 3.0) all the courses that he/she has taken so far since the beginning of the program.

4.6.2 Probationary Progress

A student who has obtained the Grade Point (GP) of less than 3.0 shall be placed on probation. Such a student shall be allowed to progress to the next semester/academic year but shall still retake the course(s) he/she has failed the assessments later on and obtained at least the pass mark (60%) in the course(s).

4.6.3 Discontinuation

When a student accumulates three consecutive probations based on CGPA, he/she shall be discontinued.

i. A student who fails to obtain at least the Pass Mark (60%) during the Third Assessment in the same course or courses retaken shall be discontinued from his/her studies at the University.

ii. A student who has overstayed on the programme by more than five (5) years shall be discontinued from his/her studies at the University.

4.7 Dissertation

Students are required to demonstrate their ability to undertake research and analysis independently. Therefore, each student will be required to pursue and complete the Dissertation. To pass the Dissertation, the candidate shall satisfy the supervisor(s), reviewers and examiners in the written report and the project presentation(s).

4.8 Requirements for the Award of the Degree

The degree of Master of Science in Artificial Intelligence shall be awarded to a candidate who obtains 60 credit units gained from 12 courses. Furthermore, the student will have to pass all the courses in a period stipulated by the University Senate and Council.

4.9 Classification of the Award

The degree of Master of Science in Artificial Intelligence shall be awarded to a student who fulfills all the requirements for the programme. The Master's degree shall not be classified.

4.10 Quality Assurance

Like the other programmes in the Faculty of Engineering in particular and Busitema University in general, the quality assurance practices shall apply. A student will be required to attend at least 70% of the lectures given in a course and do and pass all the coursework assignments, tests and laboratory exercises before he/she can sit for a written examination. The performance of each of the lecturers assigned to teach the students shall also be closely monitored to ensure they comply with the curriculum requirements. This will be partly achieved by giving the students assessment forms to assess their teaching staff on the content taught, mode of delivery, self-explanation, appearance for lectures, tutorials, and practical field study trip sessions.

5 PROGRAM STRUCTURE

5.1 The Main Knowledge Areas

The proposed program has two major knowledge areas. These are:

(i) Data Science

(ii) Systems and Robotics

All courses for the first semester of the program are mandatory for all students.

Each student will choose to either specialize in Data Science, and Systems and Robotics in the second semester. Students will also get additional skills in the elective courses in the second semester.

5.2 Program Structure

The MSc. Artificial Intelligence programme will be run on a semester system. The Tables below outline the courses and their load to be offered in the programme.

5.3.1 Year I, Semester I

Mandatory for all students

Table 4

Semester	Code	Course Name	LH	PH	CH	CU
One	MAI8101	Theoretical Computer Science	30	90	60	4
	MAI8102	Machine Learning	30	90	60	4
	MAI8103	Structures and Interpretation of Computer Programs	30	90	60	4
	MAI8104	Robotics and Intelligent Systems	30	90	60	4
	MAI8105	Design, Innovation and Professional Development	30	90	60	4
	Total Credit Units					20

5.3.2 Year I, Semester II

Option: Artificial Intelligence & Data science

Table 5

Semester	Code	Course Name	LH	PH	CH	CU
Two	MAI8201	Computer Vision	30	90	60	4
	MCF8115	Data Mining & Big Data Analysis	30	90	60	4
	MAI8202	Data Visualization	30	90	60	4
	MCF8215	Research Methodology	45	45	60	4
Electives (Select 1)						
	MAI8203	Telerobotics	30	90	60	4
	MAI8204	Deep Learning	30	90	60	4
	MCF8204	Cybercrime and Digital Forensics	30	90	60	4
	Total Credit Units					20

5.3.3 Year I, Semester II

Option: Systems and Robotics

Table 6

Semester	Code	Course Name	LH	PH	CH	CU
Two	MAI8205	Human Computer Interaction	30	60	60	4
	MAI8206	Mechatronics for Robotics	30	60	60	4
	MAI8207	Mobile Robotics and Autonomous Systems	30	60	60	4
	MCF 8215	Research Methodology	45	45	60	4
Electives (Select 1)						
	MAI8203	Telerobotics	30	90	60	4
	MAI8204	Deep Learning	30	90	60	4
	MCF8204	Cybercrime and Digital Forensics	30	90	60	4
	Total Credit Units					20

5.3.4 Year II, Semester I & II

Table 8

Semester	Code	Course Name	LH	PH	CH	CU
One	MAI9101	Research Seminar Series	30	45	45	3
		Research Proposal				
Two	MAI9102	Master's Dissertation		765	255	17
	Total Credit Units					20

Minimum Graduation Load: 60 credit units

6 DETAILED COURSE DESCRIPTION

6.1 YEAR 1: SEMESTER I

6.1.1 MAI8101: Theoretical Computer Science

Course Name: Theoretical Computer Science Course Code: MAI8101 Course Credit: 4 Contact Hours: 60 Year of Study: 1 Semester: 1
Brief Description Theoretical computer science presents an intersection between computer science and mathematics. Advanced theoretical computers science is designed to focus on the abstract, logical, and mathematical aspects of computing.
Course Objectives The objectives of the course are 1. To develop the students analytical skills 2. To expand the breadth of the students understanding in the different areas of computer science 3. To improve the student's research skills
Learning Outcomes By the end of the course, students shall be able to:- 1. Identify and critically analyze societal problems that require computing solutions 2. Explain the current fundamental concepts of algorithms and complexity, computational logic, theory of computer languages and computational modeling. 3. Develop paper reviews in critical computing areas of algorithms and complexity, computational logic, languages and modeling
Indicative Content There are Four broad areas to be covered in this course. They include; Module 1: Algorithms and Complexity (15 hours) Review of algorithms, Greedy algorithms, Scheduling algorithms, approximation algorithms, divide and conquer, dynamic programming, network flow applications, matching, matching and NP-Completeness and algorithm approximation. Time complexity (The classes P and NP, NP-complete problems), space complexity, and circuit complexity. Module 2: Computational logic (15 hours) Review of Logic, formalization within the logic, system descriptions using logic, proving theorems using logic, and selected applications of logic in Computer Science. Module 3: Optimization. Review of linear optimization and scheduling techniques. (15 hours) Module 4: Linear Algebra: Vector Spaces, subspaces, linear combinations, linear dependence, linear independence, bases and dimensions, linear transformations, null spaces and ranges. Invertibility and isomorphism, dual spaces. Eigenvalues and Eigenvectors, diagonalizability (15 hours)
Mode of Delivery

This course will be delivered through lectures, group/individual projects and coursework with class presentation.

Mode of Assessment
Course work will constitute 40% and the final end of semester examination 60%. Cousework may be a continuous assessment resulting from assignments, literature review projects, classroom presentations, and module tests. Examination question may focus on real world application of the concepts learnt in the course.

References

1. Bollobas, B. (2002) Modern Graph Theory. Springer
2. Rivest, R. (1990). Handbook of Theoretical Computer Science, Volume A: Algorithms and Complexity. van Leeuwen.
3. Leeuwen, J. V. (1990). Handbook of Theoretical Computer Science, Volume B: Formal models and semantics.
4. Marcus, D. (2008) Graph Theory: A Problem Oriented Approach MAA

6.1.2 MAI8102: Machine Learning

Course Name: Machine Learning
Course Code: MAI8102
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 1

Brief Description
Machine learning is a branch of artificial intelligence (AI) and computer science which focuses on the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy.
Machine learning techniques enable us to automatically extract features from data so as to solve predictive tasks, such as speech recognition, object recognition, machine translation, question-answering, anomaly detection, medical diagnosis and prognosis, automatic algorithm configuration, personalisation, robot control, time series forecasting, and much more. Learning systems adapt so that they can solve new tasks, related to previously encountered tasks, more efficiently.

Course Objectives
Upon completion of this course a student should be able to:-

- Understand the importance of machine Learning and its applications in real world problems.
- Demonstrate knowledge and understanding of the working concepts of Machine Learning
- Be able to evaluate and use different Machine Learning techniques and methods to solve complicated problems.
- Be able to implement the basic Machine Learning algorithms and applications using Python to solve real-world problems.

Learning Outcomes
On completion of the course student will be expected to:-

- Students will have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity etc
- Students will be able to explain the strengths and weaknesses of many popular machine learning approaches.
- Students will be able to understand the underlying mathematical relationships within and across machine learning algorithms.
- Students will be able to articulate key concepts in the application of probabilistic reasoning to problem solving.
- Students will be able to design and implement various machine learning algorithms in a range of real-world applications.

Prerequisites
- Machine Learning is a mathematical discipline, and students will benefit from a good background in probability, linear algebra and calculus. Programming experience is essential.
- This course will mainly be offered using the Python programming language. Students are encouraged to have some basic levels of programming in the python language.

Indicative Content
The course overview includes: mathematics of machine learning, supervised, unsupervised, and reinforcement learning; and important notions such as maximum likelihood, regularization, cross-validation. This course is broken up into the following modules:

Module 1: Introduction to Machine learning concepts

This module introduces the students to the major concepts of machine learning. It introduces why learning from examples is a powerful way of learning and generalizing. It introduces the broad kinds of learning; supervised, unsupervised and reinforcement learning. It introduces the concept of learning a function and selecting suitable hypotheses. It also introduces the ideas of bias and variance and generalization of a machine learning algorithm.
Students should install some of the trending machine learning packages particularly scikit-learn (http://scikit-learn.org/stable/), Numpy, SciPy and Matplotlib. A useful package that installs all these is the Anaconda package (https://www.continuum.io/downloads). [12 hours]

Module 2: Uncertainty and probability
Uncertainty is a big concept in learning. Because learning is inherently uncertain, we introduce probabilistic reasoning to try and understand learning under uncertainty. Here the concepts of conditional probability are reiterated, Bayes rule and Bayesian reasoning. The Naïve Bayes algorithm is introduced as well. [8 hours]

Module 3: Supervised learning - Classification algorithms. The learning algorithm is defined by its use of labeled datasets to train algorithms that to classify data or predict outcomes accurately. As input data is fed into the model, it adjusts its weights until the model has been fitted appropriately. This occurs as part of the cross validation process to ensure that the model avoids overfitting or underfitting. Supervised learning helps organizations solve a variety of real-world problems at scale, such as classifying spam in a separate folder from your inbox. Some methods used in supervised learning with classification include neural networks, naïve bayes, random forest, support vector machine (SVM), and more. [12 hours]

Module 4: Supervised learning - regression algorithms
Here we introduce the other type of Supervised learning; regression. We discuss the concepts behind logistic regression. We derive analytically as well as simulate learning using gradient descent. We also introduce the concept of regularization to curb overfitting. [8 hours]

Module 5: Unsupervised learning. Is a machine learning algorithm to analyze and cluster unlabeled datasets. These algorithms discover hidden patterns or data groupings without the need for human intervention. The module will give students knowledge to discover similarities and differences in information, making it the ideal solution for exploratory data analysis, cross-selling strategies, customer segmentation, image and pattern recognition. Techniques will include dimensionality reduction; principal component analysis (PCA) and singular value decomposition (SVD) are two common approaches for this. Other algorithms used in unsupervised learning include neural networks, k-means clustering, probabilistic clustering methods, and more. [10 hours]

Module 6: Feature selection and Evaluation metrics
This last module we discuss some aspects of data manipulation, feature selection, feature engineering as well as dealing with outliers. We also discuss the different evaluation metrics in broader depth. The module will discuss the implication of the Receiver Operator Characteristics (ROC) curve, the F-measure, the AUC, precision and Recall. [10 hours]

Mode of Delivery
Students will learn through hands-on experience by programming machine learning algorithms and applying them to real-world problems. The mode of study will be inclusive of a variety of methods;

- Lectures: Lectures will be conducted and students will be taken through the theoretical and practical sessions.

- Student projects: Students will be given projects at the start of the course and these will be continuous projects building on the techniques taught in class. At the end of the course, students will have built a complete course work.

Mode of Assessment
- Progressive assessment (40%). This will consist of theory and practical assignments.
- Final exam (60%). Part of the final exam may be a practical project.

References
[1]. T. Hastie, R. Tibshirani, and J. Friedman. The Elements of Statistical Learning. Springer 2011. (Available for download on the authors' web-page: http://statweb.stanford.edu/~tibs/ElemStatLearn/)
[2]. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012. (Electronic copy available through the Bodleian library.)
[3]. Christopher M. Bishop. Pattern Recognition and Machine Learning, Springer 2007.
S. Haykin. Neural networks and learning machines. Pearson 2008.
[4]. Toby Segaran. Programming Collective Intelligence: Building Smart Web 2.0 Applications 2007: O'reilly.

6.1.3 MAI8103: Structures and Interpretation of Computer Programs

Course Name: Structures and Interpretation of Computer Programs
Course Code: MAI8103
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 1

Course Description
The course is about techniques applicable in the design and implementation of software systems. A series of techniques for controlling complexity in large software systems are covered in this unit. These techniques will be illustrated using a highly expressive language such as Scheme or Python or any other language in the category. However, the course is not about teaching a particular programming language but rather examines fundamental issues underlying the design decisions of programming languages.

Course Objectives
The course aims at enabling students to:
1. Understand the major techniques of controlling complexity in large software systems
2. Explore the internals of a program execution environment
3. Acquire knowledge and skills of modifying and creating an interpreter for a new programming language

Learning Outcomes
Upon completion of this course, the learner will be able to:
- explain and apply the major techniques for controlling complexity in large software systems: Building abstractions, controlling interaction through Conventional interfaces, and designing new Languages.

- design and implement software systems that demonstrate the concepts covered in the course, specifically: recursive and iterative processes and procedures, higher order procedures, object-oriented methods, data abstractions, procedures with state and dispatch on type.
- understand, modify and create an interpreter for a new programming language, either at the level of a higher order language description or at the level of a register machine description

Module 1: Building Abstractions with Procedures
Elements of Programming; Expressions, Naming and the Environment, Evaluating Combinations, Compound Procedures, The Substitution Model for Procedure Application, Conditional Expressions and Predicates, Example: Square Roots by Newton's Method, Procedures as Black-Box Abstractions [12 hours]

Module 2: Procedures and the Processes They Generate
Linear Recursion and Iteration; Tree Recursion, Orders of Growth, Exponentiation. [8 hours]

Module 3: Formulating Abstractions with Higher-Order Procedures
Constructing Procedures Using Lambda, Procedures as General Methods, Procedures as Returned Values [8 hours]

Module 4: Building Abstractions with Data
Introduction to Data Abstraction; Example: Arithmetic Operations for Rational Numbers, Abstraction Barriers, Hierarchical Data and the Closure Property; Representing Sequences, Hierarchical Structures, Sequences as Conventional Interfaces, Example: A Picture Language, Symbolic Data; Quotation, Examples: Symbolic Differentiation, Representing Sets, Huffman Encoding Trees, Multiple Representations for Abstract Data; Representations for Complex, Tagged data, Data-Directed Programming and Additivity, Systems with Generic Operations; Generic Arithmetic Operations, Combining Data of Different Types, Example: Symbolic Algebra. [8 hours]

Module 5: Modularity, Objects, and State
Assignment and Local State; Local State Variables, The Benefits of Introducing Assignment, The Costs of Introducing Assignment, The Environment Model of Evaluation; The Rules for Evaluation, Applying Simple Procedures, Frames as the Repository of Local State, Internal Definitions, Modeling with Mutable Data; Mutable List Structure, Representing Queues, Representing Tables, A Simulator for Digital Circuits, Propagation of Constraints, Concurrency: Time Is of the Essence; The Nature of Time in Concurrent Systems, Mechanisms for Controlling Concurrency. [8 hours]

Module 6: Metalinguistic Abstraction

The Metacircular Evaluator; The Core of the Evaluator, Representing Expressions, Evaluator Data Structures, Running the Evaluator as a Program, Data as Programs, Separating Syntactic Analysis from Execution, Variations on a Scheme – Lazy Evaluation; Normal Order and Applicative Order, An Interpreter with Lazy Evaluation, Streams as Lazy Lists, Variations on a Scheme – Nondeterministic Computing; Amb and Search, Implementing the Amb Evaluator, Logic

Programming; Deductive Information Retrieval, How the Query System Works, implementing the Query System; Finding Assertions by Pattern Matching, Rules and Unification, Maintaining the Database, Stream Operations, Query Syntax Procedures, Frames and Bindings [16 hours]
Mode of Delivery The teaching will be highly student centered. It will involve teaching, classroom discussions, demonstrations, group/individual projects and self-guided research.
Mode of Assessment Substantial weekly problem sets, quizzes, and programming projects will be an integral part of the course assessment (40%). Final examination (60%). Part of the final exam may be a practical project.
References [1] Abelson, Harold, Gerald Jay Sussman, and Julie Sussman. Structure and Interpretation of Computer Programs 1996: 38 [2] MIT Press. Available: https://mitpress.mit.edu/books/ structure-and-interpretation-computer-programs

6.1.4 MAI8104: Robotics and Intelligent Systems

Course Name: Robotics and Intelligent Systems Course Code: MAI8104 Course Credit: 4 Contact Hours: 60 Year of Study: 1 Semester: 1
Course Description This course provides an opportunity for students to master advanced knowledge and skills required for analysis, design and implementation of industrial grade robotics and intelligent systems. Students are equipped with knowledge and skill required to analyze, design, and develop systems that automate manufacturing, transportation, healthcare, environmental stewardship, scientific research, and other activities. It covers a choice of essential hardware for sensing and manipulating the real world and its properties and characteristics. The study of robotics systems include robot manipulators and mobile robots, navigation techniques, planning and programming of robot actions, sensors and actuators, kinematic analysis, artificial neural nets, and fuzzy systems genetic algorithms. The programming of intelligent systems and real-world robots are explored in the context of localisation, mapping, and fuzzy logic control.
Course Objective The objectives of this course are; 1. To skill students in translating theoretical knowledge acquired regards algorithms, logic, kinematics descriptors and hardware programming to build industry-grade robots 2. To prepare students who are able to critically analyze and determine metrics/parameters for the design of robust robotic systems

3. To equip students with hands-on experience in the use of latest tools to design and program intelligent robots
4. To skill students with machine learning techniques required to develop robotic applications

Learning Outcomes

By the end of this course, students will be able to:

1. Demonstrate an understanding of a range of intelligent systems and robots
2. Understand and critically evaluate sensors and actuators to achieve a specified objective
3. Demonstrate in-depth understanding of sensors, actuators and algorithms used in mobile robotics, including the Robot Operating System (ROS).
4. Identify and describe suitable interactions between humans and robots.
5. Identify and describe ethical concerns of robotics in societyUnderstand, critically evaluate and explain the principles of kinematic descriptions for manipulator, localization and mapping
6. Make use of the principles of fuzzy logic in controlling real-world devices
7. Perform simple programming of a robot
8. Demonstrate the use of Machine Learning techniques for robotic applications.

Indicative Content

Module 1: Introduction to intelligent systems and robotics. [10 hours]
Discuss the history of robotics, types of robots, robot challenges, and potential industrial applications of intelligent systems and robotics.
Module 2: Actuators, sensors and control units: kinematics, statics and trajectory planning; sensors and actuators; sonar, laser scanner, optical encoders, and DC motors. [15 hours]
Module 3: Robotic systems modeling and simulation: [10 hours]
Module 4: Dynamics and motion control of robot manipulators: Analysis and design of robot control systems including feedback control and fuzzy controllers. [15 hours]
Module 5: Behavioral-based programming of robotic systems: Robot behaviors, potential field approach, and behavior based architecture. [10 hours]

Mode of Delivery

This course will be delivered through lectures, group/individual projects, coursework with class presentation, and practical/laboratory sessions.

Mode of Assessment

The course will be assessed through course works and end of course examinations. The coursework and examination will contribute 40% and 60%, respectively.

References

1. Choset, H., Lynch, K. M., Hutchinson, S., Kantor, G. A., & Burgard, W. (2005). Principles of robot motion: theory, algorithms, and implementations. MIT press.
2. Corke, P. I., & Khatib, O. (2011). Robotics, vision and control: fundamental algorithms in MATLAB (Vol. 73, p. 2). Berlin: Springer.
3. Liu, D., Wang, L., & Tan, K. C. (Eds.). (2009). Design and control of intelligent robotic systems (Vol. 177). Springer.

4. Volker, G (1994). Intelligent Robots and Systems. Selections of the International Conference on Intelligent Robots and Systems.

6.1.5 MAI8105: Design, Innovation and Professional Development

Course Name: Design, Innovation and Professional Development
Course Code: MAI8105
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 1

Course Description

This is an intensive idea-incubation, computing-centric design class where students will be exposed to a spectrum of tech challenges, latest and future technology trends (using case studies) and will need to iteratively propose and refine bold computing centric ideas for real problems. Students will also initiate the process of translating their ideas to initial prototypes. Right from the beginning, students in the class will form small teams where each team will work on a single project idea that solves an important real-world problem. Students will be provided exposure to basic tools and platforms that can be leveraged by individual teams in their project design and implementation. In addition to idea incubation, the class will provide a beginner's background to tech startups including: product development cycle, how to pitch your idea, product market fit, fundraising and venture capital, customer discovery. Teams are expected to constantly interact with other teams to discuss and exchange ideas.

Course Objectives
The objectives of this course are;

1. To equip students with skills required to design a network of supply chains.
2. To identify suitable frameworks/models to guide selection of location sites.
3. To present students with knowledge of the state-of-the-art in the theory and practice of solving network flow problems.

Learning Outcomes
By the end of this course, students will be able to:

1. Implement qualitative and ethnographic design research techniques.
2. Synthesize and communicate data and concepts through introduction to visualization and storytelling methods.
3. Identify the role of network design in supply chain
4. Demonstrate competency to make difficult network design decisions
5. Apply network models to solve societal optimization problems

Indicative Content

Module 1: Design toolkit and mindset for creative problem solving [10 Hours]
Topics include opportunity finding and innovation; the design thinking cycle of inspiration-interpretation-ideation-implementation; and visual communication. Besides, students should explore qualitative and ethnographic design research techniques.
Network design in the supply chain

Module 2: The role of network design [10 hours]
The supply chain, global supply chain network design models, designing global supply chain networks, supply chain network analysis, factors influencing network design decisions in the supply chain including strategic factors, technological factors, macroeconomic factors, infrastructure factors, competitive factors, customer response time and local presence, and logistics and facility costs.

Module 3: Framework for Network Design Decisions (15 Hours)
Define a supply chain strategy/design, define the regional facility configuration, select a set of desirable potential sites, and location choices.
Have a significant impact on performance because it creates the SC configuration and sets constraints to decrease SC cost or increase responsiveness

Module 4: Models for Facility Location and Capacity Allocation (15 Hours)
Network models (Continuous and Discrete Models), network optimization problems and models, gravity location models, accounting for taxes, tariffs, and customer requirements.

Module 5: Define the Regional Facility Configuration [10 hours]
Forecast demand by region. Then managers see if economies of scale are possible. Then managers look at all risks/factors that affect network design decisions.

Mode of Delivery

This course will be delivered through lectures, group/individual projects, and coursework with class presentation.

Mode of Assessment

The course will be assessed through course works and end of course examinations. Coursework will contribute 40% and end of semester examinations will contribute 60%.

References

1. Ahuja, Ravindra K., Thomas L. Magnanti, and James B. Orlin. Network Flows: Theory, Algorithms, and Applications. Upper Saddle River, NJ: Prentice Hall, 1993. ISBN: 9780136175490.
2. Chopra Sunil, Meindl Peter (2014). Supply Chain Management: Strategy, Planning, and Operation, Pearson; 6th edition.
3. European Commission (2010). The Smart Guide to Innovation Based Incubators, Luxembourg.

6.2 YEAR 1: SEMESTER II

6.2.1 MAI8201: Computer Vision

Course Name: Computer Vision
Course Code: MAI8201
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Course Description
Computer Vision is a branch of Artificial Intelligence that aims at developing methods and techniques that enable computers to see and interpret the content of digital images and video. This course provides an introduction to computer vision including fundamentals of image formation, image processing, feature detection, extraction and matching, motion estimation and tracking, and classification. We will develop basic methods for applications that include finding known feature models in images, feature extraction, tracking, and classification.

Course Objective
The main objectives of this course are:

1. To equip students with knowledge and understanding of the theoretical and practical aspects of computer vision.
2. To equip students with the ability to evaluate and use different image processing, feature extraction, tracking and classification methods to solve complicated problems for example scene understanding, recognition and scene surveillance.
3. To equip students with skills to be able to formulate solutions to problems by incorporation of computer vision algorithms. They should be able to explain these algorithms and evaluate how altering different algorithm parameters affects the system.
4. To equip students with the skills to be able to implement the basic computer vision methods and applications using Python and OpenCV, and apply these in a tractable way to solve real-world problems.

Learning outcomes
The intended learning outcomes for this course are :-

1. The student should be able to demonstrate knowledge and understanding of the theoretical and practical aspects of computer vision, and should be able to apply this knowledge to solving different types of problems that require vision..
2. The students should be able to evaluate and use different image processing, feature extraction, tracking and classification methods to solve complicated problems for example scene understanding, recognition and scene surveillance.
3. The students should be able to formulate solutions to problems by incorporation of computer vision algorithms. They should be able to explain these algorithms and evaluate how altering different algorithm parameters affects the system
4. The students should be able to write well commented, properly tested code that illustrates the use of image processing and computer vision to solve a specific real world problem of their choice using Python and OpenCV.

Indicative content
Teaching of this course will be in 6 topics. Each topic will be a complete unit of teaching and will

be assessed independently during continuous assessments. This course is broken up into the following topics.

Main Topic 1:Geometric camere models

The camera is one of the most essential tools in computer vision. It is the mechanism by which we can record the world around us and use its output - photographs - for various applications. Therefore, one question we must ask in introductory computer vision is: how do we model a camera?

Subtopic 1.1: Image formation [4 hrs]

The nature of the image capturing device used in capturing the image/ video determines the amount of information from the scene available for the vision task. This subtopics discusses camera models, light source and properties, and the various methods used in sampling the image affect the quality of image formed. This subtopic will mainly deal with light and optics (pinhole camera models, perspective projection,distortion, reflection and illumination), Radiometry (light and surfaces, light sources, radiation), Photometry (black and white video systems, color video systemes and lens distortions), Image digitization (spatial resolution, sampling and signal quantization)

Subtopic 1.2: Intrinsic and extrinsic Camera Parameters [2 hrs]

The internal and external parameters of the camera have an effect on the way an image is formed and the amount of distortion introduced in the image. The subtopic discusses how each of these parameters affects the quality of the image and how they are related with each other.

Subtopic 1.3: Camera calibration. [4 hrs]

The camera calibration is used to determine the geometric parameters of the image formation process in many computer vision applications, specifically in applications where metric information about the scene is required. The subtopic discusses both linear and nonlinear approaches to camera calibration as well as online methods.

Main Topic 2: Image preprocessing and feature extraction

Image pre-processing and feature extraction are mandatory steps for any computer vision based applications. The accuracy and convergence rate of Image pre-processing and feature extraction techniques used has a major effect on the subsequent steps for computer vision. This topic discusses various techniques for image preprocessing and feature extraction.

Subtopic 2.1: Per-pixel transformations [4 hrs]

These are preprocessing methods which return a value for one and will return a single value corresponding to each pixel of the input image. Particularly this subtopic will deal with Histogram equalization, Whitening, Linear filtering, Local binary patterns and Texton maps

Subtopic 2.2: Edges, Corners, and Interest points. [8 hrs]

In order to derive information from images, we need to extract representative features. This subtopic will deal with feature detection and extraction from images. We will investigate detection and extraction of edges, corners, SIFT features, SURF features, color features, ORB features.

Subtopic 2.3: Descriptors [4 hrs]

The subtopics deal with techniques that are used to aggregate information within an image region. Particularly it will deal with histograms, SIFT and SURF descriptors, Bag of words and shape context descriptors

Main topic 3: Image segmentation (10 hours)

Image segmentation is used to cluster pixels into salient image regions, i.e., regions corresponding to individual surfaces, objects, or natural parts of objects. Segmentation is an important technique that aids computer vision to group regions with similar properties together. This topic will deal with image segmentation approaches particularly thresholding based, edge-based, region based and contour based (specifically those deriving contours from images such as mean shift, graph cuts and normalized cuts) approaches.

Main topic 4: Detection and Tracking

Detection and Tracking of objects in video is an important computer vision technique. This topic discusses the approaches to objection detection and used in object tracking.

Subtopic 4.1 Object detections [4 hrs]
The detection of an object in video sequence plays a significant role in many applications. Specifically as video surveillance applications. This subtopic deals with object detection approaches specifically, frame differencing, optical flow and background subtraction.
Subtopic 4.2: Object Tracking [6hrs]
Tracking is used to identify the moving objects within the video sequence. The subtopic will deal particularly with approached used to track moving objects that include point tracking (Kalman and particle filters), Kernel Tracking (meanshift and support vector) and Silhoutte Tracking (Contour and shape matching)
Main topic 5: Objection and classification. [14 hrs]
Classification and recognition are very important computer vision techniques. This module will deal with classification and face recognition using HAAR cascade classifiers and other techniques

Study Material
This course will mainly be offered using the Python programming language. Students are particularly encouraged to get up to speed with Python programming by the start of the course. This course will have as its pre-require proficiency in programming complex systems in Python. Students should possess a laptop computer for doing in-class programming assessments. The course will work around open source Computer Vision toolkits. Students should install some of the trending computer vision packages particularly OpenCV (http://opencv.org), Numpy, SciPy and Matplotlib. Several other computer vision packages are available, however for this course we will use OpenCV

Mode of Delivery
Computer Vision is sufficiently learned through hands-on experience programming these algorithms and applying them to real problems. The course is broken up into topics to facilitate learning of the different concepts. The mode of study will be inclusive of a variety of methods;

- Lectures - these will be the chief mode of study. Lectures will take up 2 hours every week
- Hands-on practice sessions - these will be for each topic. Small quizzes that require students to get hands-on practice with Machine Learning will be given out every week to cover content for that particular week.
- Student mini projects - longer projects will be spaced out during the course and given after every module.
- In-class practice sessions - each lecture will include some in-class practice sessions for 2 hours every week. Students will have to attend class with a reliably powered laptop to benefit from this mode of study.

Mode of Assessment
Assessment will consist of:

1. Progressive assessment including Weekly quizzes, practical mini projects (after each module), and a test (40%)
2. Final exam - for overall assessment (60%). Part of the final exam may be a practical project.

6.2.2 MCF8115: Data Mining & Big Data Analysis

Course Name: Data Mining & Big Data Analysis
Course Code: MCF8115
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Course Description
Data is the "new oil". In this course, students will learn data mining techniques to process large datasets and extract valuable knowledge from them. Students will be introduced to modern distributed file systems for creating parallel algorithms that process very large amounts of data. The course will also cover algorithms for extracting models and information from large datasets.

Course Objectives
The main objectives of this course are:

- To equip students with techniques necessary to mine different types of data.
- To use different models of computation to mine data, i.e., MapReduce, streams and online algorithms, single machine in-memory,
- To understand data mining techniques that will be used to solve real-world problems, for example, recommender systems, market basket analysis.
- To learn and use different data mining tools for analysis of big data.

Learning Outcomes
At the end of this course unit students should be able to:

- Mine different types of data, i.e., high dimensional, graphical, labeled.
- Apply different models of computation to mine data, i.e., MapReduce, streams and online algorithms, single machine in-memory,
- Apply data mining techniques to solve real-world problems, for example, recommender systems, market basket analysis.
- Apply and use different data mining tools for analysis of big data.

Indicative content
Teaching of this course will be in six modules. Each module will be a complete unit of teaching and will be assessed independently during continuous assessments. The content of the modules will include:

Module One: Introduction to Data Mining (12 hours)
This module provides an introduction to data mining. This module will also cover the tools that will be used for the data mining tasks that will be covered in the rest of the modules. To gain hands-on experience working with data mining tasks, two main platforms will be used, that is, R and Map-Reduce/Hadoop environments. The module will provide pointers to several papers and tutorials that are intended to teach students on how to use the tools as an environment for mining big data.

Module Two: Finding Similar Items (9 hours)
This module will cover the fundamental data mining problem of examining data for "similar" items. This module will cover the problem of similarity as one of finding sets with a relatively large intersection. Topics to be covered include shingling, minhashing, and

Locality Sensitive Hashing.

Module Three: Recommender Systems (10 hours)
This module will discuss a model for recommender systems. Recommendation systems use a number of different technologies. These will be classified into two broad groups, i.e., content-based systems and collaborative filtering systems. Under content-based systems,
This module will examine properties of the items recommended while collaborative filtering systems will cover recommendation techniques based on similarity measures between users and/or items.

Module Four: Link Analysis (10 hours)
One of the biggest changes in our lives in the decade following the turn of the century was the availability of efficient and accurate Web search, through search engines such as Google. This module will discuss several techniques on which search engines are based. The focus will be on topics such as PageRank is and how it is computed efficiently. The module will also cover techniques like TrustRank and other approaches used to detect link spam.

Module Five: Analysis of Massive Graphs (10 hours)
There is much information to be gained by analyzing the large scale data that is derived from social networks. This module will cover techniques for analyzing social networks. The topics that
will be covered in this module will include: community detection in graphs and finding overlaps in social networks, detecting communities with AGM, analysis of large Graphs and Social Networks.

Module Six: Mining Data Streams (9 hours)
This module will shift away from mining a database and will cover techniques that are useful for mining data that arrives in a stream, e.g., sensor data, image data, Internet and Web traffic data. This module will discuss algorithms for processing streams which involve summarization of the stream in some way.

Mode of Delivery
The teaching will be highly student centered. It will involve teaching, classroom discussions, demonstrations, group/individual projects and self guided research.

Mode of Assessment
Substantial weekly problem sets, quizzes, and research projects will be an integral part of the course assessment (40%). Final examination (60%). Part of the final exam may be a practical/research project.

References
[1]. Leskovec, J., Rajaraman, A., and Ullman, J. Mining of Massive Datasets. 2nd Ed. Cambridge University Press, 2014, Available at http://mmds.org
[2]. Han, J., Kamber, M. and Pei, J. Data Mining: Concepts and Techniques. 3rd Ed. Morgan Kaufman, 2011
[3] Kargupta, H., Han, J. Yu, P., Motwani, R. and Kumar, V. (eds.). Next Generation of Data Mining. Taylor & Francis, 2008.
[4]. Data Mining Concepts and Techniques Third Edition by Jiawei Han, Micheline Kamber and Jian Pei

6.2.3 MAI8202: Data Visualization

Course Name: Data Visualization
Course Code: MAI8202
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Course Description

The course covers computational techniques and algorithms for analyzing and mining patterns in large-scale datasets. Techniques studied address data analysis and visualization issues related to data volume (scalable and distributed analysis), data velocity (high-speed data streams), data variety (complex, heterogeneous, or unstructured data), and data veracity (data uncertainty). The course will focus on teaching students the principles and techniques for analytics and creating visual representation from raw data. The course will be based on real-world applications and public available datasets as well as freely available tools. Students are expected to engage in hands-on projects using one or more of these technologies

Course Objectives

The objectives of the course are to:

1. Introduce students to the principles, techniques and tools for data analytics and visualization.
2. Provide knowledge of analytics and visualization as a tool to explore trends, relationships, confirm hypotheses, communicate findings and gain insight about data.
3. Expose students to tools for data analytics and visualization.

Learning Outcomes

By the end of this course, students will have gained:

1. An understanding of the principles, techniques and tools for data analytics and visualization.
2. Practical skill in data analytics and creating visualizations.
3. Able to identify appropriate tools to analyze and visualize data

Indicative Content

Module 1: Introduction to data visualization

Principles, theory and techniques Data Quality/Data Capture, Functions of Visualizations, Graphic Integrity, Data-Ink Ratio, Tables & Graphs, Multiple Datasets, Interactive Graphs. [15 hours]

Module 2: Data Visualization tools

This module will cover analytics and visualization tools like D3.JS, R and python applications. Introduction to Matplotlib, Basic plots using matplotlib, Specialized Visualization Tools using Matplotlib, Advanced Visualization Tools using Matplotlib Waffle Charts, Word Clouds. [15 hours]

Module 3: Types of Data

High dimensional data, network data, geographic data and text data. [15 hours]

Module 4: Advanced Analytics and Statistical Modeling

Scientific visualization (isosurface, volume rendering, and introduction to VisIt). Basic and Advanced Statistical Tests, Linear and Logistic Regression, Clustering Techniques, Decision Trees, Time Series Analysis, Text Analysis, Survival Analysis [15 hours]

Mode of Delivery
The teaching will be highly student centered. It will involve teaching, classroom discussions, demonstrations, group/individual projects and self guided research.

Mode of Assessment
Substantial weekly problem sets, quizzes, and programming projects will be an integral part of the course assessment (40%). Final examination (60%). Part of the final exam may be a practical project.

References
[1] EMC Education Services. Data Science and Big Data Analytics: Discovering, Analyzing, visualizing and Presenting Data 2015: WILEY. Available: ttp://eu.wiley.com/WileyCDA/WileyTitle/ productCd-111887613X.html
[2] Ossama Embarak Data Analysis and Visualization Using Python, 2018, Higher Colleges of Technology, Abu Dhabi, United Arab Emirates
[3] Core Python Programming - Second Edition, R. Nageswara Rao, Dreamtech Press.
[4]. R Graphics Essentials for Great Data Visualization by Alboukadel Kassambara

6.2.4 MCF8215: Research Methodology

Course Name: Research Methodology
Course Code: MCF8215
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Course Description
The course provides students with knowledge and practice in identification of a research problem, data collection (both qualitative and quantitative), analysis, interpretation, presentation and reporting as well as providing appropriate recommendations based on research findings. The course serves as a foundation for preparation of research projects and theses as well as providing capacity to organize and develop tangible projects.

Course objectives
This course will enable students to;

1. To enable students to make effective presentations in scientific seminars, workshops and conferences; utilize modern ICT audiovisual aids and equipment; moderate discussions and evaluate presentations.
2. To equip students with skills to carry out individual or team research work according to scientific requirements.
3. Understand Qualitative research methods, questionnaire design, sample size, sampling methods.
4. To explain underlying principles of collecting, classifying, analyzing and interpreting numerical facts or data.
5. Analyze quantitative data, descriptive and inferential statistics including contingency tables, chi-square test of independence and various research lines.

Learning Outcomes
Upon successful completion of this module, students will be able to:

1. Apply, compare and examine the different research methodologies as used in computing research.
2. Demonstrate a clear understanding of the type and source of business data handling techniques.
3. Define research problems, specify methods for carrying out scientific research and demonstrate possession of skills and attitudes to conduct such research.
4. Analyze quantitative and qualitative business / management data and arrive at appropriate conclusions by using modern statistical tools and packages.
5. To enable students to make effective presentations in scientific seminars, workshops and conferences; utilize modern ICT audiovisual aids and equipment; moderate discussions and evaluate presentations.

Inductive Content
Module 1: An Overview of Research
Meaning and importance of research and Research opportunities [3 hours]
Module 2: Problem Development
Problem identification and Background to the problem, Problem statement, Problem Objectives (types), rationale/justification, Scoping and research frameworks. Formulation and Organization of the Literature review [7 hours]

Module 3: The Research Methodology
Sources and Types of Data – Selecting Samples, Types of Methods and materials, Data collection methods (qualitative and quantitative), Data Analysis methods, The scientific method and Gender research methodology. [7 hours]
Module 4: Ethical Issues and Business Research
Research ethics (Principles of ethical research), Research and business (writing bankable research proposals and papers) [3 hours]
Module 5: Statistical Research Analysis
Procedures and techniques of data collection and analysis, Data interpretation and presentation, Understanding of an hypothesis, Statistical applications and related tools, Experimental designs, Computer statistical packages, Basic computer programming [9 hours]
Module 6: Data Analysis, Presentation and Statistical applications
Testing of hypothesis and Use of parametric statistical tests/inferences (ANOVA, MANOVA, Multiple regression, PCA, time series analysis), Non-parametric statistical tests/inferences (e.g. Chi square), Computer statistical computer packages (SAS, Genstat, SPSS, Matlab, STRATA), Assess and use appropriate research methods in applied business/management situations. [9 hours]
Module 7: Scientific Research Reports
Formatting, organization and writing of scientific reports, Presentation of scientific research reports and business reporting. [3 hours]

Mode of Delivery
The teaching will be highly student centered. It will involve teaching, classroom discussions, demonstrations, group/individual projects and self-guided research.

Mode of Assessment
Substantial weekly problem sets, quizzes, and research projects will be an integral part of the course assessment (40%). Final examination (60%). Part of the final exam may be a practical/research project.

References

1. Saunders, M.N.K. Lewis, P.and Thorn hill,, A. (2003) Research Methods for Business (3rdedn). Prentice Hall.
2. Hellerstein, Joseph (27 February 2008). "Quantitative Data Cleaning for Large Databases" (PDF). EECS Computer Science Division: 3. Retrieved 26 October 2013.
3. Rankin, J. (2013, March 28). How data Systems & reports can either fight or propagate the data analysis error epidemic, and how educator leaders can help. Presentation conducted from Technology Information Center for Administrative Leadership (TICAL) School Leadership Summit.
4. Martin, W. E., & Bridgmon, K. D. (2012). Quantitative and statistical research methods: From hypothesis to results (Vol. 42). John Wiley & Sons. ISBN 9781118234570 5.
5. Politano, P. M., & Walton, R. O. (2017). Statistics and Research Methodology: A Gentle Conversation 2nd ed. Lulu. com. ISBN 9780692166598
6. Adam, F. and M. Healy (2000). A Practical Guide to Postgraduate Research in the Business Area. Dublin, Blackhall Publishing.Montgomery, D. C., & Runger, G. C. (2010). Applied statistics and probability for engineers. John Wiley & Sons. ISBN 9780470053041

6.2.5 MAI8205: Human Computer Interaction

Course Name: Human Computer Interaction
Course Code: MAI8205
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Course Description
In this course, fundamental theories and concepts of human computer interaction (HCI) are handled. HCI is an interdisciplinary field that integrates theories and methodologies across many domains including cognitive psychology, neurocognitive engineering, computer science, human factors, and engineering design. Students will gain theoretical knowledge and practical experience in the fundamental aspects of human perception, cognition, and learning as relates to the design, implementation, and evaluation of interfaces. In addition to lectures, students will work on individual and team assignments to design, implement, and evaluate various interactive systems.

Course Objectives
The objectives of the course are to:

1. Explore the physiological, perceptual, and cognitive components of human learning and memory.
2. Impart theoretical knowledge and practical experience in the fundamental aspects of designing and implementing user interfaces.
3. Develop skills to analyze interaction problems from a technical, cognitive, and functional perspective.

Learning Outcomes
By completing this course students will,

1. Have a clear reflection of issues and challenges in designing digital technology for people.
2. Be able to understanding and apply user centered design processes
3. Be Skilled to develop an innovative idea for interactive media technologies
4. Able to address complex real-world challenges in an innovative and self-organized way.

Indicative Content

Module 1: The human brain vs. the computer: human information processing
Differences between humans and computers, Philosophy of mind Brains vs. Circuit Boards, The user as an information processing system, Human sensation, perception, and cognition, Problem solving and reasoning, Attention and change blindness, Relation of memory to HCI [8 hours]
Module 2: Human vision and visual displays
Difference between sensation, perception, and cognition: Relation of each to HCI design, Physiology of visual system, information transduction, and cortical representation, Perceptual distortions and visual illusions, Visual design and infographics visualization issues, Guidelines for font and reading, color usage, and display structure and layout, Good design for buttons, icons, and lists Fitt's law. [8 hours]
Module 3: Human audition and auditory displays

In-class presentations of auditory displays (assignment). Auditory sensation, perception, and cognition. Physiology of hearing Text-to-speech and speech-to-text Auditory displays: verbal interfaces vs. 3D spatialized sound Other uses of auditory interfaces. [10 hours]

Module 4: Human touch and tactual displays

Three subsystems of touch: Cutaneous, kinesthetic, and haptic, Mechanoreceptors most relevant to HCI and touch-based interfaces, Consideration of exploratory procedures--patterns of hand movement that facilitate encoding of spatial properties through touch--in the design of tactual interfaces, Perceptual illusions with touch, Types of touch-based interfaces: Force-feedback haptic devices, cutaneous devices, and vibro-tactile devices. [10 hours]

Module 5: Brain-Computer Interaction (BCI) and Neuroprosthetics/ Sensory substitution

BCI and brain plasticity Neuroergonomics and Neurocognitive Engineering, Medical applications of BCI: Neuroprosthetics Commercial Applications of BCI, Ethical implications of these interfaces, Neuroprosthetics vs. sensory substitution, Most sensory substitution devices compensate for loss of vision: discussion of visual to tactile and visual to auditory devices, Components of sensory substitution devices, Underlying theories and why it works. [12 hours]

Module 6: Trending human machine interaction technologies

Smart phones, PDAs and HCI; In-class presentations of new Smart phone interfaces (assignment). Information input and its evolution on the cell phone. Look up information on augmented reality (AR); how AR could be used for new applications or to improve existing design techniques. Virtual and augmented reality and Ubiquitous computing; Virtual reality: pros and cons Augmented reality: pros and cons, What is ubiquitous computing and ambient intelligence?. Wearable devices and the miniaturization of computing platforms, Uses and benefits of these technologies. Future directions of HCI; Future HCI Themes, How will they change from those discussed in this course? The aging of our population, Greater reliance on computers for more tasks. [12 hours]

Mode of Delivery

The teaching will be highly student centered. It will involve teaching, classroom discussions, demonstrations, group/individual projects and self-guided research.

Mode of Assessment

Substantial weekly problem sets, quizzes, and programming projects will be an integral part of the course assessment (40%). Final examination (60%). Part of the final exam may be a practical project.

References

1. Designing the User Interface: Strategies for Effective Human-Computer Interaction (5th Edition) Authors: Shneiderman, Plaisant, Cohen, and Jacobs Publisher: Addison Wesley; 5th edition (2009) ISBN: 978-0321537
2. Human-Computer Interaction (3rd Edition) Authors: Dix, Finlay, Abowd and Beale. Publisher: Pearson, 2003 ISBN: 0130461091
3. Introduction to Human Factors Engineering (2nd Edition) Authors: Wickens, Lee, Liu, and Gordon-Becker Publisher: Pearson, 2004 SBN-10: 0131837362

6.2.6 MAI8206: Mechatronics for Robotics

Course Name: Mechatronics for Robotics
Course Code: MAI8206
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Course Description
Definition of mechatronics. Mechatronics in manufacturing, products and design. Review of fundamentals of electronics. Data conversion devices, sensors, micro sensors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs. Description of PID controllers. Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems. Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, and pumps. Design of hydraulic circuits. Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems. CNC machines and part programming.

Course Objective
This course is designed for graduate students to:-

1. Understand the concept of mechatronics
2. Learn design principles to integrate multidisciplinary components as a system to meet requirements of products
3. Gain the fundamental knowledge about robots and automation,
4. Have hand-on skills in developing basic mechatronic products.

Learning outcomes
A student who successfully fulfills the course requirements will be able to:-

1. Identify, select, and integrate mechatronic components to meet product requirements
2. Develop kinematic, dynamic and control models for robots
3. Use commercial software tools for modeling and simulation of mechatronic system
4. Design, analyze, and optimize mechatronic product
5. Write technical reports and present engineering design solutions efficiently

Indicative Content

Module 1: Introduction
Definition of mechatronics. Mechatronics in manufacturing, products and design. Review of fundamentals of electronics. [10 hours]

Module 2: Mechatronics elements
Data conversion devices, sensors, micro-sensors, transducers, signal processing devices, relays, contactors and timers. [8 hours]

Module 3: Processors /controllers
Microprocessors, microcontrollers, PID controllers and PLCs. [10 hours]

Module 4: Drives and mechanisms of an automated system

Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems. [8 hours]

Module 5: Hydraulic system

Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits.[8 hours]

Module 7: Pneumatic system

Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems. [8 hours]

Module 8: CNC technology and Robotics

CNC machines and part programming. Industrial Robotics. [8 hours]

Mode of Delivery

Students will learn through hands-on experience by programming machine learning algorithms and applying them to real-world problems. The mode of study will be inclusive of a variety of methods;

- Lectures: Lectures will be conducted and students will be taken through the theoretical and practical sessions.
- Student projects: Students will be given projects at the start of the course and these will be continuous projects building on the techniques taught in class. At the end of the course, students will have built a complete course work.

Mode of Assessment

- Progressive assessment (40%). This will consist of theory and practical assignments.
- Final exam (60%). Part of the final exam may be a practical project.

References

1. Boucher, T. O., Computer automation in manufacturing - an Introduction, Chapman and Hall, 1996.
2. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988
3. Deb,S. R., Robotics technology and flexible automation, Tata McGraw-Hill, New Delhi, 1994.
4. Boltan, W., Mechatronics: electronic control systems in mechanical and electrical engineering, Longman,Singapore, 1999.
5. Fundamentals of Mechatronics," Musa Jouaneh, Cengage Learning, 2011.
6. Mechatronics," Sabri Cetinkunt, Wiley, 2006.
7. Mechatronics: a Foundation Course", Clarence de Silva, CRC Press, 2010.
8. Mechatronics Systems Fundamentals", Rolf Isermann, Springer, 2005.

6.2.7 MAI8207: Mobile Robotics and Autonomous Systems

Course Name: Mobile Robotics and Autonomous Systems
Course Code: MAI8207
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Course Description
This course is designed to prepare students in advanced topics in robotics, with a particular emphasis on mobile robots. Mobile robots are capable of dynamically interacting with their environments through relocation and environment manipulation. The next age in robotics will be enabled by rapid and profound advances in autonomous mobile robotics.
The course will teach students to apply concepts from machine learning, AI, control, and programming to synthesize algorithms for robots that operate in harsh, unstructured, and changing environments. Mobile robots are complex Cyber-Physical systems characterized by strong interdependency between hardware and software, and the need to perceive, reason over, and control physical dynamics at multiple scales. Cyber components include software, embedded computers, sensors, and other electronic and computational artifacts; while physical components include hardware (cars, airplanes, power lines) that is subject to the rules of physics (dynamics, kinematics, electromechanics, fluid flows).
The interplay between perception, planning, and control is central to many autonomous systems and robots. Recent advances to mobile robotics have focused on different ways of achieving this interaction, in many cases through the addition of learning. Therefore, we will put a special emphasis on learning based methods for mobile robotics.

Course Objectives

This course is designed to: -
1. Prepare students in advanced topics in mobile robotics
2. Prepare students for research and development of autonomy algorithms and software for mobile robots.
3. Train students to think critically and understand the literature landscape in mobile robotics

Learning outcomes
A student who successfully completes the course will: -
1. Have an insight into the current state of the art in mobile robotics and autonomous systems
2. Be able to critically examine, experiment and implement algorithms for robotic perception.
3. Be familiar with development of hardware and software used in mobile robotics

Indicative Content
Module One: Introduction
- Overview of various mobile robot systems (9 Hours)
- The autonomy triad: Perception, Planning and Control (3 Hours)
- Behavioral robotics (2 Hours)

Module Two: Localization and Mapping (21 Hours)
- Classical Simultaneous Localization and Mapping (SLAM) (3 Hours)
- SLAM in dynamic environments (3 Hours)
- Multi robot SLAM (3 Hours)
- Learning based SLAM (3 Hours)

- Semantic and spatial SLAM (3 Hours)
- Topological map navigation (3 Hours)
- Traversibility mapping (3 Hours)

Module Three: Robotic Learning (26 Hours)

- Privileged learning (2 Hours)
- Variants of Model Predictive Control (MPC) for learning (3 Hours)
- Model based Reinforced Learning (RL) (3 Hours)
- Self-supervised learning in robotics (3 Hours)
- Domain randomization for Simulation to real robotic system (sim2real) (3 Hours)
- Model based Meta Reinforced Learning (3 Hours)
- Learning uncertainty in dynamics (3 Hours)
- Learning based control adaptation (3 Hours)
- End to end imitation learning (3 Hours)

Module Four: Bioinspired Robots (6 Hours)

- Trends in bioinspired robotics (2 Hours)
- Soft robots (2 Hours)
- Neuro inspired architectures (2 Hours)

Mode of Delivery

- Lectures: Lectures will be conducted and students will be taken through the theoretical and practical aspects of the course.
- Student projects: Students will be given projects at the start of the course and these will be continuous projects building on the techniques taught in class. At the end of the course, students will complete projects.

Mode of Assessment

- Progressive assessment (40%). This will consist of theory and practical assignments (projects).
- Final exam (60%). Part of the final exam may be a project.

References

1. Robin R. Murphy, Introduction to AI Robotics, 2nd Ed.,2019, MIT Press.
2. Roland Siegwart, Illah R. Nourbakhsk and Davide Scaramuzza, Introduction to Autonomous Mobile Robots, 2nd Ed., 2011, MIT Press
3. Thurn S., Burgard W., and Fox D., Probabilistic Robotics, 2010, MIT Press, Cambridge MA.
4. Howie Choset et al., Principals of Robot Motion,2005, MIT Press.
5. Gregory Dudek and Michael Jenkin, Computational Principles of Mobile Robots, 2nd Ed., 2010, Cambridge University Press.

6.2.8 MAI8203: Telerobotics

Course Name: Telerobotics
Course Code: MAI8203
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Course Description

This course presents an introduction to telerobotics, with special emphasis on haptic teleoperation. Teleoperator systems with haptic interfaces allow humans to feel and physically manipulate virtual or remote environments. These systems have applications in many areas, including computer-assisted and simulated surgery, exploration of hazardous or remote environments, micro/nano manipulation, education and entertainment. The objective of this course is to give an overview of the field, provide students with the necessary theoretical background, and prepare them for research work in the area of haptic teleoperation.

Course Objectives

The course is designed to enable students:-

1. Gain general knowledge of telerobotics and haptic teleoperation, including main application areas.
2. Understand the theoretical framework for teleoperation and haptics, including basic mathematical models of teleoperators and haptic systems, notions of stability, passivity, transparency and wave variables.
3. Learn main properties of the human haptics and construction of haptic devices/interfaces.
4. Understand basic issues and challenges related to communication aspects of Internet Based teleoperation.

Learning outcomes

A student who successfully completes the course will: -

1. Have specialist knowledge (theoretical and practical) of the field of telerobotics
2. Have knowledge of the construction and use of advanced sensory system
3. Be able to carry out research in the field of telerobotics and haptic teleoperation

Indicative Content

Module 1: Introduction (6 Hours)
Telerobotics, teleoperation, haptics

Module 2: Applications of Telerobotics (8 Hours)
Minimally-invasive surgery, surgical simulators, exoskeletons and assistive devices, computer-aided design, space teleoperation, entertainment.

Module 3: Telerobotic systems architectures (8 Hours)

Module 4: Haptics systems (14 Hours)
Human haptics, haptic devices and interfaces

Module 5: Mathematics of the teleoperation and haptics (16 Hours)
Mathematical models, passivity, stability and control, transparency, wave variables, issues related to communication delays and quantization

Module 6: Internet-based teleoperation (8 Hours)
Mode of Delivery - Lectures: Lectures will be conducted and students will be taken through the theoretical and practical aspects of the course. - Student projects: Students will be given projects at the start of the course and these will be continuous projects building on the techniques taught in class. At the end of the course, students will complete projects.
Mode of Assessment - Progressive assessment (40%). This will consist of theory and practical assignments (projects). - Final exam (60%). Part of the final exam may be a project.
References 1. G. Niemeyer, C. Preusche, and G. Hirzinger, ``Telerobotics", in Springer Handbook of Robotics Bruno Siciliano, Oussama Khatib (Eds.), Springer, 2008, pp. 741-757. 2. B. Hannaford and A. M. Okamura, ``Haptics", in Springer Handbook of Robotics, Bruno Siciliano, Oussama Khatib (Eds.), Springer, 2008, pp. 719-739. 3. T. B. Sheridan ``Telerobotics, Automation, and Human Supervisory Control", MIT Press, 1992. 4. ``Advances in Telerobotics", M. Ferre, M. Buss, R. Aracil, C. Melchiorri, C. Balaguer (Eds.), Springer, 2007

6.2.9 MAI8204: Deep Learning

Course Name: Deep Learning
Course Code: MAI8204
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Brief Description

The Deep Learning (DL) course is a foundational program that will help students to understand the capabilities, challenges, and consequences of deep learning and prepare them to participate in the development of leading-edge AI technology.

In this course, students will build and train neural network architectures such as Convolutional Neural Networks, Recurrent Neural Networks, LSTMs, Transformers, and learn how to make them better with strategies such as Dropout, BatchNorm, Xavier/He initialization, and more. Get ready to master theoretical concepts and their industry applications using Python and TensorFlow and tackle real-world cases such as speech recognition, music synthesis, chatbots, machine translation, natural language processing, and more.

Course Objectives

The objectives of the course are to :-

- Provide students with knowledge and an understanding of deep neural networks, identify architecture parameters, and apply DL to their applications.
- Equip best practices to train and develop test sets and analyze bias/variance for building DL applications, use standard NN techniques, apply optimization algorithms, and implement a neural network in TensorFlow.
- Equip students with the ability to write well commented, properly tested code that illustrates the use of deep neural networks and convolutional neural networks to solve a specific real world problem of their choice.

Learning Outcomes

Upon completion of this course, students should be able to:-

- Use strategies of DL and apply them to end-to-end applications.
- Build a Convolutional Neural Network, apply it to visual detection and recognition tasks, use neural style transfer to generate art, and apply these algorithms to image, video, and other 2D/3D data
- Build and train Recurrent Neural Networks and its variants, apply them to real world problems e.g character-level language modeling, work with NLP and Word Embeddings, and use HuggingFace tokenizers and transformers to perform Named Entity Recognition and Question Answering.
- Be able to evaluate and use different deep learning methodologies and tools to solve complicated problems for example Tensorflow, Cafe, Nolearn, Theano.

Indicative Content

Module 1: Machine learning to deep learning introduction

This module shall deal with the transition from machine learning to deep learning. Topics will include the motivation for deep learning (from machine learning), basics of machine learning algorithms and optimization using gradient descent and SGD. [15 hours]

Module 2: Deep neural networks

This module will focus on neural networks, training a basic deep network, regularization of a deep network and model exploration and hyperparameter tuning. [15 hours]

Module 3: Convolutional neural networks
Convolutional neural networks have been used very successfully in practice for doing computer vision tasks. This module will concentrate in introducing convolutional neural networks and applying them for computer vision tasks. [15 hours]

Module 4: Application of deep learning using toolboxes; Tensorflow, Caffe, Theano, Nolearn
This module will focus on getting up and running with the different deep learning platforms. In this module students will investigate the different platforms and perform simple tasks on each to understand the relative differences and advantages. [15 hours]

Mode of Delivery
Students will learn through hands-on experience by programming machine learning algorithms and applying them to real-world problems. The mode of study will be inclusive of a variety of methods;

- Lectures: Lectures will be conducted and students will be taken through the theoretical and practical sessions.
- Student projects: Students will be given projects at the start of the course and these will be continuous projects building on the techniques taught in class. At the end of the course, students will have built a complete course work.
- Hands-on Project
- Every Specialization includes a hands-on project. You'll need to successfully finish the project(s) to complete the Specialization and earn your certificate. If the Specialization includes a separate course for the hands-on project, you'll need to finish each of the other courses before you can start it.

Mode of Assessment

- Progressive assessment (40%). This will consist of theory and practical assignments.
- Final exam (60%). Part of the final exam may be a practical project.

References
Several reference books are available for this course - some of them free books and downloadable.
[1] Yoshua Bengio, Ian Goodfellow, Aaron Courville. Deep Learning 2016: MIT Press. Available: http://www.deeplearningbook.org
[2] Alex Krizhevsky, Ilya Sutskever, Geoffrey E Hinton. ImageNet Classification with Deep Convolutional Neural Networks 2012: NIPS. Online: http://books.nips.cc/papers/files/nips25/NIPS2012_0534.pdf
[3] Itamar Arel, Derek C. Rose, and Thomas P. Karnowski. Deep Machine Learning A New Frontier in Artificial Intelligence Research 2010. Available: http://www.ece.utk.edu/~itamar/Papers/DML_Arel_2010.pdf

6.2.10 MCF8204: Cybercrime and Digital Forensics

Course Name: Cybercrime and Digital Forensics

Course Code: MCF8204
Course Credit: 4
Contact Hours: 60
Year of Study: 1
Semester: 2

Course Description

This course addresses the comprehension and application of Computer Forensic. Students will evaluate and synthesize technical and legal issues in relation to digital evidence. Students will apply various skills and techniques, combined with numerous investigative software tools to analyze seized electronic media.

Course objectives

This course aims to enable students to:

i. Comprehend the internal technology of the forensic computer.
ii. Apply knowledge through demonstration of multi-boot systems for their forensic computer.
iii. Evaluate password recovery tools (PRTK) and Distributed Network Attack Software.
iv. Describe the operation of different computer forensic tools.
v. Apply technologies for creating sterile electronic media for imaging.

Learning outcomes

By the end of this course, the students should be able to;

i. Identify various digital crimes
ii. Describe forensic investigation tools
iii. Analyze digital evidence acquisition mechanism
iv. Investigate digital crime incidences
v. Prepare technical investigative report for legal/court actions

Indicative Content

Module 1: Introduction

Types of forensics, Types of Computer Forensics Investigations, Types of criminals [5 hours]

Module 2: Digital Evidence

Identifying Digital Evidence, Reasons for Evidence, Collecting Digital Evidence, How to Keep a Digital Chain of Custody, Seizing Digital Evidence at the Scene, Documenting Evidence[6 hours]

Module 3: Types of Information Acquisition

Logical vs. physical, Basic Memory Acquisition, Basic Disk Based Acquisition, E-discovery Acquisition, Full disk image acquisition tools and techniques (Seize Evidentiary Image of a USB Device, Seize Evidentiary Image From a Hard Drive) [12 hours]

Module 4: Forensic field kits and Methodology

Methodology of Field Acquisitions, Field Acquisitions of Electronic Media, Adapters/Cables, Write Blockers, Laptops/Handheld Imagers, Smart Phones [15 hours]

Module 5: Computer forensic tools

Access Data – Password Recovery Tool Kit Software , Password Recovery Issues / Investigations, Profile of the Suspect / Password Database , Password Recovery Toolkit , Distributed Network Attack Software, Packet analyzers [12 hours]

Module 6: Steganography
Explanation and Usages , How Steganography Applies to Computer Forensics
[10 hours]

Mode of Delivery
The teaching will be highly student centered. It will involve teaching, classroom discussion, demonstrations, laboratory experiments and self guided research. A student will be expected to do self paced research in each of the modules.

Mode of Assessment
This course will be delivered through lectures, practical and case studies and will be assessed through coursework and exams, 60% Exams and 40% coursework

References

1. Brian Carrier: File Systems Forensics Analysis, Addison welsea Professional 2005, ISBN 0-32-126817-2
2. Digital Evidence and Computer Crime (Second Edition), Eoghan Casey, Elsevier Academic Press, ISBN 0-12-163104-4. www.elsevier.com/forensic
3. Bruce Middleton, Cyber Crime Investigator's Field Guide, Boca Raton, Florida:Auerbach Publications, 2001, ISBN 0-8493-1192-6.
4. Chris Prosise and Kevin Mandia, Incident Response: Investigating Computer Crime, Berkeley, California: Osborne/McGraw-Hill, 2001, ISBN 0-07-213182-9.

6.3 YEAR 2: SEMESTER I

6.3.1 MAI9101: Research Seminar Series

Course Name: Research Seminar Series
Course Code: MAI9101
Course Credit: 3
Contact Hours: 45
Year of Study: 2
Semester: 1

Course Description
The course provides students with space to present their experiences in the research journey, introduces them to their formal research agenda in the main MAI programme, and improves their presentation skills. It basically emphasizes an interface with the audience more in a professional and formal direction. This includes but not limited to presenting information on literature reviews, research concepts/synopsis and proposal development. It will be in the form of open presentations, sessions and workshops and actual presentations shall take approximately 30-50 minutes including commentary and discussions. The course serves as a foundation for the research journey at this stage and therefore targets the students' preparedness for managing his/her research at this level.

Course objectives
This course will enable students to;

1. To prepare students in managing their research for effective data handling through this program.
2. To equip students with skills to carry out individual or team research work according to scientific requirements.
3. To enable students to share their research experiences and increase their presence for the effective programme completion.
4. To gain experience in professional presentation and peer evaluation in line with graduate research.

Learning outcomes
Upon successful completion of this module, students will be able to:

1. Apply, compare and examine the different research experiences from other researchers.
2. Define research problems, specify methods for carrying out scientific research and demonstrate possession of skills and attitudes to conduct such research.
3. To enable students to improve towards effective presentation techniques in scientific seminars, workshops and conferences.

Indicative Content

Teaching of this course will be in three modules. Each module will be a complete unit of teaching and will be assessed independently during continuous assessments. The content of the modules will include:

Module 1: Scientific paper writing
Meaning and importance of research seminars, Learning from case studies [5 hours]

Module 2: Presentation and discussion of research progress

- Problem Development, Review of Literature and Scientific Research Reports

- Problem identification and Background to the problem
- Problem statement
- Problem Objectives (types), rationale/justification, Scoping and research frameworks.
- Formulation and Organization of the Literature review
- Formatting, organization and writing of scientific report
- Presentation of scientific research reports and business reporting.

[10 hours]

Module 3: Scientific paper presentation

- Presentations and sessions of 30-60 minutes from each student [30 hours]

Mode of Delivery

The teaching will be highly student centered. It will involve teaching, classroom discussions, demonstrations, group/individual presentations and self-guided research. As part of the course, the student will also be obliged to attend all (weekly) research talks in the school for the entire semester.

Mode of Assessment

Students are expected to attend class every week, participate in discussions, and prepare and deliver presentation(s) during the semester. The method of assessment will be categorized as:

- Attendance of weekly research seminars (10%)
- Scientific paper write up and presentation (40%)
- Research proposal presentation (40%)
- Knowledge of subject matter (10%)

References

1. Martin, W. E., & Bridgmon, K. D. (2012). Quantitative and statistical research methods: From hypothesis to results (Vol. 42). John Wiley & Sons. ISBN 9781118234570 5.
2. Adam, F. and M. Healy (2000). A Practical Guide to Postgraduate Research in the Business Area. Dublin, Blackhall Publishing.
3. How to Present a Paper in Theoretical Computer Science:
4. A Speaker's Guide for Students. https://larc.unt.edu/ian/pubs/speaker.pdf
5. Giving a Talk: Guidelines for the Preparation and Presentation of Technical Seminars. http://www.comm.toronto.edu/%7Efrank/ guide/guide.pdf
6. The Paper Reviewing Process. http://greatresearch.org/ 2013/10/18/the-paper-reviewing-process/

6.4 YEAR 2: SEMESTER II

6.4.1 MAI9102: Master's Dissertation

Course Name: Master's Dissertation Course Code: MAI9102 Course Credit: 17 Contact Hours: 255 Year of Study: 2 Semester: 2
Description Students write and defends their dissertation (17 credit units)

APPENDICES

APPENDIX 1: PROGRAMME FUNDING

The Master of Science in Artificial Intelligence will be funded through:

1. Tuition fees (See Table below)
2. Government funding.

The presidential initiative proposal has been incorporated into funding for the programme

3. Development partners

- Project Proposals to donor agencies
- Engage funders such as SIDA, DAAD, RUFORUM, Madhavan Fund, e.t.c; for possible support of MSc in Artificial Intelligence .

The MSc in Artificial Intelligence budget has been developed based on costs chargeable to Uganda students admitted to the course. The budget assumes that 15 students are admitted to the course each academic year. The budget includes recurrent expenditures and projected staff costs (academic, administrative and support staff) and capital and other running costs.

Assuming an enrolment of 30 students per intake		
A. REVENUE PER SEMESTER	Semester I	Semester II
Tuition fees	Amount (UGX)	Amount (UGX)
A student fees (UGX 4,000,000 per annum)	2,000,000/=	2,000,000/=
Tuition fees for 25 students @UGX 2,000,000	50,000,000/=	50,000,000/=
Total Collection per semester	50,000,000/=	50,000,000/=
B. EXPENDITURE PER SEMESTER		
University Council 9%	4,500,000	4,500,000
Teaching Expenses 50%	25,000,000	25,000,000

Administrative Expenses 5%	2,500,000	2,500,000
Office Expenses 3%	1,500,000	1,500,000
Library Materials 2%	1,000,000	1,000,000
Faculty levy 5%	2,500,000	2,500,000
Utilities/Furniture 2%	1,000,000	1,000,000
Staff Development 2%	1,000,000	1,000,000
Computer Hardware and software Repair/Updates 10%	5,000,000	5,000,000
Workshops/Research Seminars 12%	6,000,000	6,000,000
Total 100%	50,000,000/=	50,000,000/=

APPENDIX 2: HUMAN RESOURCES

Table A1-1: Academic Staff available to Teach Masters in Artificial Intelligence

SN	NAME	POSITION	COURSES	Qualification	Staff Status	Current Load
1	Dr. Musinguzi Wilson Babu	Assoc. Prof.	• Research Seminar Series • Research Methods	• PhD Energy Engineering (Makerere University, Uganda) • MSc. Sustainable Energy Engineering (The Royal Institute of Technology, Sweden) • BSc Mechanical Engineering (Makerere University, Uganda)	Full time	9 CU
2	Prof. Rwawiire Samson	Assoc. Prof.	• Mechatronics for Robotics • Research Seminar Series	• PhD Material Engineering (Technical University of Liberec) • Integrated MSc and Bachelor of Science in Mechanical Engineering (Czech Technical University)	Full time	6 CU
3	Prof. Twaib Semwogere	Assoc. Prof.	• Advanced Theoretical Computer Science • Research Methods	• PhD Mechanical Engineering (MAK,) • MSc. Mathematics, BSc. Mathematics (MAK)	Full time	12 CU
4	Mr. Matovu Davis	Lecturer	• Computer Vision • Cloud Technologies and Architectures	• PhD Candidate IT ongoing (Masinde Muliro University of Science and Technology-Kenya) • MSc. Computer systems and Networks Engineering (Kharkov National University of Radio Electronics-Ukraine) • BSc. Computer Engineering (Kharkov National University of Radio Electronics-Ukraine)	Full time	9 CU

5	Mr. Arineitwe Joshua	Lecturer	• Robotics and Intelligent System • Mobile Robotics and Autonomous Systems	• MSc (EE), MSc. (Physics), BSc(Ed)– Physics/Mathematics (MAK) •	Full time	12 CU
6	Mr. Alunyu Andrew	Lecturer	• Emerging Trends in Computer Science	• PhD in information systems (ongoing) MAK • MSc (Data Communication & Networks) (MAK) • BSc. Education (Physics/Maths) MUST	Full time	9 CU
7	Dr. Gilbert Gilibrays Ocen	Senior Lecturer	• Cloud and Web Security • Cybercrime and Digital Forensics	• PhD. In information technology. Masinde Muliro University of Science and Technology-Kenya) • MSc. Information Technology (CUU) • BSc. Computer Engineering (Kharkov National University of Radio Electronics-Ukraine)	Full time	9 CU
8	Dr. Odongtoo Godfrey	Senior Lecturer	• Computer Systems Security • Data Security and Privacy	• PhD. Information Technology (MAK) • MSc (Information Technology) (UCU) • PGD Data communication & Software Engineering (MAK) • BSc. Education (Physics/Maths) MUST	Full time	12 CU
9	Dr. Godliver Owomugisha	Senior Lecturer	• Machine Learning • Data Mining	• PhD in Computer Science, University of Groningen, The Netherlands. • MSc. Computer Science, Makerere University • BSc. Computer Science, Makerere University	Full time	9 CU
10	Mr. Lusiba Badru	Lecturer	• Structures and Interpretation of	• PhD. In information technology (ongoing) Masinde Muliro	Full time	12 CU

			Computer Programs ● Human-Computer Interaction	University of Science and Technology- Kenya) ● Master of Science (Computer Science), Gadjah Mada University, Yogyakarta, Indonesia, 1997. ● B.Sc. (Economics & Mathematics) with Education, IslamicUniversity In Uganda, Mbale, Uganda 1992.		
11	Dr. Rose Nakasi	Senior Lecturer	● Data Analytics and Visualization ● Deep Learning	● PhD in Computer Science, Makerere University. ● MSc. Computer Science, Makerere University ● BSc. Computer Studies, Busitema University	Part time	
12	Ms. Asingwire Barbra	Lecturer	● Information and Network Security	● PhD Student ● MSc (Data Communication & Networks) (MAK) ● Bachelors of Computer Engineering (BU)	Full time	9 CU
13	Dr. Lukyamuzi Andrew	Senior Lecturer	- Human-Computer Interaction - Emerging Trends in Computer Science	PhD in Computer Science, Mbarara University	Part time	
14	Dr. John Ngubiri	(External Expert) Makerere University	● Computer Systems Security	PhD. CS (RUN) MSc. CS (Mak) PGD. CS (Mak) BSc. Educ (Mak)	Part time	
15	Dr. Rose Nakibuule	(External Expert) Makerere University	● Computer Vision ● Machine Learning	PhD. CS (Mak) MSc. CS (Mak) BSc. CS (Mak)	Part time	

APPENDIX 3: LIBRARY RESOURCES

Table A3-1. Electronic Resources Subscription by Busitema University Library

SN	DATABASE	URL FOR LOGIN
1	Emerald Insight	http://www.emeraldinsight.com
2	Libhib	http://libhub.kiox.org
3	Ebrary	http://site.ebrary.com/lib/busitemau
4	Edudonor Index	www.edudonorindex.com
5	ARDI (Access to Research for Development and Innovation)	http://ardi2.wipo.int
6	CTA Publishing	http://publications.cta.int/en/
7	TEEAL (The Essential Electronic Agricultural Library)	
8	Research4Life (This is a Gateway to other Databases) such as HINARI	http://www.who.int/hinari/en/
9	INASP: International Network for Availability of Scientific Publications	http://www.inasp.info/en
10	EIFL: Electronic Information for Libraries	http://www.eifl.net
11	AGORA (Access to Global Research in Agriculture)	www.fao.org/agora/en
12	OARE (Online Access to Research in the Environment)	http://www.unep.org.oare

APPENDIX 4: Preparatory Activities

The following preparatory activities were undertaken:

- Consultation of stakeholders (Academics at Makerere University, Uganda Industrial Research Institute (UIRI), and Telecommunication Service providers (MTN and Airtel) among others.
- A four-day workshop with the stakeholders at Sports View Hotel, Kireka. Held from 10th May - 13th May 2022. Workshop minutes are attached.
- The curriculum was taken through (i) BCT Department Board; (ii) Faculty of Engineering Board (55th Faculty Board held on 26th May, 2022), Higher Degrees and Research Committee; and (iii) Board of Graduate Studies, Research and Innovations, a committee of the Senate.