University of Engineering and Technology
School of Computer Science
Syllabus of Course – Academic Period 2017-I

1. Code and Name: CS261. Artificial intelligence
2. Credits: 4
3. Hours of theory and Lab: 2 HT; 4 HP;
4. Professor(s)
Meetings after coordination with the professor
5. Bibliography

[De 06] L.N. De Castro. *Fundamentals of natural computing: basic concepts, algorithms, and applications*. CRC Press, 2006.

[Gol89] David Goldberg. *Genetic Algorithms in Search, Optimization and Machine Learning*. Addison Wesley, 1989.

[Hay99] Simon Haykin. *Neural networks: A Comprehensive Foundation*. Prentice Hall, 1999.

[Nil01] Nils Nilsson. *Inteligencia Artificial: Una nueva visión*. McGraw-Hill, 2001.

[Pon+14] Julio Ponce-Gallegos et al. *Inteligencia Artificial*. Iniciativa Latinoamericana de Libros de Texto Abiertos (LATIn), 2014.

[RN03] Stuart Russell and Peter Norvig. *Inteligencia Artifical: Un enfoque moderno*. Prentice Hall, 2003.

6. Information about the course

(a) **Brief description about the course** Research in Artificial Intelligence has led to the development of numerous relevant tonic, aimed at the automation of human intelligence, giving a panoramic view of different algorithms that simulate the different aspects of the behavior and the intelligence of the human being.

(b) **Prerrequisites:** MA203. Estadística y Probabilidades. (4^{to} Sem)

(c) **Type of Course:** Elective

7. Competences

- Evaluate the possibilities of simulation of intelligence, for which the techniques of knowledge modeling will be studied.
- Build a notion of intelligence that later supports the tasks of your simulation.

8. Contribution to Outcomes

a) An ability to apply knowledge of mathematics, science. (**Usage**)

h) A recognition of the need for, and an ability to engage in life-long learning. (**Familiarity**)

i) An ability to use the techniques, skills, and modern computing tools necessary for computing practice. (**Familiarity**)

j) Apply the mathematical basis, principles of algorithms and the theory of Computer Science in the modeling and design of computational systems in such a way as to demonstrate understanding of the equilibrium points involved in the chosen option. (**Familiarity**)

9. Competences (IEEE)

C1. An intellectual understanding and the ability to apply mathematical foundations and computer science theory.⇒ **Outcome a**

C20. Ability to connect theory and skills learned in academia to real-world occurrences explaining their relevance and utility.⇒ **Outcome c**

CS2. Identify and analyze criteria and specifications appropriate to specific problems, and plan strategies for their solution.⇒ **Outcome i,j**

10. List of topics

1. Fundamental Issues
2. Basic Search Strategies
3. Basic Knowledge Representation and Reasoning
4. Advanced Search
5. Advanced Representation and Reasoning
6. Agents
7. Natural Language Processing
8. Basic Machine Learning
9. Robotics
10. Perception and Computer Vision

11. Methodology and Evaluation

Methodology:

Theory Sessions:
The development of the theoretical sessions is focused on the student, through his active participation, solving problems related to the course with the individual contributions and discussing real cases of the industry. The students will develop throughout the course a project of application of the tools received in a company.

Lab Sessions:
Practical sessions are held in the laboratory. Laboratory practices are performed in teams to strengthen their communication. At the beginning of each laboratory the development of the practice is explained and at the end the main conclusions of the activity in group form are highlighted.

Oral Presentations :
Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

Reading:
Throughout the course different readings are provided, which are evaluated. The average of the notes in the readings is considered as the mark of a qualified practice. The use of the UTEC Online virtual campus allows each student to access the course information, and interact outside the classroom with the teacher and with the other students.

Evaluation System:

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12. Content

<table>
<tr><td colspan="2">Unit 1: Fundamental Issues (2)</td></tr>
<tr><td colspan="2">Competences Expected: C1</td></tr>
<tr><td>Learning Outcomes</td><td>Topics</td></tr>
<tr><td>

Describe Turing test and the “Chinese Room” thought experiment [Usage]
Determing the characteristics of a given problem that an intelligent systems must solve [Usage]

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Overview of AI problems, examples of successful recent AI applications
What is intelligent behavior?

The Turing test
Rational versus non-rational reasoning

Problem characteristics

Fully versus partially observable
Single versus multi-agent
Deterministic versus stochastic
Static versus dynamic
Discrete versus continuous

Nature of agents

Autonomous versus semi-autonomous
Reflexive, goal-based, and utility-based
The importance of perception and environmental interactions

Philosophical and ethical issues.

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<tr><td colspan="2">Readings : [De 06], [Pon+14]</td></tr>
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<table>
<tr><td colspan="2">Unit 2: Basic Search Strategies (4)</td></tr>
<tr><td colspan="2">Competences Expected: C20</td></tr>
<tr><td>Learning Outcomes</td><td>Topics</td></tr>
<tr><td>

Formulate an efficient problem space for a problem expressed in natural language (eg, English) in terms of initial and goal states, and operators [Usage]
Describe the role of heuristics and describe the trade-offs among completeness, optimality, time complexity, and space complexity [Usage]
Describe the problem of combinatorial explosion of search space and its consequences [Usage]
Select and implement an appropriate uninformed search algorithm for a problem, and characterize its time and space complexities [Usage]
Select and implement an appropriate informed search algorithm for a problem by designing the necessary heuristic evaluation function [Usage]
Evaluate whether a heuristic for a given problem is admissible/can guarantee optimal solution [Usage]
Formulate a problem specified in natural language (eg, English) as a constraint satisfaction problem and implement it using a chronological backtracking algorithm or stochastic local search [Usage]
Compare and contrast basic search issues with game playing issues [Usage]

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Problem spaces (states, goals and operators), problem solving by search
Factored representation (factoring state into variables)
Uninformed search (breadth-first, depth-first, depth-first with iterative deepening)
Heuristics and informed search (hill-climbing, generic best-first, A*)
Space and time efficiency of search
Two-player games (introduction to minimax search)
Constraint satisfaction (backtracking and local search methods)

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<tr><td colspan="2">Readings : [Nil01], [Pon+14]</td></tr>
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<table>
<tr><td colspan="2">Unit 3: Basic Knowledge Representation and Reasoning (6)</td></tr>
<tr><td colspan="2">Competences Expected: C24</td></tr>
<tr><td>Learning Outcomes</td><td>Topics</td></tr>
<tr><td>

Translate a natural language (eg, English) sentence into predicate logic statement [Usage]
Convert a logic statement into clause form [Usage]
Apply resolution to a set of logic statements to answer a query [Usage]
Make a probabilistic inference in a real-world problem using Bayes' theorem to determine the probability of a hypothesis given evidence [Usage]

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Review of propositional and predicate logic
Resolution and theorem proving (propositional logic only)
Forward chaining, backward chaining
Review of probabilistic reasoning, Bayes theorem

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<tr><td colspan="2">Readings : [Nil01], [RN03], [Pon+14]</td></tr>
</table>

Unit 4: Advanced Search (4)	
Competences Expected: C1	
Learning Outcomes	**Topics**

• Design and implement a genetic algorithm solution to a problem [Usage]
• Design and implement a simulated annealing schedule to avoid local minima in a problem [Usage]
• Design and implement A*,beam search to solve a problem [Usage]
• Apply minimax search with alpha-beta pruning to prune search space in a two-player game [Usage]
• Compare and contrast genetic algorithms with classic search techniques [Usage]
• Compare and contrast various heuristic searches vis-a-vis applicability to a given problem [Usage]
	• Constructing search trees, dynamic search space, combinatorial explosion of search space
	• Stochastic search
	  – Simulated annealing
	  – Genetic algorithms
	  – Monte-Carlo tree search
	• Implementation of A* search, beam search
	• Minimax search, alpha-beta pruning
	• Expectimax search (MDP-solving) and chance nodes

Readings : [Gol89], [Nil01], [RN03], [Pon+14]	

Unit 5: Advanced Representation and Reasoning (6)	
Competences Expected: C1	
Learning Outcomes	**Topics**

• Compare and contrast the most common models used for structured knowledge representation, highlighting their strengths and weaknesses [Usage]
• Identify the components of non-monotonic reasoning and its usefulness as a representational mechanisms for belief systems [Usage]
• Compare and contrast the basic techniques for representing uncertainty [Usage]
• Compare and contrast the basic techniques for qualitative representation [Usage]
• Apply situation and event calculus to problems of action and change [Usage]
• Explain the distinction between temporal and spatial reasoning, and how they interrelate [Usage]
• Explain the difference between rule-based, case-based and model-based reasoning techniques [Usage]
• Define the concept of a planning system and how it differs from classical search techniques [Usage]
	• Knowledge representation issues
	  – Description logics
	  – Ontology engineering
	• Non-monotonic reasoning (e.g., non-classical logics, default reasoning)
	• Argumentation
	• Reasoning about action and change (e.g., situation and event calculus)
	• Temporal and spatial reasoning
	• Rule-based Expert Systems
	• Semantic networks
	• Model-based and Case-based reasoning

Readings : [Nil01], [RN03], [Pon+14]	

Unit 6: Agents (6)	
Competences Expected: C1	
Learning Outcomes	**Topics**

• List the defining characteristics of an intelligent agent [Usage]
• Characterize and contrast the standard agent architectures [Usage]
• Describe the applications of agent theory to domains such as software agents, personal assistants, and believable agents [Usage]
• Describe the primary paradigms used by learning agents [Usage]
• Demonstrate using appropriate examples how multi-agent systems support agent interaction [Usage]
	• Definitions of agents
	• Agent architectures (e.g., reactive, layered, cognitive)
	• Agent theory
	• Rationality, game theory
	  – Decision-theoretic agents
	  – Markov decision processes (MDP)
	• Software agents, personal assistants, and information access
	  – Collaborative agents
	  – Information-gathering agents
	  – Believable agents (synthetic characters, modeling emotions in agents)
	• Learning agents
	• Multi-agent systems
	  – Collaborating agents
	  – Agent teams
	  – Competitive agents (e.g., auctions, voting)
	  – Swarm systems and biologically inspired models

Readings : [Nil01], [RN03], [Pon+14]	

<table>
<tr><td colspan="2">Unit 7: Natural Language Processing (4)</td></tr>
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<tr><td>Learning Outcomes</td><td>Topics</td></tr>
<tr><td>

Define and contrast deterministic and stochastic grammars, providing examples to show the adequacy of each [Usage]
Simulate, apply, or implement classic and stochastic algorithms for parsing natural language [Usage]
Identify the challenges of representing meaning [Usage]
List the advantages of using standard corpora Identify examples of current corpora for a variety of NLP tasks [Usage]
Identify techniques for information retrieval, language translation, and text classification [Usage]

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Deterministic and stochastic grammars
Parsing algorithms

CFGs and chart parsers (e.g. CYK)
Probabilistic CFGs and weighted CYK

Representing meaning / Semantics

Logic-based knowledge representations
Semantic roles
Temporal representations
Beliefs, desires, and intentions

Corpus-based methods
N-grams and HMMs
Smoothing and backoff
Examples of use: POS tagging and morphology
Information retrieval

Vector space model
TF & IDF
Precision and recall

Information extraction
Language translation
Text classification, categorization

Bag of words model

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<tr><td colspan="2">Readings : [Nil01], [RN03], [Pon+14]</td></tr>
</table>

Unit 8: Basic Machine Learning (10)	
Competences Expected: C1	
Learning Outcomes	**Topics**
• List the differences among the three main styles of learning: supervised, reinforcement, and unsupervised [Usage] • Identify examples of classification tasks, including the available input features and output to be predicted [Usage] • Explain the difference between inductive and deductive learning [Usage] • Describe over-fitting in the context of a problem [Usage] • Apply the simple statistical learning algorithm such as Naive Bayesian Classifier to a classification task and measure the classifier's accuracy [Usage]	• Definition and examples of broad variety of machine learning tasks, including classification • Inductive learning • Simple statistical-based learning, such as Naive Bayesian Classifier, decision trees • The over-fitting problem • Measuring classifier accuracy
Readings : [Hay99], [Nil01], [RN03], [Pon+14]	

Unit 9: Robotics (6)	
Competences Expected: C1	
Learning Outcomes	**Topics**

• List capabilities and limitations of today's state-of-the-art robot systems, including their sensors and the crucial sensor processing that informs those systems [Usage]
• Integrate sensors, actuators, and software into a robot designed to undertake some task [Usage]
• Program a robot to accomplish simple tasks using deliberative, reactive, and/or hybrid control architectures [Usage]
• Implement fundamental motion planning algorithms within a robot configuration space [Usage]
• Characterize the uncertainties associated with common robot sensors and actuators; articulate strategies for mitigating these uncertainties [Usage]
• List the differences among robots' representations of their external environment, including their strengths and shortcomings [Usage]
• Compare and contrast at least three strategies for robot navigation within known and/or unknown environments, including their strengths and shortcomings [Usage]
• Describe at least one approach for coordinating the actions and sensing of several robots to accomplish a single task [Usage]
	• Overview: problems and progress
	  – State-of-the-art robot systems, including their sensors and an overview of their sensor processing
	  – Robot control architectures, e.g., deliberative vs. reactive control and Braitenberg vehicles
	  – World modeling and world models
	  – Inherent uncertainty in sensing and in control
	• Configuration space and environmental maps
	• Interpreting uncertain sensor data
	• Localizing and mapping
	• Navigation and control
	• Motion planning
	• Multiple-robot coordination

Readings : [Nil01], [RN03], [Pon+14]	

<table>
<tr><td colspan="2">Unit 10: Perception and Computer Vision (6)</td></tr>
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<tr><td>Learning Outcomes</td><td>Topics</td></tr>
<tr><td>
• Summarize the importance of image and object recognition in AI and indicate several significant applications of this technology [Usage]
• List at least three image-segmentation approaches, such as thresholding, edge-based and region-based algorithms, along with their defining characteristics, strengths, and weaknesses [Usage]
• Implement 2d object recognition based on contour-and/or region-based shape representations [Usage]
• Distinguish the goals of sound-recognition, speech-recognition, and speaker-recognition and identify how the raw audio signal will be handled differently in each of these cases [Usage]
• Provide at least two examples of a transformation of a data source from one sensory domain to another, eg, tactile data interpreted as single-band 2d images [Usage]
• Implement a feature-extraction algorithm on real data, eg, an edge or corner detector for images or vectors of Fourier coefficients describing a short slice of audio signal [Usage]
• Implement an algorithm combining features into higher-level percepts, eg, a contour or polygon from visual primitives or phoneme hypotheses from an audio signal [Usage]
• Implement a classification algorithm that segments input percepts into output categories and quantitatively evaluates the resulting classification [Usage]
• Evaluate the performance of the underlying feature-extraction, relative to at least one alternative possible approach (whether implemented or not) in its contribution to the classification task (8), above [Usage]
• Describe at least three classification approaches, their prerequisites for applicability, their strengths, and their shortcomings [Usage]
</td><td>
• Computer vision
  – Image acquisition, representation, processing and properties
  – Shape representation, object recognition and segmentation
  – Motion analysis
• Audio and speech recognition
• Modularity in recognition
• Approaches to pattern recognition
  – Classification algorithms and measures of classification quality
  – Statistical techniques
</td></tr>
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