Islamic Republic of Iran

Ministry of Health and Medical Education

High Council for Medical Science Planning

PhD curriculum for specialized field of artificial intelligence in medical sciences

(General information, program, course titles and evaluation)

Date 2016.05.29

Ministry of Health and Medical Education of the Islamic Republic of Iran

High Council for Medical Sciences Planning

Approved by the seventy-fifth session of the High Council for Medical Science Planning

On June 28, 2020

In the name of God, Most Gracious, Most Merciful

Major: Artificial Intelligence in Medical Sciences

Degree: PhD

Specialized Secretariat: Secretariat of the Council for Education of Basic Medical, Health and Specialized Sciences

In the seventy-fifth session, the High Council for Medical Science Planning, based on the plan of the specialized doctoral course in artificial intelligence in medical sciences, which has been approved by the Secretariat of the Council for Basic Medical, Health and Specialized Education, described the training curriculum in five chapters (including general specifications, syllabus, course titles, and syllabus evaluation). It is approved and stipulates as follow:

1. The curriculum of the specialized doctoral course in the field of artificial intelligence in medical sciences is valid from the date of notification for all universities and higher education institutions of the country that have the following specifications.

A) Universities and institutions of higher education that are managed under the supervision of the Ministry of Health and Medical Education.

B) Institutions that are established with the official permission of the Ministry of Health and Medical Education and in accordance with the laws and are therefore subject to the approvals of the High Council for Medical Science Planning.

C) Other higher education institutions that are established in accordance with special laws and must be subject to the academic standards of the Islamic Republic of Iran.

2. From the date of notification of this program, all training courses and similar programs of institutions in the field of doctoral courses of artificial intelligence in medical sciences, in all universities and institutes of higher education mentioned in Article 1, will be obsolete and according to the regulations, the mentioned universities and institutions of higher education can establish this course and implement a new program.

3. General specifications, curriculum, course titles, standards and evaluation of the doctoral program in the field of artificial intelligence in medical sciences will be announced in five chapters for implementation.

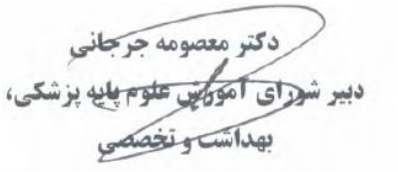
Vote issued in the seventy-fifth session of the High Council for Medical Science on June 28, 2020

Planning on the PhD curriculum of the artificial intelligence in medical sciences

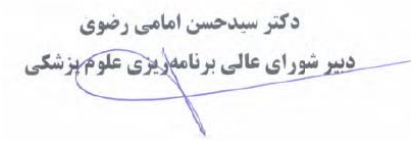
The PhD curriculum of the artificial intelligence in medical sciences approved by the majority of votes.

The PhD curriculum of the artificial intelligence in medical sciences is valid from the date of approval.

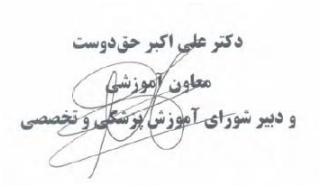
it is approved.



it is approved.



it is approved.



The vote issued in the seventy-fifth session of the High Council for Medical Science Planning, dated June 28, 2020, regarding the educational program of PhD in the field of artificial intelligence in medical sciences, is valid and will be implemented.

Dr. Saeed Namaki

Minister of Health, Treatment and Medical Education and Chairman of the High Council for Medical Science Planning

Members of the committee for compiling the PhD curriculum in the field of artificial intelligence in medical sciences

Name and Family name	University/ Institute
Dr. Amin Aminzade Gohari	Sharif University of Technology
Dr. Hamidreza Rabiee	Sharif University of Technology
Dr. Hamid Beigi	Sharif University of Technology
Dr. Hamid Karbalay Aghajan	Sharif University of Technology
Dr. Ali Sharifi Zarchi	Sharif University of Technology
Dr. Ali Ghazizade	Sharif University of Technology
Dr. Reza Khosroabadi	Iran University of Medical Sciences
Dr. Leila Alibeiglou	Iran University of Medical Sciences
Dr. Mansour Parvaresh	Iran University of Medical Sciences
Dr. Mohammad Taghi Jaghtai	Iran University of Medical Sciences
Dr. Mahmoud Ghadiri Vasfi	Iran University of Medical Sciences
Dr. Mohammad Rouhani	Iran University of Medical Sciences
Dr. Amin Jahanbakhshi	Iran University of Medical Sciences
Dr. Mahdi Nikubakht	Iran University of Medical Sciences
Dr. Mohammad Arbabi	Iran University of Medical Sciences
Dr. Amir Homayoun Jafari	Iran University of Medical Sciences
Dr. Mehrdad Oveisi Fordoi	Shaheed Rajaie Cardiovascular, Medical & Research Center
Dr. Seyed Abdolreza Mortazavi Tabatabaei	Ministry of Health and Medical Education
Ms. Rahele Daneshnia	Ministry of Health and Medical Education
Ms. Soude Moravej	Ministry of Health and Medical Education

List of members and guests presented at the 223rd meeting of the Deputy Council of the High Council for Medical Sciences Planning dated January 19, 2020.

Attendees:

Dr. Hasti Sanaee Shoar (Representative of the Deputy Minister of Health)

Dr. Marziye Nojumi

Dr. Tayeb Ghadimi (Representative of the Deputy of Treatment)

Dr. Farhad Adhami Moghaddam (Representative of the deputy of Islamic Azad University of Medical sciences)

Dr. Hassan Behboudi

Dr. Gholamreza Asghari

Dr. Mohammad Taghi Joghtai

Dr. Abtin Heidarzade

Dr. Fereidun Nouhi

Dr. Seyed Hassan Emami Razavi

Invited:

Dr. Leila Alibeiglou

Dr. Alireza Mirbagheri

Dr. Reza Khosroabadi

Dr. Hamidreza Rabiee

Dr. Amir Homayoun Jafari

Dr. Seyed Abdolreza Mortazavi Tabatabaei

List of Attendants

List of Participants in Council of Medical Sciences at the time of approval of the Artificial Intelligence Program

Attendants

Dr. Maryam Hazrati

Dr. Masume Jorjani

Dr. Marziye Nojumi

Dr. Yasna Behmanesh (t**he representative of the deputy of Food and Drug Administration**)

Dr. Ali Akbar Haghdoust

Dr. Mohammad Reza Rahbar (the representative of the ministry of health)

Dr. Farhad Adhami Moghaddam (Representative of the deputy of Islamic Azad University of Medical sciences)

Dr. Naser Ostad

Dr. Hamid Akbari

Dr. Gholam Reza Asghari

Dr. Mohammad Hossein Ayati

Dr. Ali Bidari

Dr. Hossein Behnia

Dr. Mehdi Tehranidoust

Dr. Mohammad Taghi Joghtai

Dr. Ali Jafarian

Dr. Seyed Ali Hosseini

Dr. Jamshid Salamzade

Dr. Alireza Salimi (Representative of the Secretary-General of the Islamic Republic of Iran)

Dr. Mohammad Reza Sabri

Dr. Jalil Kuhpayezade

Dr. Fereidun Nouhi

Dr. Saeed Hashemi Nazari

Dr. Behzad Houshmand

Dr. Seyed Hassan Emami Razavi

Dr. Seyed Abdulreza Mortazavi Tabatabiee

Chapter one

PhD curriculum for specialized major of artificial intelligence in medical sciences

Introduction

Artificial intelligence is a branch of science concerned with the natural intelligences and their structures in nature, and use their models for different applications in various scientific fields. Artificial intelligence in medical sciences is composed of the combination of knowledge in science such as computer science and engineering, artificial intelligence, electrical engineering, neuroscience, physiology and neuroanatomy. Research has shown that artificial intelligence technology will undergo medical science and will create dramatic changes in this science.

The primary goal of this field is related to applications, such as the establishment of advanced diagnostic methods based on artificial intelligence, planning to predict pre-surgical results, evaluate different data with large volumes in medical sciences and the use of patterns found in these data. In order to predict the effects of different drugs or different treatments on the patient, evaluation and treatment of remote patients, quantifying the raw data of clinical imaging, providing specialized training on the treatment staff with virtual reality techniques and adding engineering processes and many other new applications. Artificial intelligence programs by converting raw data collected in the health system and treatment can provide new methods in diagnostic processes, develop treatment protocols, predict results before surgery, design drug and its impact prediction, medical personal, monitoring and patient care, increasing the performance of medical equipment, and so on. So, as the applications of this field were identified, the main objective of artificial intelligence in medical sciences on the one hand is to enjoy the knowledge and expertise of doctors and other therapists, neurologists and biologists, and on the other hand, combining it with intelligence capabilities and knowledge of Artificial and Engineering Science. According to the national vision document, which emphasizes the first economic, scientific and technological position in the region of Southwest Asia, the need for this discipline in our beloved country is very evident in achieving these goals, and this field in order to fill this gap and promote the scientific position of our country technology.

Title of the major and its grade in English:

Artificial Intelligence in Medical Sciences (PhD)

Description of the major

Artificial intelligence is to study and develop machines (computers, robots and physical systems) that can carry out tasks commonly dependent on human intelligence such as seeing, understanding, recognition, communication, decision making and translating languages independently without the human assistance. Artificial intelligence systems are called systems that can be similar to human intelligent behaviors, including understanding complex conditions, simulating thinking processes

and human reasoning practices and their response to them, learning and the ability to gain knowledge and reason for solving issues.

Secretariat of the High Council of Medical Sciences

Artificial Intelligence in Medical Sciences specifically is focusing and developing applications of artificial intelligence in medical sciences such as predicting, prevention, diagnosis and treatment of diseases, its use in areas such as pharmacy, psychiatry, rehabilitation, making smart monitoring device health, building robots and devices help patients and people with disabilities and build devices for promoting the human senses.

Terms and conditions for the course acceptance

Acceptance in the entrance exam is in accordance with the Ministry of Health, Treatment and Medical Education.

The volunteers entered the doctorate of artificial intelligence in medical sciences should have one of the following academic degrees:

Graduates of General Practitioner (Medicine, Dentistry and Pharmacy)

Masters of Computer Sciences, Computer Engineering (all specialties and fields), Electrical Engineering (all fields), Medical Engineering (all fields), Mechanical Engineering (Biomechanical field, Applied Design and Mechatronics), Bioinformatics and Medical Biotechnology can participate in the entrance exam.

For more information about the latest changes in academic degrees that are acceptable and examination materials and entrance examination of each school year, refer to the medical sciences booklet related to that academic year.

History and the evolutionary course in the world

Conducting many researches, in the 1960s and 1970s, Artificial Intelligence provides the first problem solving program or specialist system called Denderal. While this program was designed for applications in organic chemistry, the basis for the next MYCIN system was considered as one of the most important applications of artificial intelligence in medicine. Nevertheless, MYCIN and other systems, such as INTERNIST-1 and CASNET, were not usual applications by specialists.

In the 1980s and 1990s, with the increase of microcomputers and new network connection levels, researchers found the fact that Artificial Intelligence (AI) systems would be used in the field of health to correct the lack of information or modify it if they used the specialties of doctors and engineers together.

For this purpose, new methods including fuzzy set theory, statistical methods such as Bayesian network, artificial neural networks, evolutionary algorithms and other learning algorithms were created to reflect the growing needs of computational intelligent systems in health.

Medical and technological advances that have occurred during this half century has simultaneously lead to the growth of AI applications in the health domain, including:

- Improving computational power of systems that lead to faster collection of data and processes.
- Improvement of data storage systems, which leads to increased storage capacity and availability of health related data from health care and personal care centers.
- Database development such as bioinformatics databases to determine the genome sequence
- Implementing extensive electronic registration systems for data related to the health care fields.
- The progression of pattern recognition algorithms and the empowerment of machines in the proliferation of human perceptual processes, especially in the field of natural language processing and computer vision, prediction and treatment applications in the field of diagnosis.

Course history in Iran

Artificial intelligence in Iran has a long history, for example, the first undergraduate degree in 1995 with the name of artificial intelligence and robotics entered the higher education system, and now with titles such as computer science- the soft computing and the artificial intelligence sub-disciplines, computer engineering with the artificial intelligence and robotic sub-disciplines, and cognitive science-cognitive neuroscience- the computer and artificial intelligence sub-disciplines which are taught in the graduate and postgraduate degrees. Iran is ranked fifteen internationally in the publication of international papers, but this science has not yet been specialized in the field of medical sciences applications.

By considering the wide range of applications related to the artificial intelligence in medicine and the growing trend of the applications of this field in medicine in the world, the formation of this field was considered at universities of medical sciences with the aim of training specialists in this regard to developed our beloved country Iran in this major, as well as other countries in the world. Considering some practical applications of this field, the following can be referred to:

Diagnosis of diseases, plan and production for formulating new drugs, evaluation and assessment of health programs at the macro levels of the country, monitoring of health, providing remote therapeutic counseling sessions, education and development of surgical procedures with robot assistance, medical data management, computer-brain interface for medical applications, personal-based medical treatment, system development and modern rehabilitation methods.

Given the wide range of applications of this field, the promotion of artificial intelligence in medical sciences can have benefits, including the development of cooperation between different disciplines in medical sciences and the development of specialized interdisciplinary activities in universities and institutes.

It should be noted that with the establishment of artificial intelligence in medical sciences, the facilities available in medical science universities can be achieved in accordance with the construction of many devices needed in the field of artificial intelligence in medical sciences.

Finally, it should be noted that by studying and examining many researches done at the prestigious and autoreactive universities of the world and national projects defined in many European, American and Asian countries. The creation of artificial intelligence in medical sciences alongside other disciplines in the Faculty of Medical Technology seemed essential for Iran, in order to be active like world's developed countries in this area and produce high-tech products too. Therefore, the formation of this field with the aim of producing knowledge and related products in this field, given that current knowledge and technologies in Iran are responsive to the construction of such products in the field of medicine, is essential and necessary.

Meanwhile, the absence of this field can remove Iran from this competition, in spite of the possibilities, talents, capabilities and knowledge of this competition and turn our country into a consumer country. For this reason, universities of medical science must be determined seriously to establish this field and resolve existing barriers to take effective steps in science and technology advance in Iran.

The typical jobs for graduates

Since the graduates of this field are entered into the cycle of scientific and research activities for the first time in Iran and achieve the ability to play educational, research, consulting and facilitating roles, therefore, they can cover the range of various tasks in different centers as follows:

- Departments of Medical Sciences Universities
- Research Centers of Medical Sciences, Ministry of Science and Nonprofit Universities
- Research centers and knowledge based companies
- Business incubators
- Hospitals and research centers of hospitals
- Administrations and organizations that are active in the macro level of health and medical services.
- Pharmacy factories
- Advanced medical equipment manufactures
- Diagnosis centers

Philosophy (Values and Beliefs)

Artificial intelligence in medical sciences has many values, including the following:

Forming an effective interaction among medical professionals and health activists with engineering groups such as computer science and data mining, information technology specialists in the therapeutic

center, which makes the health group's questions for real problems and the work provided by the engineering group is practically beneficial.

Increasing effectiveness in macro management of health, with the creation of an online appropriate hospitalization for health information, treatment and equipment from all geographical range of Iran's vast country and reducing the cost and time of transmission to the most up-to-date achievements and experiences to the most remote parts of the country.

With access to mass data and processing them, it will provide an appropriate hospitalization for adopting important decisions and macro policies in the health system, which will help to expand the spirit of social justice and sustainable development.

Using modern facilities such as virtual reality and augmented reality technologies in education and treatment will improve the level of information in health and treatment and increase the efficiency of health care providers.

Prospect (outlook)

It is hoped that human resource education and knowledge of artificial intelligence in medical sciences will be educated by the production of knowledge and technology, the development and implementation of applied research and participation in the administrative sectors of the health system, and direct cooperation with the health staff while promoting health services in the prevention, diagnosis, health and treatment.

Mission

The mission of this field of education is training graduates who are capable, creative, researcher, responsible and susceptible to the health of society while by means of artificial intelligence knowledge in different areas of medical sciences, such as brain sciences, cancer, cellular and molecular disorders, predicting effectiveness medications, developing advanced therapeutic protocols, develop new methods of prevention, diagnosis and treatment of diseases and evolve remote treatments to the country and the health system. The graduates are expected to be the cause of significant developments in these areas, and they can progress our beloved country in the category of new and leading sciences too.

Main objectives

- Training the creative force and processor to increase the efficiency of information in the field of health
- Organizing the information storage and facilitating access to them in health fields
- Processing and converting data collected in the health area to quantitative information required for treatment staff to distinguish, predict and provide effective treatment

- Reducing the risk of diagnostic and therapeutic errors and reducing medical costs
- Eliminating the limitation of providing medical treatments to help patients who are not allowed to attend a specialist doctor and help treat patients through developed diagnostic and therapeutic methods developed by artificial intelligence as well as products produced with artificial intelligence knowledge.
- Qualitative and quantitative provision of health care services with reduced related costs
- Using current developed models or new models in artificial intelligence to solve the issues of medical sciences and meet the needs of this area

Expected competencies

a. basic expected competencies

The expected public capabilities for graduates of this field are:

- Communication skills- effective interdisciplinary interaction
- Acquiring the ability to instruct artificial intelligence courses in medical sciences
- Accomplishing research and writing scientific articles on the use of artificial intelligence knowledge in medical sciences
- Critical thinking and problem solving skills to help early diagnosis of diseases and predicting the effect of treatment, lowering cost and risk by modeling facts
- Management skills (policy, planning, organizing, monitoring, and control, evaluation) founded on evidence-based issues
- Professionalism

b. Expected special capabilities

Expected capabilities and professional tasks for graduates of this field are:

Exclusive capabilities	Duties	Lesson code(s)
Communication skills and interaction	Effective interdisciplinary relationship in the field of health	Project related to lesson 5, 10, 11, 12
Educational skills	Ability to program and apply specialized software, extracting the pattern of bulky	11

	medical data in order to detect and predict diseases	
	The ability to program and use specialized software, processing software and quantitative quantification by extracting functional patterns in order to detect and use in treatment.	13
	The ability to program and apply specialized software, processing software for quantifying these data, including the volume, thickness for diagnostic applications in radiology and neurology and neurological surgery	13
	The ability to program and apply specialized software modeling in virtual environments and designing educational and therapeutic systems in these environments	14
	Computational modeling skills of medical data	5, 10, 11, 12
	Performing complex mathematical calculations on medical bulk data and their statistical analysis to help diagnose, predict and control the treatment process	4
Research Skills	Modeling facts and cases in medical issues that involve	10, 11, 12, 14

	high risk and expenses for implementation.	
	Ability to use biosensors and remote sensing methods to help diagnose and control the treatment process	7, 19, 23, 27
	Setting up and working with data and processing servers	4, 5, 3
	Acquiring skills in using moving robots in medicine and rehabilitation	07
	Design of environments for medical applications such as brain and car interface algorithms **brain–computer interface** (**BCI**)	14, 29
	Designing new systems and algorithms for diagnostic assistance and financial process control	9
	Designing, implementing and monitoring big data mining in medical sciences	PhD thesis
Critical thinking and problem-solving skills	Problem solving skills to help early diagnosis of diseases and predicting the effect of treatment	10, 11, 12, 14
	Lowering the cost and risk by modeling the realities	PhD thesis
Professional commitment	Practical training by clinical training	Workshops, PhD thesis

Expected Procedural Skills

Skill	Minimum number of skills to learn			
	Observation	Assistance	Performed independently	Total times
Programming and Application of Specialized Software for Extraction from Big Medical Data to Diagnosis and Predicting Diseases	2	-	4	6
Programming and application of specialized software processing and quantifying them by extracting applied patterns in order to diagnose and use in treatment	2	-	2	4
Programming and application of specialized software processing of medical images to quantify data, including the volume, thickness for diagnostic applications in radiology and neurology and neurological surgery	2	1	2	5
Designing intermediate environments for medical applications such as brain-computer interference algorithms	1	1	1	3
Performing complex mathematical calculations on medical data and their statistical analysis to help diagnose, predict and control of the treatment process	1	1	1	3
Design of new systems and algorithms of diagnostic and processing therapeutic process	1	1	1	3
Applying biosensors and remote sensing methods to help diagnose and control of the treatment process	1	-	1	2

Performing and working with data and processing servers	-	1	-	1
Programming and applying mobile robots in medicine and rehabilitation	-	1	-	1
Programming and applying specialized Software Modeling Reality in Virtual Environment and Designing Educational and Medical Systems in these environments	1	1	-	2

Educational strategies

This program is based on the following strategies:

- Task based education
- Problem based education
- Subject based education
- Evidence based education
- Simultaneous student- teacher based education
- Hospital based education
- Lab based education

Methods and techniques

In this course, the following methods and techniques will be used:

Different types of intra-departmental, inter-departmental wards, hospitals, interdisciplinary, and inter-university seminar conferences

Discussion in small groups, training workshops, the journal clubs, and reading book, case presentation

Entrepreneurship, outpatient education, research laboratories

Using Simulation and Remote Training Techniques in terms of facilities

Participation in lower classes

Self-study, self-education

Other necessary educational techniques and methods and educational goals

It is expected that students:

comply with the patients' legal charter (1).

consider the provisions associated with the protection and safety of patients, employees and work environments in a precisely respected way (these regulations are reviewed by the relevant educational group).

observe regulations associated with the Dress Code (2).

consider professionalism

protect resources and equipment used under any circumstances

respect the professors, employees and learners and participate in the creation of intimate and respectful atmosphere in the workplace.

consider ethical, social and professional attentions in the critique of programs.

should observe research ethical laws in conducting research related to the discipline.

The assessment program:

The student will be evaluated in the following methods:

Written ■ oral ■ computer-interactive based test ■ DOPS ■ 360 degree evaluation ■ Portfolio ■

Evaluating based on portfolio, includes the evaluation of the log book, the results of the tests, articles, advancements, and remarks, certificates etc.

B. Evaluation

continuous■ periodic■ final■

In-group tests are available to the educational group.

According to the selected research area of students in this major, and with the supervisor guidance, each student is required to provide specialized services related to its research field during the doctoral period in the centers.

Chapter Two:

Minimum requirements of the program

Artificial Intelligence Program for PhD candidates

Composition of the program

A. The minimum number of faculty members

Full-time faculty members are required by the approval of the Administration of Medical Universities with the following specialties:

At least one associate professor of artificial intelligence with concentration on applied medical sciences

At least one associate professor of neuroscience or related majors such as Anatomy or Physiology

At least one associate professor of medical engineering with expertise in processing signals and medical images

At least one associate professor of specialist physician in accordance with the group activities

The universities of medical sciences desiring to establish this major should have a collaborative agreement with the Ministry of Science Universities presenting artificial intelligence major.

Essential specialties for supporters

Direct collaboration with professors of computer science, bioinformatics, electrical engineering, biomechanics, medical robotics, pharmacology, medical physics with brain imaging, internal specialists and relevant specialties

General special facilities and necessary places

Classrooms

Conference hall

Instructors' room

Students' room

Computer room and high-enough-speed internet

Required spaces and special arenas:

Clinical neuroscience laboratory

Access to medical and molecular imaging systems

Access to hospitals and clinical centers

Computer labs equipped with data and processing servers, processing software, medical images and pattern recognition

The robotics vision laboratory

Brain computer interface lab

The required capital for preparing education equipment

Access to the following devices:

Magnetic Resonance Imaging (MRI)

Computer Tomography (CT) Scan

Bio signals Recording Systems: EMG, ECG, SGR, SPO2

Advanced computers

Rehabilitation Robots

The required populations or samples

High volume data from patients' clinical information, laboratory samples, food samples and pharmaceuticals.

Chapter Three

Curriculum Details and Courses
Artificial Intelligence in Medical Sciences
at Ph.D. Level

Ministry of Health and Medical Education of the Islamic Republic of Iran

High Council for Medical Science Planning

Secretariat of the High Council for Medical Sciences Planning

Course Details:

Course Name: Artificial Intelligence in Medical Sciences at Ph.D. Level

Course Length and Structure:

Course length is in accordance with the educational regulations of the Ph.D. program, approved by the High Council for Medical Sciences Planning.

Total number of Credits:

The total number of credits in this program are 40 which are as follows:

Credits	**Number of credits**
Compulsory specialized credits (core)	16 credits
Optional specialized credits (non- core)	6 credits
Thesis	18 credits
Total	**40 credits**

Table 1 – Deficiency or Compensation Courses of the Ph.D. Level in Artificial Intelligence in Medical Sciences

Lesson Code	**Name of Course**	**Number of Credits**			**Course Hours**			**Prerequisite or Concurrent**
		Total	**Theoretical**	**Practical**	**Total**	**Theoretical**	**Practical**	
01	Neurophysiology and Neuroanatomy	2	2	--	34	34	--	No
02	Cellular and Molecular Neurobiology	2	2	--	34	34	--	No
03	Basics of Machine Learning	2	2	--	34	34	--	No
04	Advanced Statistics and Research Methodology	2	2	--	34	34	--	No
05	Matlab & Python Programming	2	--	2	64	--	64	No
06	Basic Digital Signal Processing	2	2	--	34	34	--	No
07	Principles of Robotic Applications in Medical Sciences	2	1	1	51	17	34	No
08	Medical Information Systems*	1	0.5	0.5	26	9	17	--
Total		**15**						

In addition to the course credits, the student is required to pass a maximum of 12 credits of deficiency or compensation courses (Table A) at the discretion of the department and with the approval of the Graduate Council of the University.

* Passing this course is mandatory for all students who have not passed it before, as a deficiency or compensation course.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Table 2 – Compulsory (Core) Specialized Courses of the Ph.D. Level in Artificial Intelligence in Medical Sciences

Lesson Code	Name of Course	Number of Credits			Course Hours			Prerequisite or Concurrent
		Total	Theoretical	Practical	Total	Theoretical	Practical	
09	Principles of Neuroscience	2	2	--	34	34	--	01 & 02
10	Technology and the Future of Medicine	2	2	--	34	34	--	No
11	Real and Artificial Neural Networks	2	1	1	51	17	34	03 & 04
12	Big Data in Medicine	3	2	1	68	34	34	03 & 04
13	Computational Neuroscience	2	1	1	51	17	34	01 & 02 & 04
14	Biomedical Signal and Image Processing	3	2	1	68	34	34	06
15	Intelligent Interfaces in Medical Sciences	2	1	1	51	17	34	05 & 07
Total		**16**						

Table 3 – Optional (non- core) Courses of the Ph.D. Level in Artificial Intelligence in Medical Sciences

Lesson Code	Name of Course	Number of Credits			Course Hours			Prerequisite or Concurrent
		Total	Theoretical	Practical	Total	Theoretical	Practical	
16	Computational Medicine	3	2	1	68	34	34	04
17	Neuroimaging	3	2	1	68	34	34	01 & 06
18	Fuzzy Logic in Medicine Decision Analysis	3	2	1	68	34	34	04
19	Advanced Data Mining in Medical Sciences	3	2	1	68	34	34	03 & 04 & 05
20	Remote Sensing in Medical Sciences	2	2	--	34	34	--	05 & 06
21	Medical Expert Systems	2	2	--	34	34	--	03
22	Clinical Image Processing	3	2	1	68	34	34	01 & 06
23	Natural Language Processing	2	2	--	34	34	--	03
24	Biosensors	2	2	--	34	34	--	14
25	Cognitive Neuroscience	3	3	--	51	51	--	01
26	Bioinformatics	2	1	1	51	17	34	02 & 04
27	Game theory	3	3	--	51	51	--	04
28	Medical Data Bank Security	3	3	--	51	51	--	12
29	Mobile Robots in Medical Sciences	3	2	1	68	34	34	No
30	Brain Computer Interface	3	2	1	68	34	34	01 &15

Lesson Code	Name of Course	Number of Credits			Course Hours			Prerequisite or Concurrent
		Total	**Theoretical**	**Practical**	**Total**	**Theoretical**	**Practical**	
31	Special Topics in Computing, Artificial Intelligence, and Cognition	2	2	--	34	34	--	No
Total		**42**						

*The students need to take 6 credits of the above courses (Table 3) relevant to the required dissertation topic, and at the approval of supervisor and the Graduate Council of the University.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Neurophysiology and Neuroanatomy **Code: 01**

Prerequisite or Concurrent: None

Number of credits: 2 credits

Credit Type: Theoretical

Overall Course Objectives: Introduction to the human's nerve system, familiarity with the function of various nerve cells and systems (sensory, movement, cognitive, …).

Outline (34 theoretical hours)

1. Anatomy of the peripheral nervous system

2. Anatomy of the central nervous system

3. Physiology of nerve cells (resting potential)

4. Physiology of neurons (action potential)

5. Physiology of signal transmission at synapse

6. Neurophysiology of the olfactory nervous system

7. Neurophysiology of the optic nervous system

8. Neurophysiology of the nervous system of deep senses

9. Neurophysiology of the auditory nervous system

10. Neurophysiology of the equilibrium nervous system

11. Neurophysiology of the neuromotor system

12. Neurophysiology of the cognitive nervous system (centers and control of learning, memory, …)

References:

1. Mark F. Bour, Neuroscience. Last edition.

2. Patricia S. Churchland, The Computational Brain. Last edition.

Student's evaluation: Students take part in the theoretical (written) midterm and final exams.

Secretariat of the High Council for Medical Science Planning

Course Name: Cellular and Molecular Neurobiology Code: 02
Prerequisite or Concurrent: None
Number of credits: 2 credits
Credit Type: Theoretical
Overall Course Objectives: Familiarity with the cellular and molecular mechanisms regulating the nervous system functions.
Outline (34 theoretical hours):
1. Neuronal cytology, structure, and function of organelle
2. Protein traffic channels in neurons
3. Molecular properties of ion channels
4. Action potential
5. Transporters: transporters of vesicular, presynaptic, postsynaptic, and glial
6. Receptors: protein-conjugated receptors, ligand-dependent valvular ion channel receptors, enzyme-related receptors, nuclear receptors
7. Structure and function of electrical synapse: Gap junction channels, connexin expression and its function in the nervous system
8. Structure and function of chemical synapse (Active area structure in the presynaptic nerve terminal, Cytomatrix of active area (CAZ)
9. Neurotransmitter release, mechanisms of endocytic exocytosis and recycling of synaptic vesicles
10. Synaptic transmission: signaling mechanisms in excitatory and inhibitory synapses 11. Synaptic and neuroplastic plasticity
12. Cytoskeletal regulation
13. Mechanisms of neuronal development (Neuritogenesis), Oxon orientation and Snaptogenesis (synaptogenesis)
14. Transynaptic signaling: adhesion molecules, extracellular matrix of the brain
15. Neurodegeneration mechanisms (Neurodegeneration)
16. Neurotrophic factors and their organoleptic receptors
17. Model organisms and techniques in cellular and molecular neurobiology researches
References:

1. Kandel ER, Schwartz JH, JH, Jessell TM, Siegelbaum SA, & Hudspeth AJ (Eds). Principle of neural science. Fifth edition: McGraw- Hill, Last edition.
2. Purves D. Augustine GH, Fitzpatrick D, Hall WC, LaMantia AS, & White LE, Neuroscience. Sinauer Associates, Last edition.
3. Levitan IB & Kaczmarek LK. The neuron: cell and molecular biology. Oxford university press, Last Edition.
Student's evaluation: Students take part in the theoretical (written) midterm and final exams.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning
Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Basics of Machine Learning **Code: 03**
Prerequisite or Concurrent: None
Number of credits: 2 credits
Credit Type: Theoretical
Overall Course Objectives: Familiarity of the students with the themes of machine learning

Outline (34 theoretical hours):
The lesson deals with different ways of learning with observer and without observer.

1. Neural network

2. Reinforced learning

3. Bayesian learning

4. Clustering

5. Analytical learning

6. Inductive learning

7. Evolutionary Learning

8. Inferential Learning

References:

1. E. Alpaydin, Introduction to Machine Learning, MIT Press, Last edition.

2. S. Marsland, Machine Learning, an Algorithmic Perspective, CRC Press, Last edition.

Student's evaluation: Students will be evaluated based on the written final exam and doing experimental researches. The proportion of the exam at the end of the semester and the class activities will be determined by the relevant professor.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Advanced Statistics and Research Methodology Code: 04
Prerequisite or Concurrent: None
Number of credits: 2 credits
Credit Type: Theoretical
Overall Course Objectives: Familiarity of the students with the principles and foundations of Research Methodology, learning how to design a research project, and the rules of critique and review of other research studies, preparing students for scientific confrontation with the issues around them and familiarizing students with how to examine hypotheses based on statistical criteria

Outline (34 theoretical hours):

1. Review of the principles of research method

2. Familiarity with research and types of quantitative and qualitative studies

3. Theoretical framework of research and how to review relevant studies

4. How to determine research objectives, research questions and research hypotheses

5. How to select and determine methods used in research

6. How to determine the number of samples of a research work

7. Determining the appropriate methods and statistical tests for each type of research work

8. Familiarity with how to scientifically and consciously criticize other research works and published articles

9. Principles of writing a research proposal

References:

1. Beth DawsonRobert G., Basic and clinical biostatistics, Last edition.

2. George M Hall, How to Write a paper, Last edition.

Student's evaluation:
Students take part in the theoretical (written) midterm and final exams.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Course Name: Matlab & Python Programming **Code: 05**
Prerequisite or Concurrent: None
Number of credits: 2 credits
Credit Type: Practical
Overall Course Objectives: Learning the Basics and elements of Programming and description of the main algorithms, students' familiarity with the practical use of MATLAB and Python software and a widely used toolbox for signal and image processing, data mining and statistical analysis

Outline (34 practical hours):

1. Familiarity with flowcharts in programming

2. Familiarity with MATLAB and Python software: introduction of software environment, menus and main commands, constants, formula writing

3. General mathematical functions, matrices and determinants: Introduction to general mathematical functions, matrix definition, mathematical operations on matrices, solving linear equations, determinants, inverse matrices, cellular and structural arrays.

4. Programming: Familiarity with logical and conditional operators, familiarity with the programming environment, loops, and files, creating functions

5. Interpolation, extrapolation and fitting of polynomial diagrams

6. Multi -sects, derivatives, integrals and solving equations.

7. Draw diagrams

8. Familiarity with the most used toolbox.

References:

Library of the above-mentioned software.

Student's evaluation:
In this course, students will be evaluated based on practical projects. The proportion of each practical programming project and the class activities will be determined by the relevant professor.

Secretariat of the High Council for Medical Science Planning

Course Name: Basic Digital Signal Processing **Code: 06**
Prerequisite or Concurrent: None
Number of credits: 2 credits
Credit Type: Theoretical
Overall Course Objectives: Explaining the issues related to reception and processing; and basic and common methods in signal processing
Outline (34 theoretical hours):

1.Introduction to the signal processing system
2. Filters and their application
3. Application of fast Fourier transform (FFT) and discrete Fourier transform (DFT)
4. Short-time Fourier transform (STFT)
5. Sampling of continuous signals
6. Introduction to wavelet and filter sources

References:

1. AV. Oppenheim, R.W. Schafer, "Discrete - Time Signal Processing", Prentice Hall. Last edition.
2. SK. Mitra, "Digital Signal Processing: A Computer - Based Approach", NcGraw Hill. Last edition.
3. C. S. Burrus, R. A. Gopinath, and H. Guo, "Introduction to Wavelets and Wavelet Transforms: A Primer", Prentice Hall. Last edition.

Student's evaluation:
Students take part in the theoretical (written) midterm and final exams.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Principles of Robotic Applications in Medical Science **Code: 07**
Prerequisite or Concurrent: None
Number of credits: 2 credits (1 Theoretical – 1 Practical)
Credit Type: Theoretical - Practical
Overall Course Objectives: Explaining the issues related to reception and processing; and basic and common methods in signal processing
Outline (34 theoretical hours): Familiarity with the basics of robotics and how to use different types of robots in medical sciences

Outline (17 theoretical hours - 34 practical hours)
1. Introduction and general principles of robots working
2. Control the location of robots
3. Positioning methods in humans and robots
4. Intelligent robots
5. Perceiving the environment by sensors, encoder, polarizer, zarscope, accelerometer, speedometer, laser, sonar, vision.
6. Application of robots in surgery

References:
1. Introduction to Robotics: Mechanics and Control, J. Craig. Last edition.
2. Related Articles

Student's evaluation:
In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Medical Information Systems **Code: 08**

Prerequisite or Concurrent: None

Number of credits: 1 credit (0.5 Theoretical – 0.5 Practical)

Credit Type: Theoretical - Practical

Overall Course Objectives: At the end of this course, the student should be able to get acquainted with the search engines and the role of the five software: spider, crawler, indexer, database and ranking. The student should be able to identify and compare the differences and capabilities of these software in several search engines such as Bing, Yahoo and Google. Also, while getting acquainted with several Meta search engines, the student should be able to use advanced search methods and the factors affecting them, as well as the advanced search, the Boolean operators system of the existing errors in shortness of key words (Truncation) such as asterisk, application of parentheses and the interaction of keywords on the findings of the study. The student needs to become familiar with the features available in software related to Internet Explorer, Mozilla Firefox, and Google chrome. Another purpose of this course is to acquaint the student with the library service of the university where he studies. Student's awareness of databases and publishers related to health and medical sciences, important websites in health and medical sciences especially PubMed, Cochrane, criteria for assessment of articles (like Citations), journals (Impact factor), and authors (H-inedx), and one of the Reference Manager software are obligatory.

Course description: In this course, the student will be taught the scientific research methods, internet search problems, and overcoming them. The student will get familiar with the concepts of article assessment, journals, and search in some important publisher sites. In this way, the student will be able to have an organized search of browsers and databases. Finally, the student will be able to create a dedicated library by one of the resource management software to prepare the total resources required to write dissertations, articles and prepare reports.

Outline (9 theoretical hours-17 practical hours):

Familiarity with general search engines, their differences and comparison between several search engines in terms of the same search (Practical work: individual advanced search, Boolean search Not, Or, And in PubMed search engine in the class)

Familiarity with the five software Spider, crawl, indexer, database, and ranker (ranking) in each search engine.

Familiarity with Internet Explorer, Mozilla Firefox, Google Chrome browsers and their features (Practical work: sorting and saving Favorites on flash disk)

Familiarity with the services available in the library of the university where you study, including access to domestic and foreign journals and comprehensive software

Familiarity with publishers such as Elsevier, EBSCO, Wiley, Springer

Familiarity with databases and information resources, Web of Science, Science Scopus, proQuest, Biological Abstract, etc.

Familiarity with documentary databases

Secretariat of the High Council for Medical Science Planning

Familiarity with the comprehensive database of medical articles, Medlib, Iranmedex, lrandoc, etc.
Search methods by Medical main titles (MeSH)
Familiarity with article assessment criteria (like Citation), journal assessment (Impact factor), and Author assessment (H-index) in related databases
Familiarity with DOI application
Familiarity with PubMed and a collection of articles on Medline database, Gene bank, and online software in it
Familiarity with EndNote software and creating a personal library of resources practically

Student's evaluation:

Exam during the semester	25%
Final written exam	50%
Assignments	10%
Attendance and active participation in class	10%

References:

1. www.medlib.ir
2. www.proquest.com
3. www.ncbi.nlm.nih.gov

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Principles of Neuroscience **Code: 09**

Prerequisite or Concurrent: Neurophysiology and Neuroanatomy-Cellular and Molecular Neurobiology

Number of credits: 2 credits

Credit Type: Theoretical

Overall Course Objectives: Familiarity with the structure of the nervous system and its evolution, familiarity with the role and function of different components and parts of the nervous system, deep and practical understanding of the relationship between the brain and different behaviors

Outline (34 theoretical hours):

1. Review of various nervous system cells, classification and types of neurons, types of neurocellular cells, and the characteristics of each of them
2. Introduction to the general structure, how information is transmitted, and the function of the sensory nervous systems
3. Types of sensory nervous systems and sensory perception: Sight, hearing, mechanical sensations and pain, smelling and hearing.
4. The structure and function of muscles, motor neurons, and spinal reflexes
5. The function of different parts of the brain in planning, initiating, and controlling voluntary movements
6. The structure of the spinal cord, spinal neural networks, and how to control involuntary and rhythmic body movements with Central Pattern Generators.
7. Different parts of the nervous system controlling the balance and posture of the body, the vestibular system and its role in controlling the balance
8. Nervous mechanism of motor learning
9. Genetic mechanisms in neurodegenerative diseases of the nervous system.
10. Evolution and creation of behavior in the nervous system
11. Conscious and unconscious processing of nervous information in the central nervous system (sensory, motor, cognitive)
12. The structure and functions of the nervous system: language, thought, feeling, emotion, learning, memory
13. An introduction to autism and other developmental brain diseases affecting cognitive abilities
14. The structure and function of the autonomic nervous system
15. Specialization of brain development and behavior
16. Neuroplasticity: before and after central and peripheral nervous system injuries

References:

1. Kandel ER, Schwarts JH, Jessell TM, Siegelbaum SA, & Hudspeth AJ (Eds). Principles of Neural Science. McGraw - Hill. Last edition.
2. Gazzaniga MS, Ivry RB, & Mangun GR. Cognitive Neurosciences. Norton & Company. Last edition.
3. Shepherd GM. Foundations of the Neuron Doctrine. Oxford univ press. Last edition.
4. Sporns O. Networks of the Brain. MIT Press. Last edition.

Student's evaluation:

Students take part in the theoretical (written) midterm and final exams.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning
Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Technology and the Future of Medicine **Code: 10**

Prerequisite or Concurrent: None

Number of credits: 2 credits

Credit Type: Theoretical

Overall Course Objectives: Students' familiarity with the subject of new technologies in education, diagnosis and treatment in medical sciences and pharmacy, familiarity with advanced methods of predicting the effectiveness of drugs, familiarity with new techniques based on mechanics, electronics and biology in the design of biosensors, introduction of robot applications in future therapies, familiarity with tissue engineering, genes treatment, and modern methods of injection and drug delivery based on the use of pattern recognition from high volume data.

Outline (33 theoretical credits):

1. Fundamentals of pharmacy, tissue engineering, genetics and the horizons of medicine 2. Pharmaceutical, genetic, and tissue data architecture
3. How to Explore the above information in medical databases
4. Introduction of valid patterns from medicine, genetics and tissue databases
5. Modern biological sensors
6. The role of convergent technologies in the future of medicine and technologies related to the future of medicine.
7. Submitting new articles in the field of methods of diagnosis, prediction and treatment
8. New educational methods in medical science
9. Ethical considerations in the application of new technologies

References:

1. Alexandru Mihai Grumezescu, Nanomaterials for Drug Delivery and Therapy, Last edition.
2. Shyam S. Mohapatra, Shivendu Ranjan, Sabu Thomas, Applications of Targeted Nano Drugs and Delivery Systems, Last edition.
3. Bertalan Meskó, The Guide to the Future of Medicine: Technology AND The Human Touch, Last edition.
4. Stephen C. Schimpff, The Future of Medicine: Megatrends in Health Care That Will Improve Your Quality of Life, Last edition.
5. Q.C. Est, van, D Stemerdink, V. Rerimassie, M. Schuijff, J. Timmer, F. Brom, From bio to NBIC: from medical practice to daily life, Last edition.
6. Bert Gordijn, Ruth Chadwick, Medical Enhancement and Posthumanity, Last edition.

Student's evaluation:

Students take part in the theoretical (written) midterm and final exams.

Ministry of Health and Medical Education of the Islamic Republic of Iran

High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Course Name: Real and Artificial Neural Networks **Code: 11**

Prerequisite or Concurrent: Fundamentals of machine learning - statistics and advanced research methods

Number of credits: 2 credits (1 Theoretical – 1 Practical)

Credit Type: Theoretical - Practical

Overall Course Objectives: Brief introduction of peripheral and central nervous system and familiarity with theoretical principles and practical use of various neural networks with supervised and unsupervised learning to solve various classification problems, function approximation, optimization and the like.

Outline (17 theoretical hours - 34 practical hours):

1. Introduction: Introduction of real and artificial neural networks, history of neural networks, applications
2. Basic concepts and models of neural networks: Human brain, neuron models, network architectures, supervised and unsupervised learning, various learning rules of networks
3. Overview of real neural networks: Reward circuit, learning circuit, sensory circuits, central pattern generators (CPGs)
4. Network perceptron monolayer: Classification problem, introduction of perceptron, problem solving with perceptron
5. Upcoming multilayer network: Introduction of upcoming multilayer networks, error post-learning learning law, effective factors in learning, improving network performance, network performance in categorizing and estimating network grid function
6. Network Radial base functions: Detachability of patterns, network of radial functions, and methods of instruction, regulatory theory, network of generalized radial basis functions, comparison with multilayer perceptron networks
7. Principal component analysis: Analysis of the principal component analysis, using Hubb's law, comparative principal component analysis, partial principal component analysis based on the core of the networks
8. Organized mapping models: Models of writing features, self-organizing map, learning of vector quantization.
9. Associative Memories: Linear associative memory, basic concepts, and function of recursive self-associated memory, 2-way double-associated memory
10. Recursive Networks: Single-layer recursive networks, dynamic systems, stability modal model, recursive network architectures, tutorial return networks
11. Random Networks: Simulated annealing, Boltzmann machine, liquid belief networks 12. Comparative resonance theory: stability contradiction, impact, ART1 network
13. Time processing networks: Appropriate architectures, delayed forward concentrated networks, forward delayed forward networks
13. Time error post-algorithm, cascade correlation network specifications and benefits, Upcoming delayed distributed networks, time error post-algorithm
14. Cascade Correlation: Features and specifications of the network, method of making the network, instruction of the network
15. Deep networks

Required Software

Matlab Software – Neural network toolbox

Stuttgian Neural Network Simulator (SNNS)

References:

1. S. Haykin, Neural Networks and Learning Machines, Prentice - Hall, Last edition

2. J.M. Zurado, Introduction to Artificial Neural Systems, West Publishing Carinary, Last edition

3. L Fauselt, Fundamentals of Neural Networks, Prentice - Hall, Last edition

4. K. Mehrotra, C. Molan, and S. Ranka, Elements of Artificial Neural Networks, MIT Press, Last edition

5. M. Hagan, H. Demuth and M. Beale, Neural Network Design, PWS Publishing Company, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Secretariat of the High Council for Medical Science Planning

Course Name: Big Data in Medicine **Code: 12**

Prerequisite or Concurrent: Fundamentals of machine learning - statistics and advanced research method

Number of credits: 3 credits (2 Theoretical – 1 Practical)

Credit Type: Theoretical - Practical

Overall Course Objectives: Introduction of different components and parts of pattern recognition systems with special application for pattern recognition from bulk data in medical sciences, introduction of different approaches to pattern recognition problems, introduction of different classification methods, especially statistics methods, introduction of basic concepts in extraction and reduction of dimensions, clustering methods, parameter estimation and statistical distribution.

Outlines (34 theoretical hours - 34 practical hours):

1. Introduction of pattern recognition systems and applications
2. Introduction and review of required mathematical concepts.
3. Categorizers and decision functions
4. Statistical classifiers
5. Linear separator functions
6. Introduction of various extraction and reduction methods
7. Introduction of principal component analysis
8. Fisher image function methods
9. Introducing the problem of parameter estimation and different methods
10. Introduction of different methods for estimating statistical distribution function (EM, GMM, …)
11. Clustering and introduction of different algorithms
12. Other related topics include: Combination of categories, evaluation criteria, validation and its various methods
13. Deep Networks and its users
14. Introduction to bulk medical data
15. Considerations of working on medical data collected in various centers.

References:

1. Thodoridis, S. and Koutroumbas, K. Pattern Recognition. Edition 4. Academic Press, Last edition.
2. Duca, R.O., Hart, P.E. and Stork, D.G. Pattern Classification, Wiley. Last edition.
3. Fukunaga, K. Statistical Pattern Recognition, Academic Press. Last edition.
4. Bishop. C. M. Pantern Recognition and Machine Learning, Springer, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Secretariat of the High Council for Medical Science Planning

Course Name: Computational Neuroscience **Code: 13**

Prerequisite or Concurrent: Neurophysiology and neuroanatomy - Cellular and molecular neurobiology - Statistics and advanced research method

Number of credits: 2 credits (1 Theoretical – 1 Practical)

Credit Type: Theoretical – Practical

Overall Course Objectives: Instruction on the use of computational methods in medical sciences, especially neuroscience, introduction of quantification of cognitive behavior and brain mechanisms to better understand the disorders and provide more effective treatment strategies

Outline (17 theoretical hours - 34 hours of practice):

1. Familiarity with data collection methods in neuroscience
2. How to encode and decode information in neurons
3. Information theory and dynamic models
4. Neural models and neural networks
5. Flexibility and learning in neural networks
6. Application of monitoring neural mechanisms in cognitive modeling

References:

1. Patricia S. Churchland, The Computational Brain. Last edition.
2. Peter Dayan, Theoretical Neuroscience, Last edition.
3. Andrew Gillies, Bruce Graham, and David Sterratt, Principles of Computational Modeling in Neuroscience, Last edition.
4. Érdi, Péter, Sen Bhattacharya, Basabdatta, Cochran, Amy L., Computational Neurology and Psychiatry, Last edition.
5. Perlovsky, Leonid I., Kozma, Robert, Neurodynamics of Cognition and Consciousness, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning
Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning
Course Name: Biomedical signals and images processing **Code: 14**
Prerequisite or Concurrent: Basic digital signal processing
Number of credits: 3 credits (2 Theoretical – 1 Practical)
Credit Type: Theoretical – Practical
Overall Course Objectives: Explaining the issues related to receiving and processing, explaining basic and common methods in processing signals and digital images, especially medical-biological cases.

Outline (34 theoretical hours - 34 practical hours):

1. Introduction to bio-medical signal processing system

2. Filters and their application in bio-medical signal processing

3. Application of fast Fourier transform (FFT) and discrete Fourier transform (DFT) in medical-biological signal processing

4. Change the short-time Fourier (STFT) for processing biological signals

5. Sampling the bio-medical continuous signals

6. Introduction to wavelettes and filter banks

7. Detection of incident

8. Biological Signal Compression

9. Captrom and its applications in medical signal processing

10. Basics of medical image processing

11. Familiarity with conventional medical image filters

12. Familiarity with quantitative methods of medical images

References:

1. AV. Oppenheim, R.W. Schafer, "Discrete - Time Signal Processing", Prentice Hall, Last edition.
2. SK. Mitra, "Digital Signal Processing: A Computer - Based Approach", NcGraw Hill, Last edition.
3. M. Akay, "Biomedical Signal Processing", Academic Press, Last edition.
4. Mike Cohen, "Biomedical Signal Processing", CRC Press, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Intelligent Interfaces in Medical Sciences **Code: 15**

Prerequisite or Concurrent: Programming in MATLAB and Python - Basics of robotics application in medical sciences

Number of credits: 2 credits (1 Theoretical – 1 Practical)

Credit Type: Theoretical – Practical

Overall Course Objectives: Introduction of human interaction techniques with machines and computers, and instruction on the use of virtual reality and augmented reality environments to model the facts and cases in medicine which are costly and have implementation and administration risks.

Outline (17 theoretical hours - 34 practical hours):

1. Introduction of human-machine interaction techniques

2. Introduction of human-computer interaction techniques

3. Interface environment design

4. How to design virtual reality and augmented reality environments for reality modeling 5. Introduction of medical scenarios requiring human interaction with machine or computer

6. Use of Internet of things in medical sciences

References:

1. Sherman W. Tyler, Joseph William Sullivan, Intelligent User Interfaces, Last edition.

2. V. Suma, Zubair Baig, Noureddine Bouhmala, Fuqian Shi, Brain Computer Interface for Smart Medical Applications, Last edition.

3. Matthias Harders and Robert Riener, Virtual Reality in Medicine, Last edition.

4. James Roland, Virtual Reality and Medicine, Last edition.

5. Aboul Ella Hassanien, Nilanjan Dey, Surekha Borra, Medical Big Data and Internet of Medical Things: Advances, Challenges and Applications, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Computational Medicine **Code: 16**

Prerequisite or Concurrent: Statistics and advanced research

Number of credits: 3 credits (2 Theoretical – 1 Practical)

Credit Type: Theoretical – Practical

Overall Course Objectives: Teaching the application of computational methods in medical sciences, for example, computational psychiatry, helping to quantify disorders with a holistic view of behavior, cognition and brain components

Outline (34 theoretical hours - 34 practical hours):

1. Basics of evaluating conscious and unconscious behavior and introducing behavioral models

2. Quantification of behavior with questionnaires and basics of behavior modeling

3. Behavior assessment methods and cognition

4. Basics of cognitive modeling based on accuracy and speed of response

5. Leveling based on research scope criteria and differential diagnosis criteria

6. Dynamic review of the answer with Drift Diffusion Model

7. Applications of monitoring brain mechanisms in diagnostic leveling

8. Principles and application of computational psychiatry

References:

1. Alan Anticevic John Murray, Computational Psychiatry: Mathematical Modeling of Mental Illness, Last edition.

2. Erdi, Peter, Sen Bhattacharya, Basabdatta, Cochran, Amy L. Computational Neurology and Psychiatry, Last edition.

3. Perlovsky, Leonid I., Kozma, Robert, Neurodynamics of Cognition and Consciousness, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Secretariat of the High Council for Medical Science Planning

Course Name: Neuroimaging **Code: 17**

Prerequisite or Concurrent: Neurophysiology and Neuroanatomy-Basic Digital Signal Processing

Number of credits: 3 credits (2 Theoretical – 1 Practical)

Credit Type: Theoretical – Practical

Overall Course Objectives: Familiarity of students with conventional methods of neural imaging with the introduction of capabilities and differences of various methods, teaching data collection methods, noise removal and data analysis using software available in various types of neural imaging.

Outline (34 theoretical hours - 34 practical hours):

1. Fundamentals of structural and functional imaging through magnetic exacerbation method

2. Principles of diffusion and perfusion

3. Principles of Spectrography MRS

4. Principles of imaging through near-red light spectroscopic imaging

5. Principles of imaging by positron emission tomography imaging

6. Noise removal methods from brain images

7. Quantification of structural and anatomical images of the brain

8. Local processing of images at rest and functional images

9. Clinical and diagnostic uses of neuroimaging in neurology, neurosurgery, and psychiatry

10. Brain Network Survey

References:

1. Jeanette Mumford, Russell Poldrack, and Thomas E. Nichols, Handbook of fMRI data analysis, Last edition.
2. Massimo Filippi, Oxford Textbook of Neuroimaging, Last edition.
3. Jasmin Cloutier, Neuroimaging Personality, Social Cognition, and Character. Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning
Course Name: Fuzzy Logic in Medical Decision Analysis **Code: 18**
Prerequisite or Concurrent: Statistics and advanced research methods
Number of credits: 3 credits (2 Theoretical – 1 Practical)
Credit Type: Theoretical – Practical

Overall Course Objectives: Familiarity with theoretical topics and mathematical methods related to set theory and fuzzy logic, familiarity with the basic operators of set theory and classical logic and how to develop them in fuzzy mode, introduction to important applications of set theory and fuzzy logic, including:

- Fuzzy modeling and modeling with fuzzy data

- Fuzzy decision-making

- Fuzzy control, fuzzy classification, fuzzy clustering

- Fuzzy knowledge base and approximate reasoning

- Application of items discussed on medical data

Outline (34 theoretical hours - 34 practical hours):

1. Review of set theory and logic, moving from non-fuzzy sets to fuzzy sets
2. Basic concepts and definitions including fuzzy operators, fuzzy arithmetic, fuzzy numbers, linguistic variables, fuzzy arithmetic operations, fuzzy order, fuzzy equivalence and fuzzy logic, fuzzy descriptors and familiarity with the interpretation of information based on uncertainty.
3. Applied topics on medical data
4. Generating fuzzy sets and operators using medical datasets or using expert opinions
5. Neuro fuzzy systems
6. Fuzzy data and recovery of fuzzy data in medicine

References:

1. Klir GJ & Yuan B. Fuzzy sets and fuzzy logic: Theory and application. Prentice Hall, Last edition.
2. Yen J & Langari R. Fuzzy logic: Intelligence, control, and information. Prentice Hall, Last edition.
3. Wang L-X. A course in fuzzy systems and control. Prentice Hall, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Secretariat of the High Council for Medical Science Planning
Course Name: Advanced Data Mining in Medical Sciences Code: 19
Prerequisite or Concurrent: Fundamentals of machine learning-Advanced research statistics and methods-Programming in MATLAB and Python
Number of credits: 3 credits (2 Theoretical – 1 Practical)
Credit Type: Theoretical – Practical

Overall Course Objectives: Familiarity of students with the subject and students entering the field of research in the field of data mining on medical science data, teaching more advanced data mining topics and existing solutions and their features, preparing students for research in the field of advanced data mining in medical sciences.

Outline (34 theoretical hours - 34 practical hours):

1. Exploring data in medical science databases
2. Methods of medical science data processing
3. Medical Science Data Architecture
4. Ranking of data properties based on entropy, classification and methods based on it
5. (Bizi classification, classification with neural networks and classification with fuzzy sets ...), predictive methods (regression, validation, …), data clustering methods, data mining in fluid data, parallel data mining.

References:
1. J. Han, M. Kamber, Data Mining: Concepts, Models, Methods, and Algorithms, Elsevier Inc, Last edition.
2. Carlos Fernández Llatas, Juan Miguel Garcia - Gómez, Data Mining in Clinical Medicine, Last edition.
3. C. C. Aggarwal, Data Mining: the textbook, springer, Last edition.
4. C. C. Aggarwal, J. Han, Frequent pattern mining, springer, Last edition.
5. M. J. Zaki, W. Meira, the handbook of data mining, Cambridge university press, Last edition.
6. Bifet. Adaptive Stream Mining: Pattern Learning and Mining from Evolving Data Streams, IOS Press, Last edition.
7. P. Kumar, Pattern Discovery Using Sequence Data Mining: Application and Studies, IGI Global, Last edition.
8. W. Wang, J. Yang, Mining Sequential Patterns from Large Data Sets, Springer, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning
Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Remote Sensing in Medical Sciences **Code: 20**

Prerequisite or Concurrent: Programming in Matlab and Python environment - Basic digital signal processing

Number of credits: 2 credits

Credit Type: Theoretical

Overall Course Objectives:

Introducing the concepts related to production, processing and interpretation, sending data related to medical sciences via the internet, instruction methods of how to work with them and how to extract information from this data

Outline (34 theoretical hours):

1. Introduction to Remote sensing, including primary definitions, components and features of remote sensing systems and energy sources.
2. Describing the resolution of signals and images including spatial, spectral and radiometric resolution, resolution measurement
3. Introduction of optical sensitivities and related imaging systems including familiarity with active and transient (passive) imaging methods, introduction of various cameras and sensors and their applications.
4. Remote sensing for various medical data types such as (electrophysiological signals, brain images, etc.)
5. Data interpretation, data calibration, and data analysis and storage
6. Review of medical information systems

References:

1. Paul M. Mather, computer processing of remotely - sensed images, John Wiley, Last edition.
2. Jensen, J. R., remote sensing of the environment an earth resource perspective, Prentice - Hall, Inc., Last edition.
3. Lillesand, T. M, R. W. Keifer and J. W. Chipman, Remote sensing and image interpretation. Wiley, Last edition.
4. James B. Campbell and Randolph H. Wynne, introduction to remote sensing, Guilford Press, Last edition.
5. John A. Richards, Xiuping Jia, remote sensing digital image analysis: an introduction, springer, Last edition.

Student's evaluation:

Students participate in the theoretical written midterm and final exams.

Secretariat of the High Council for Medical Science Planning
Course Name: Medical Expert Systems **Code: 21**
Prerequisite or Concurrent: Basics of machine learning
Number of credits: 2 credits
Credit Type: Theoretical

Overall Course Objectives: Familiarity of students with expert systems, machine arguments and how to use them in medicine

Outline (34 theoretical hours):

1. Paradigm of medical expert systems

2. Expert systems architecture

3. Auxiliary tools in expert systems

4. Inference based on the law

5. Acquisition and extraction of needs

6. Machine reasoning

7. Machine learning

8. Proving theory, data mining

9. Knowledge-based structures

10. Uncertainty management, verification and validation

11. Implementing of expert systems

References:

1. A.J. Gonzalez and D. D. Dankel, the Engineering of Knowledge - Based Systems, Prentice Hall, Last edition.

2. Talmon, Jan L. Fox, John, Knowledge Based Systems in Medicine: Methods, Applications and Evaluation, Last edition.

3. Nilmini Wickramasinghe and Sushil Sharma, Creating Knowledge - Based Healthcare Organizations, Last edition.

Student's evaluation:

Students participate in the theoretical written midterm and final exams.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Clinical Image Processing **Code: 22**

Prerequisite or Concurrent: Neurophysiology and neuroanatomy and basic digital signal processing

Number of credits: 3 credits (2 Theoretical – 1 Practical)

Credit Type: Theoretical – Practical

Overall Course Objectives: Familiarity with the principles, methods and algorithms of digital image processing and its applications in medical sciences, teaching how to implement image processing in practice and comparing the strengths and weaknesses of different algorithms and methods by doing small projects with software Matlab software

Outline (34 theoretical hours - 34 practical hours):

1. Basic concepts of image processing including a brief introduction of image processing systems, its components and applications

2. Concepts, definitions, and introductory practices

3. Sampling

4. Two-dimensional Fourier transform

5. Convolution

6. Digital image processing method

7. Image improvement in spatial fields and frequency, histogram

8. Image recovery, examining recovery methods at the presence of noise

9. Picturual conversions, compression

10. Principles of formal operations

11. Identification of objects in image

12. Practicing the above items on clinical images, especially ultrasound images and CT scans.

References:

1. "Fundamental of Digital Image Processing", Written by Jain, Last edition.
2. "Digital Image Processing", Written by Gonzalez, Last edition.
3. "Digital Image Processing". Written by Castleman, Last edition.
4. Relevant articles.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Secretariat of the High Council for Medical Science Planning

Course Name: Natural Language Processing **Code: 23**

Prerequisite or Concurrent: Basics of machine learning

Number of credits: 2 credits

Credit Type: Theoretical

Overall Course Objectives:

Familiarity of students with the subject of natural language processing

Outline: (34 theoretical hours):

Various topics of language processing such as modeling, formulation, and related algorithms that are used in the stages of analysis (syntactic analysis, semantic analysis, etc.) and the production of a text.

References:

1. D. Jurafsky, J. H. Martin, Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistic and Speech Recognition, Prentice Hall, Last edition.

2. V. A. Fomichov, Semantics Oriented Natural Language Processing: Mathematical Models and Algorithms, Springer, Last edition.

Student's evaluation:

Students participate in the theoretical written midterm and final exams.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Biosensors **Code: 24**

Prerequisite or Concurrent: Processing of vital signals and medical images

Number of credits: 2 credits

Credit Type: Theoretical

Overall Course Objectives:

Students' familiarity with the subject and students entering the field of biosensors in medical sciences

Outline (34 theoretical hours):

1. Introduction to biosensors and physical, chemical and optical methods

2. Bioreceptors, immunosensors and enzymatic biosensors

3. Biological sensors based on Microfluidic and Lab-on-a-chip

4. Biosensors based on nanomaterials

5. Drawing standard curve and examining the validation, accuracy, specialty, reproducibility and stability

6. Designing biosensor, biosensor reading, and electronic section

References:

1. Henry Baltes, Sensors: A Comprehensive Survey, John Wiley & Sons, Inc., Last edition.

2. Brain R.Eggins, Biosensors: An Introduction, John Wiley & Sons, Inc, Last edition.

3. Eggins, Brain R. Chemical Sensors and Biosensors, John Wiley & Sons, Inc. Last edition.

Student's evaluation:

Students participate in the theoretical written midterm and final exams.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Course Name: Cognitive Neuroscience **Code: 25**

Prerequisite or Concurrent: Neurophysiology and Neuroanatomy
Number of credits: 3 credits
Credit Type: Theoretical
Overall Course Objectives: Familiarity with the mechanism of processes and cognition functions such as decision making, attention, emotions, feelings and motivations; introduction of patterns and existing theories in cognitive sciences and their interrelation, introductory acquaintance with the structural and functional organization of the brain in higher cognitive functions

Outline (51 theoretical hours):

1. Cognitive neuroscience: Definitions, topics and approaches

2. Organizing cognition

3. Neurobiological approach to cognition, meta-analysis and convergence

4. Pre-motor cognitive functions

5. Evaluation methods in cognitive neurosciences

6. Measuring neural activity during cognitive processing and functional imaging

7. Cognition and awareness

8. Motivational behaviors

9. Organizing emotions and feelings including: the lymphatic system, social brain, and emotional brain (perceiving emotional stimuli, understanding social stimuli, and regulating emotions).

10. Learning and memory with a cognitive approach

11. Higher cognitive practices: Decision making, visual and auditory perception, attention and its types, executive functions

References:
Kandel ER, Schwartz JH, Jessell TM, Siegelbaum SA, & Hudspeth AJ, Principles of Neural Science. McGraw - Hill, Last edition.
2. Gazzaniga MS, Ivry RB, & Mangun GR. The Cognitive Neurosciences. Third edition: Norton & Company, Last edition.
3. Baars BJ & Gage NM, Fundamentals of Cognitive Neuroscience: A Beginner's Guide. Academic press, Last edition.
4. Baars BJ & Gage NM, Cognition, Brain, and Consciousness: introduction to cognitive neuroscience. Last edition.
5. New scientific articles published in validated sources
Student's evaluation:

Students participate in the theoretical written midterm and final exams.

Course Name: Bioinformatics **Code: 26**

Prerequisite or Concurrent: Cellular and molecular neurobiology-Statistics and advanced research method
Number of credits: 2 credits (1 Theoretical – 1 Practical)
Credit Type: Theoretical – Practical
Overall Course Objectives:

Teaching the principles and basics of bioinformatics, explaining the main algorithms, practical training in the use of bioinformatics software and tools, familiarity with bioinformatics programming skills

Outline (17 theoretical hours - 34 practical hours):

1. Introduction, history and importance of informatics

2. Introduction to biology, comparison of two biological sequences

3. Introduction to biological databases, Gene search, PHIBLAST, PSIBLAST, BLAST

4. Comparison of multiple biological sequences, phylogenetic prediction, prediction of RNA structures, prediction of protein structures, prediction and analysis of genes

5. Analysis of microarray data and its applications

6. Bioinformatics applications in drug design

7. Modelling the Immune System and Immuno-informatics, and Reverse vaccine design

8. Practice of programming with Perl, Python, and Java and familiarity with Bioperl, BioPython, and BioJAVA

References:

1. J. Pevzuer, "Bioinformatics and Functional Genomics", Wiley - Blackwell, Last edition.

2. D. Mount, Bioinformatics: "Sequence and Genome Analysis", Cold Spring Harbor Laboratory Press, Last edition.

3. A. M. Campbell and L. J. Heyer, "Discovering Genomics, Proteomics and Bioinformatics", Benjamin Cummings publisher, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Course Name: Game Theory **Code: 27**
Prerequisite or Concurrent: Statistics and Advanced Research Method
Number of credits: 3 credits
Credit Type: Theoretical
Overall Course Objectives:

Familiarity with the main concepts of Game Theory, teaching how to use game theory to analyze and present effective mechanisms in the field of research issues related to artificial intelligence in medical sciences

Outline (51 theoretical hours):

1. Preliminary mathematics: Basic concepts of mathematical analysis, sequences, convergence, closed, convex and compact sets, continuous functions of fixed points and related theorems.
2. Static games with complete information: Strategic form, specific and hybrid strategies, elimination of recessive strategies and Nash equilibrium as concepts of answer to the problems of Nash equilibrium, rationality and correlated equilibrium as other concepts of response.
3. Dynamic games with complete information on multi-stage expansion games, strategies and equilibrium in the form of expansion, backward induction and sub-game - Integrity as concepts of dynamic response, the principle of single-stage violation and its application in multi-stage and repetitive game analysis, analysis of some bargaining models.
4. Repetitive modeling games, general theorems of repetitive games with definite horizon, repetitive games with infinite horizon, repetitive games with incomplete information
5. Games with incomplete information Bayesian static games, type concept, Bayesian equilibrium response concepts, total Bayesian equilibrium, sequential equilibrium signaling games, refinements related to the strategic and expansion form.
6. Markov equilibrium: random games, the existence of total Markov equilibrium, differential games.
7. Mechanism design: Social choice, monetary mechanisms, motivational mechanisms, moneyless mechanism design, composite auctions, maximizing interest in cooperative game mechanism design
8. Cooperative games: Game model, Core response concept, concept of Shapley values
9. Evolutionary games: Demographic games and the concept of sustainable evolutionary strategies, the relationship between sustainable evolutionary strategies and Nash equilibrium, evolutionary dynamics.

References:
1. Drew Fudenberg and Jean Tirol, Game Theory, MIT Press, Last edition.
2. Martin Osborne, An Introduction to Game Theory. Oxford University Press, Last edition.
3. Noam Nisan et al. (Ed.). Algorithmic Game Theory. Cambridge University Press, Last edition.
4. James Webb, Game Theory: Decisions, Interactions and Evolution, Springer, Last edition.
5. Thomas Vincent and Joe Brown, Evolutionary Game Theory, Natural Selection and Darwinian Dynamics, Cambridge University Press, Last edition.

6. George Mailath and Larry Samuelson, Repeated Games and Reputations, Oxford University Press, Last edition.

7. Bezalel Pelege and Peter Sucholter, Introduction to the Theory of Cooperative Games, Springer, Last edition.

Student's evaluation:

Students participate in the theoretical written midterm and final exams.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Prerequisite or Concurrent: Big data in medicine
Number of credits: 3 credits
Credit Type: Theoretical
Overall Course Objectives:

Familiarity with logical tips in relation to the security of medical databases, introduction of access control models (optional, mandatory and role-based), familiarity with issues such as publishing in secure database design, and types of database architectures

Outline (51 theoretical hours):

1. Introduction to medical data

2. Introduction to databases (concepts of a database, components of an inquiry database, benefits of its use)

3. Security needs (integrity of database and validity of the elements, inspection possibility, access control, authentication of the user, accessibility, reliability)

4. Sensitive information (sensitizing factors, various decisions about data accessibility, accessibility of data, ensuring authenticity, types of state disclosure and accuracy)

5.Security models

6. Obligatory accessibility control models

7. Access control models and their management

8. Statistical database security

9. Database inspection mechanisms in relationship databases

References:

1. S. Castano, M. G. Fugini, G. Martella and P. Samarati, "Database Security" Addision-Wesley, Last edition.
2. E. Bertino, R. Sandhu, "Database Security - Concepts, Approaches, and Challenges", IEEE Transaction on Dependable and Secure Computing, vol. 2, Last edition.
3. M. Bishop, Computer Security. Art and Science, Addison - Wesley, Last edition.
4. Relevant articles

Student's evaluation:

Students participate in the theoretical written midterm and final exams.

Prerequisite or Concurrent: None
Number of credits: 3 credits (2 Theoretical – 1 Practical)
Credit Type: Theoretical – Practical
Overall Course Objectives:

Introduction to the basics and principles of working with robots, familiarity with the dynamics of movement of secret robots and how to control the position of robots, and familiarity with various applications of robots in medical sciences and different fields of medicine

Outline (34 theoretical hours - Practical 34 hours):

1. Introduction and general principles of how robots work, direct and reverse kinematics

2. Overview of movement dynamics of secret robots

3. Robot position control, softness control in arm and joint, force control and texture modeling from a movement perspective including static modeling, dynamic modeling with trivial derivatives, haptic, and force transfer.

4. Routing methods in humans and robots

5. Smart robots

6. Remote control of robots

7. Mobile robots, various methods of moving the robot, position control maneuvers robot (open loop and closed loop)

8. Perception of the environment by sensors, encoder, direction (compass, gyroscope), acceleration gauge, speedometer, laser, sonar, vision and navigation of path design concepts.

9. Application of robots in surgery

10. Application of robots in rehabilitation

References:

1. M.W. Spong, M, Vidyasagar, Robot Dynamics and Control, Last edition.
2. J. Craig, Introduction to Robotics: Mechanics and Control, Last edition.
3. R. Siegwart and Illah R. Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Course Name: Brain Computer Interface **Code: 30**

Prerequisite or Concurrent: Neurophysiology and neuroanatomy and intelligent interfaces in medical sciences
Number of credits: 3 credits (2 Theoretical – 1 Practical)
Credit Type: Theoretical – Practical
Overall Course Objectives:

Familiarity with the technologies used to collect and process brain mechanisms, how to turn them into quantitative components to create an effective relationship between the user and the external environment.

Outline (33 theoretical hours - 34 practical hours):

1. Introduction to the principles of brain-machine or brain-computer

2. Introduction to brain imaging techniques with emphasis on electroencephalography (EEG) and functional imaging near red light.

3. Capabilities of using EEG, fNIRS in human-machine-computer interface systems

4. Methods of processing and quantifying electroencephalographic data

5. Widely used patterns of brain electrical signals, including event-dependent potentials, quantitative spectra, synchronous and spatial patterns, etc.

6. Compare offline and online systems

7. Methods of optimizing brain-computer interface technology

8. Aggressive and non-invasive interfaces

9. Integration with brain stimulation methods

10. Medical Applications of brain-computer relationships

References:

1. Jonathan R. Wolpaw, Elizabeth Winter Wolpaw, Brain - computer interfaces: principles and practice, Last edition.

2. Anton Nijholt, Fabien Lotte, Brain - Computer Interfaces Handbook: Technological and Theoretical Advances, Last edition.

3. Dipali Bansal, Rashima Mahajan, EEG - Based Brain - Computer Interfaces: Cognitive Analysis and Control Applications, Last edition.

Student's evaluation:

In this course, students will be evaluated based on the results of the theoretical final exam and the practical projects. The proportion of each practical project and the class activities will be determined by the relevant professor.

Course Name: Special Topics in Computing, Artificial Intelligence, and Cognition
Prerequisite or Concurrent: None
Number of credits: 2 credits
Credit Type: Theoretical

Overall Course Objectives:

Familiarity with research topics and areas in the field of artificial intelligence in medical sciences, preparing students for selection and entry to the research field of their Ph.D. dissertation.

Outline (34 theoretical hours):

Advanced and/or new topics in computing, artificial intelligence and cognition courses which will be presented based on the professor's and the postgraduate committee of the relevant department.

References:

Books and articles in scientific journals are selected in accordance with the topics discussed.

Student's evaluation:

In this course, the student will be evaluated based on the level of participation in the discussions in the class and completing assignments of required projects.

Ministry of Health and Medical Education of the Islamic Republic of Iran

High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Chapter Four

Curriculum Standards of
Artificial Intelligence in Medical Sciences
at Ph.D. Level

Ministry of Health and Medical Education of the Islamic Republic of Iran

High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Curriculum standards of the disciplines covered by the High Council for Medical Planning

Following are the minimum issues that should be considered in the curriculum evaluation process by evaluators:

* It is essential that the required course possesses **the spaces and general educational facilities** such as dedicated classroom, conference hall, dedicated bookshelf in the group, public library, computer center equipped with Internet with sufficient speed and special software, specialized department website and educational archiving system.

* It is essential for the educational department to provide the required **specialized spaces**, including: specialized laboratories, hospital and social areas to the students, based on the provisions of the educational program.

* It is essential for the educational department to provide the required **welfare and cultural spaces**, including: professors' room, students' room, self-service, prayer hall, dormitory, and cultural and sports facilities.

* It is essential that educational fields outside the department **(rotational courses)** be definitely approved by the assessment team.

* It is essential that **population and required specialized materials** for education including: patient, active hospital bed, laboratory samples, food samples, medicine or cosmetics be accessible to the students, according to the educational needs of the curriculum and in sufficient quantity and variety approved by the assessment team.

* It is essential that the required **investment and consuming equipment** in the program be provided to the program executors and their quality be approved by the assessment team.

* It is essential that the **necessary facilities for educational exercises and conducting related researches** be available to the faculty and students in accordance with the field under evaluation, and this should be approved by the evaluators.

* It is essential that the educational department under evaluation has the required **faculty** based on the items in the educational program and the approvals of the development council, and its documents to be provided to the assessment team.

* It is essential that the educational department possesses the **trained staff** to train the course learners according to what is stated in the training program.
*It is necessary that the **educational program (Curriculum)** is available to all the audience.
*It is essential that **regulations, instructions, guidelines, rules and bylaws** be available to all audiences and learners should be informed about them at the beginning of the course and the documentation should be provided to the assessors.

*It is essential that **course materials** including books and journals required by learners and faculty members are available on the department shelf.

*It is essential that learners are **actively present** at their workplace during the week, according to the number of days required by current rules, perform their duties under the supervision of faculty with senior learners, and have a weekly or monthly group schedule available.
*It is essential that the **content of the theoretical class curriculum** is at least 80% consistent with the syllabus contained in the curriculum.
*It is essential that learners actively participate in all of the **department educational and research programs**, such as in-group conferences, seminars, hands-on work, research, and lower-level training, according to the department regulatory program, and provide documentation to evaluators.
*It is essential that the training process in the course be relatively satisfactory to the learners and approved by the evaluators.
*It is essential that **Dress code** be informed to the learners at the beginning of the program, and to monitor it, there are appropriate executive mechanisms approved by the evaluators in the department.
Ministry of Health and Medical Education of the Islamic Republic of Iran High Council for Medical Science Planning
*It is essential that learners are aware of and act on the **ethical codes** contained in the curriculum and that their actions are approved by the evaluators.

*It is essential to form an **educational portfolio** for all learners in the educational department and to keep the results of evaluations, certificates of educational activities, inside and outside the educational department, incentives, reminders and other necessary documents.

*It is essential that learners have an acceptable **log book** in accordance with the general and specific competencies contained in the program being evaluated.

*It is essential that learners, based on the semester, have performed the necessary **specific intervention skills** based on the items in the program and have recorded them in their workbook and signed them by the supervising professors.

*It is essential that the **worksheet** is continuously completed by the learners and monitored by the relevant professors and the necessary written feedback is provided to them.

*It is essential for learners to participate in the **research programs of the scientific department** during their program and its documents are available.

*It is essential for the learners, according to the academic year, to pass the **credits outside the educational department** (if any) and to have received a **certificate** from the person in charge of the relevant field, and its documents should be presented to the evaluation group.

*It is essential that there is pre-planned and planned **interdisciplinary scientific cooperation** between the main educational department and other educational departments, and the documents indicating this cooperation be available.

*It is essential to use at least 70% of the **educational methods and techniques** in the program.

*It is essential that learners be **evaluated** during the program according to the methods mentioned in the program and the documentation be provided to the assessment team.

*It is essential that the university or educational center under evaluation meets the criteria set forth in the curriculum.

Ministry of Health and Medical Education of the Islamic Republic of Iran
High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Chapter Five

Curriculum Evaluation
Artificial Intelligence in Medical Sciences
at Ph.D. Level

Ministry of Health and Medical Education of the Islamic Republic of Iran

High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning
Program Evaluation

Formative Evaluation of the Program:

- Survey of beneficiaries
- Survey of professors
- Survey of students

Summative Evaluation of the Program:

This program will be evaluated under the following conditions:

1.Five years after the administration of the program

2. Major technological changes that necessitate review of the program

3- Decisions made by the key policy-makers related to the program

Program Evaluation Indicators:

Index	**Criteria**
* Graduates' satisfaction with the program:	70%
* Faculty members' satisfaction with the program:	80%
* Health system managers' satisfaction with the program results:	80%
* Estimation of needs and solving health problems by graduates:	Based on evaluators' opinion
* Quantity and quality of intellectual and research products by graduates:	Based on evaluators' opinion

Program Evaluation Method

• Survey of the faculty involved in the program, assistants and graduates with pre-reviewed questionnaires

• Using the existing questionnaires in the evaluation and accreditation section of the secretariat

Trustees of Program Evaluation

The trustees of program evaluation are the development council of medical science universities in collaboration with the program development or review group and other educational secretariats and other faculty members.

Program Review Method

The steps of reviewing this program are as follows:

• Gathering information from surveys, comparative and field research, suggestions and opinions of experts

• Requesting the secretariat to form a program review committee

• Presenting the collected data in the program review committee

• Review the required parts of the program and submit a draft of the revised educational program to the secretariat of the high council for medical sciences planning

Ministry of Health and Medical Education of the Islamic Republic of Iran High Council for Medical Science Planning

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Secretariat of the High Council for Medical Science Planning

Appendices

Ministry of Health and Medical Education of the Islamic Republic of Iran

High Council for Medical Science Planning

Appendix No. 1 Charter of Patients' Rights in Iran

1- Optimal receipt of health services is the patient's right.
- Presenting health services should be:
1-1) Worthy of human dignity and respect values, cultural and religious beliefs;

1-2) Based on honesty, fairness, politeness and kindness;

1-3) Free from any discrimination, including ethnic, cultural, religious, type of disease and gender;

1-4) Based on updated knowledge;

1-5) Based on the advantage of the patient's interests;

1-6) Regarding the distribution of health resources, it should be based on fairness and the patients' medical priorities.

1-7) Based on the coordination of care elements including prevention, diagnosis, treatment and rehabilitation;

1-8) With the provision of all basic and essential welfare facilities and away from imposing suffer and unnecessary restrictions;

1-9) Pay special attention to the rights of vulnerable groups in society, including children, pregnant women, the elderly, the mentally ill patients, prisoners, mentally and physically disabled, and unaccompanied persons;

1-10) In the fastest possible time and with respect to the patient's time;

1-11) Considering variables such as language, age and gender of service recipients;

1-12) In necessary and urgent cases (emergency), services should be provided regardless of the cost. In case of non-urgent cases, it should be defined according to the standard terms;

1-13) In necessary and urgent cases (emergency), if it is not possible to provide appropriate services, it is necessary to provide the necessary services and necessary explanations in order to transfer the patient to an equipped unit;

1-14) In the final stages of life, when the patient's condition is irreversible and death is imminent, the goal is to maintain the patient's comfort. Comfort means reducing the patient's pain and suffering, paying attention to the psychological, social, spiritual and emotional needs of him and his family at the time of death. The dying patient has the right to be with the person he wants in the last moments of his life.

2- The information should be provided to the patient in a satisfactory and sufficient manner.

2-1) The information needs to cover the following content:

2-2-1) The content of the charter of patients' rights at the time of admission;

2-1-2) Standards and predictable costs of the hospital such as treatment and non-treatment costs, insurance rules and introducing supportive oppression at the time of admission;

2-1-3) Name, responsibility and professional rank of members of the medical team responsible for providing care, including doctors, nurses and students and their professional relationship with each other;

2-1-4) Diagnostic and therapeutic methods and the strengths and weaknesses of each method and its possible side effects, diagnosis of the disease, prognosis and its side effects, as well as all the information influencing the patient's decision-making process;

2-1-5) How to access the treating physician and key members of the medical team during treatment;

2-1-6) All actions with a research nature.

2-1-7) Provide necessary training to continue treatment

2-2) Presenting information should be provided as follows:

2-2-1) Information should be timely and appropriate to the patient's condition, including anxiety, pain and his characteristics including language, education, and comprehension, unless:

-Delay in initiating treatment by providing the above information is considered harmful to the patient; (In this case, the transfer of information after the necessary action, should be done at the first appropriate time.)

-Despite being informed of the right to receive information, the patient refuses to do so, in which case the patient's request should be respected; unless not being informed put the patient at serious risk with others;

2-2-2) The patient can access all the information recorded in his clinical file and receive its image and request the correction of errors contained in it.

3- The patient's right to choose and decide freely in receiving health services must be respected.

3-1) The scope of selection and decision-making needs to be about the following:

3-1-1) Selection of the treating physician and the center providing health services within the framework of the criteria;

3-1-2) Selection and conference with the second physician as the consultant;

3-1-3) Participation or non-participation in any research, with the assurance that his decision will not affect the continuity of how to receive health services.

3-1-4) Accepting or rejecting the proposed treatments after being aware of the possible side effects of accepting or rejecting it, except in cases of suicide or in cases that refusing to treat would put another person is in serious danger;

3-1-5) Announcing the patient's previous opinion about future treatment measures when the patient has the capacity to make decisions and as a guide to medical procedures in the absence of his decision-making authority in accordance with legal standards considered by health care providers and the decision maker replaces the patient.

3-2) The conditions for selection and decision-making include the following:

3-2-1) The patient's choice and decision-making should be free and informed, based on receiving sufficient and comprehensive information (mentioned in article 2);

3-2-2) After providing information, the patient should be given the necessary and sufficient time to make a decision and select.

4- The provision of health services should be based on respect for the patient's privacy (right to privacy) and the principle of confidentiality.

4-1) Observance of the principle of confidentiality regarding all information about the patient is mandatory, except in cases where the law has excluded it;

4-2) In all stages of care, both diagnostic and therapeutic, the patient's privacy must be respected. It is necessary for this purpose to provide all the necessary facilities to ensure the privacy of the patient;

4-3) Only the patient and group therapy and authorized persons on behalf of the patient and persons who are considered authorized by law can access the information;

4-4) The patient has the right to be accompanied by a trusted person in the diagnostic process, including examinations. Accompanying one of the child's parents in all stages of treatment is the child's right, unless it is contrary to medical necessities.

5. Access to an efficient complaints system is the patient's rights.
5-1) Every patient has the right to file a complaint to the competent authorities in the event of a violation of his or her rights, which is the subject of this charter, without interfering the quality of health services;

5-2) Patients have the right to be informed of the procedure and the results of their complaint;

5-3) Damage resulting from the error of health care service providers must be compensated as soon as possible after review and proof in accordance with regulations.

In the implementation of the provisions of this charter, if the patient for any reason does not have the capacity to make decisions, the exercise of all the rights of the patient - mentioned in this charter - will be the responsibility of the alternative legal decision maker. Of course, if a substitute decision-maker obstructs the patient's treatment, contrary to the physician's opinion, the physician can appeal to review the decision through the relevant authorities.

-If a patient is without required qualities to make decisions, but can make a reasonable decision in a part of the treatment, his decision must be respected.

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level

Appendix No. 2

Executive Regulations for Dress Code and Students' Professional Ethics

In Laboratory-Clinical Environments

The dress code and behaviour of all the staff in the professions related to medical sciences department needs to be in a way that besides maintaining the professions' dignity, provides effective professional communication with patients, patients' companions, colleagues and others in educational settings.

Therefore, it is morally necessary for all ones who are studying or providing services in clinical and laboratory educational settings to observe the following rules.

Chapter 1: Dressing and Dress Code

The students' clothes to enter educational environments, especially clinical and laboratory environments, should be uniform and include the following set of features:

1-White knee-high non-stick cape with long sleeves

2- The cape must be sealed with the logo of Medical Sciences University and the relevant medical health services.

3- All buttons on the cape must be completely closed during the entire period of attendance in educational environments.

4-Using a valid identification card (ID) with a photo attached (containing first name, last name, faculty name, field of study) on the cover, in the left chest area during the entire period of attendance in educational environments is mandatory.

5-Female students should cover the entire head, neck, under the neck and hair with a suitable cover.

6-Pants should be long, conventional, plain, and non-stick; use of ripped jeans and the like is not appropriate for the medical dignity.

7-It is essential to wear simple socks that cover the entire foot and leg.

8-It is forbidden to wear lace socks with embellishments.

9- Shoes should be comfortable and appropriate, there should be no noise when walking.

10-The cape, dress, and shoes must be comfortable, clean, neat, and conventional, and they should not have sharp and inappropriate colours.

11- It is forbidden to use inappropriate badges for the medical field and hang them on the cape, pants, and shoes.

12- It is forbidden to use and expose any ring, bracelet, necklace, and earrings (except wedding ring) in educational environments.

13- The use of slippers and sandals in educational environments except in operating room and delivery room is prohibited.

Executive Regulations for Dress Code and Students' Professional Ethics

In Laboratory-Clinical Environments

Chapter 2: Personal hygiene and make-up standards in educational environments of the country

1- Those related to the medial professions are models for personal cleanness and hygiene. Thus, cleanness in appearance and hygiene are essential in medical science educational environments.

2- Nails should be short and clean. Using nail polish and nail stickers in any form is prohibited. The use of artificial nails and long nails increases the chances of transmitting the infection and the possibility of damage to others and medical equipment.

3- Unconventional make-up of the head and face is far from the practice of the medical profession.

4- It is forbidden to show any make-up in the form of a tattoo and using a ring with a jewel in the nose or any part of the hands and face.

Chapter 3: Criteria for students' behavior in medical education environments

1- Observance of the principles of professional ethics, humility and modesty in dealing with patients, patients' companions, professors, students and staff is mandatory.

2- Speaking in educational settings should be accompanied by calm and courtesy, and making any loud noise or uttering words that are not appropriate in the medical profession is prohibited.

3- Smoking at all times when a person is present at educational environments is prohibited.

4- Chewing gum and the like are prohibited in laboratories, conference halls, patient rounds and in the presence of professors, staff and patients.

5- When attending classes, laboratories and rounds of patients, the mobile phone should be turned off and at other times, its use should be reduced as necessary.

6- Any discussion or joke in related public places such as elevators, coffee shops and restaurants are prohibited.

Chapter 4: Supervising the administration and follow-up cases of violations of regulations

1- Supervising the principles of this regulations in educational hospitals and other clinical education medical environments is the responsibility of the deputy of the hospital, director of the department, chairman of the department, and educational and student experts.

2- People who do not observe the professional ethics and principles of this regulation will be warned first and if they insist on committing a violation, they will be referred to the Student Disciplinary Council.

Curriculum of Artificial Intelligence in Medical Sciences at Ph.D. Level