**Peruvian Computing Society (SPC)**
School of Computer Science
Sillabus 2022-I

## 1. COURSE

CS261. Intelligent Systems (Mandatory)

## 2. GENERAL INFORMATION

| | | |
|---|---|---|
| **2.1 Credits** | : | 4 |
| **2.2 Theory Hours** | : | 2 (Weekly) |
| **2.3 Practice Hours** | : | 2 (Weekly) |
| **2.4 Duration of the period** | : | 16 weeks |
| **2.5 Type of course** | : | Mandatory |
| **2.6 Modality** | : | Face to face |
| **2.7 Prerrequisites** | : | MA203. Statistics and Probabilities. ($4^{th}$ Sem) |

## 3. PROFESSORS

Meetings after coordination with the professor

## 4. INTRODUCTION TO 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.

## 5. GOALS

- 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.

## 6. COMPETENCES

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

## 7. SPECIFIC COMPETENCES

**a15)** Use count theory definitions to solve sorting or selection problems in a set of single and repeated elements.

**a17)** Define functions by recognizing dependent and independent variables by recognizing functions as parameters

**a22)** Apply operations on matrices to build algorithms.

**a23)** Apply probability theory and Bayes' theorem to the construction of probability network models(*Probabilistic graphical models*).

**a24)** Apply sampling and cross validation techniques

**a25)** Apply informed and uninformed search computer techniques.

**a26)** Apply computer vision techniques.

**a27)** Apply natural language processing techniques.

**a28)** Apply machine learning techniques.

## 8. TOPICS

| **Unit 1: Fundamental Issues (2)** | |
|---|---|
| **Competences Expected: a** | |
| **Topics** | **Learning Outcomes** |
| • Overview of AI problems, examples of successful recent AI applications<br>• What is intelligent behavior?<br>– The Turing test<br>– Rational versus non-rational reasoning<br>• Problem characteristics<br>– Fully versus partially observable<br>– Single versus multi-agent<br>– Deterministic versus stochastic<br>– Static versus dynamic<br>– Discrete versus continuous<br>• Nature of agents<br>– Autonomous versus semi-autonomous<br>– Reflexive, goal-based, and utility-based<br>– The importance of perception and environmental interactions<br>• Philosophical and ethical issues. | • Describe Turing test and the "Chinese Room" thought experiment [Usage]<br>• Determing the characteristics of a given problem that an intelligent systems must solve [Usage] |
| **Readings :** [De 06], [Pon+14] | |

**Unit 2: Agents (2)**

**Competences Expected: a**

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

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

**Unit 3: Basic Search Strategies (2)**

**Competences Expected: a,j**

| Topics | Learning Outcomes |
|---|---|
| • Problem spaces (states, goals and operators), problem solving by search<br>• Factored representation (factoring state into variables)<br>• Uninformed search (breadth-first, depth-first, depth-first with iterative deepening)<br>• Heuristics and informed search (hill-climbing, generic best-first, A*)<br>• Space and time efficiency of search<br>• Two-player games (introduction to minimax search)<br>• Constraint satisfaction (backtracking and local search methods) | • Formulate an efficient problem space for a problem expressed in natural language (eg, English) in terms of initial and goal states, and operators [Usage]<br>• Describe the role of heuristics and describe the trade-offs among completeness, optimality, time complexity, and space complexity [Usage]<br>• Describe the problem of combinatorial explosion of search space and its consequences [Usage]<br>• Compare and contrast basic search issues with game playing issues [Usage] |

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

| **Unit 4: Advanced Search (18)** | |
|---|---|
| **Competences Expected: a,j** | |
| **Topics** | **Learning Outcomes** |
| • Stochastic search<br>  – Simulated annealing<br>  – Genetic algorithms<br>  – Monte-Carlo tree search<br>• Constructing search trees, dynamic search space, combinatorial explosion of search space<br>• Implementation of A* search, beam search<br>• Minimax search, alpha-beta pruning<br>• Expectimax search (MDP-solving) and chance nodes | • Design and implement a genetic algorithm solution to a problem [Usage]<br>• Design and implement a simulated annealing schedule to avoid local minima in a problem [Usage]<br>• Design and implement A*,beam search to solve a problem [Usage]<br>• Apply minimax search with alpha-beta pruning to prune search space in a two-player game [Usage]<br>• Compare and contrast genetic algorithms with classic search techniques [Usage]<br>• Compare and contrast various heuristic searches vis-a-vis applicability to a given problem [Usage] |
| **Readings :** [Gol89], [Nil01], [RN03], [Pon+14] | |

| **Unit 5: Reasoning Under Uncertainty (18)** | |
|---|---|
| **Competences Expected: a,j** | |
| **Topics** | **Learning Outcomes** |
| • Review of basic probability<br>• Random variables and probability distributions<br>  – Axioms of probability<br>  – Probabilistic inference<br>  – Bayes' Rule<br>• Conditional Independence<br>• Knowledge representations<br>  – Bayesian Networks<br>  * Exact inference and its complexity<br>  * Randomized sampling (Monte Carlo) methods (e.g. Gibbs sampling)<br>  – Markov Networks<br>  – Relational probability models<br>  – Hidden Markov Models | • Apply Bayes' rule to determine the probability of a hypothesis given evidence [Usage]<br>• Explain how conditional independence assertions allow for greater efficiency of probabilistic systems [Usage]<br>• Identify examples of knowledge representations for reasoning under uncertainty [Usage]<br>• State the complexity of exact inference Identify methods for approximate inference [Usage] |
| **Readings :** [KF09], [RN03] | |

**Unit 6: Basic Machine Learning (4)**

**Competences Expected: a,j**

| Topics | Learning Outcomes |
|---|---|
| • Definition and examples of broad variety of machine learning tasks, including classification<br>• Inductive learning<br>• Simple statistical-based learning, such as Naive Bayesian Classifier, decision trees<br>• The over-fitting problem<br>• Measuring classifier accuracy | • List the differences among the three main styles of learning: supervised, reinforcement, and unsupervised [Usage]<br>• Identify examples of classification tasks, including the available input features and output to be predicted [Usage]<br>• Explain the difference between inductive and deductive learning [Usage]<br>• Describe over-fitting in the context of a problem [Usage]<br>• Apply the simple statistical learning algorithm such as Naive Bayesian Classifier to a classification task and measure the classifier's accuracy [Usage] |

**Readings :** [Mit98], [RN03], [Pon+14]

**Unit 7: Advanced Machine Learning (20)**

**Competences Expected: a,j**

| Topics | Learning Outcomes |
|---|---|
| • Definition and examples of broad variety of machine learning tasks<br>• General statistical-based learning, parameter estimation (maximum likelihood)<br>• Inductive logic programming (ILP)<br>• Supervised learning<br>  – Learning decision trees<br>  – Learning neural networks<br>  – Support vector machines (SVMs)<br>• Unsupervised Learning and clustering<br>  – EM<br>  – K-means<br>  – Self-organizing maps<br>• Semi-supervised learning<br>• Learning graphical models<br>• Performance evaluation (such as cross-validation, area under ROC curve)<br>• Application of Machine Learning algorithms to Data Mining (cross-reference IM/Data Mining) | • Explain the differences among the three main styles of learning: supervised, reinforcement, and unsupervised [Usage]<br>• Implement simple algorithms for supervised learning, reinforcement learning, and unsupervised learning [Usage]<br>• Determine which of the three learning styles is appropriate to a particular problem domain [Usage]<br>• Compare and contrast each of the following techniques, providing examples of when each strategy is superior: decision trees, neural networks, and belief networks [Usage]<br>• Evaluate the performance of a simple learning system on a real-world dataset [Usage]<br>• Characterize the state of the art in learning theory, including its achievements and its shortcomings [Usage]<br>• Explain the problem of overfitting, along with techniques for detecting and managing the problem [Usage] |

**Readings :** [RN03], [KF09], [Mur12]

**Unit 8: Natural Language Processing (12)**

**Competences Expected: a,j**

| Topics | Learning Outcomes |
|---|---|
| • Deterministic and stochastic grammars<br>• Parsing algorithms<br>– CFGs and chart parsers (e.g. CYK)<br>– Probabilistic CFGs and weighted CYK<br>• Representing meaning / Semantics<br>– Logic-based knowledge representations<br>– Semantic roles<br>– Temporal representations<br>– Beliefs, desires, and intentions<br>• Corpus-based methods<br>• N-grams and HMMs<br>• Smoothing and backoff<br>• Examples of use: POS tagging and morphology<br>• Information retrieval<br>– Vector space model<br>∗ TF & IDF<br>– Precision and recall<br>• Information extraction<br>• Language translation<br>• Text classification, categorization<br>– Bag of words model | • Define and contrast deterministic and stochastic grammars, providing examples to show the adequacy of each [Usage]<br>• Simulate, apply, or implement classic and stochastic algorithms for parsing natural language [Usage]<br>• Identify the challenges of representing meaning [Usage]<br>• List the advantages of using standard corpora Identify examples of current corpora for a variety of NLP tasks [Usage]<br>• Identify techniques for information retrieval, language translation, and text classification [Usage] |

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

| Unit 9: Perception and Computer Vision (12) | |
|---|---|
| **Competences Expected: a,j** | |
| **Topics** | **Learning Outcomes** |
| • Computer vision<br>– Image acquisition, representation, processing and properties<br>– Shape representation, object recognition and segmentation<br>– Motion analysis<br>• Modularity in recognition<br>• Approaches to pattern recognition<br>– Classification algorithms and measures of classification quality<br>– Statistical techniques | • Summarize the importance of image and object recognition in AI and indicate several significant applications of this technology [Usage]<br>• 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]<br>• Implement 2d object recognition based on contour- and/or region-based shape representations [Usage]<br>• 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]<br>• 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]<br>• Implement a classification algorithm that segments input percepts into output categories and quantitatively evaluates the resulting classification [Usage]<br>• 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] |
| **Readings :** [Nil01], [RN03], [Pon+14] | |

## 9. WORKPLAN

### 9.1 Methodology

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

### 9.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

### 9.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

## 10. EVALUATION SYSTEM

********* EVALUATION MISSING ********

## 11. BASIC 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.

[KF09] Daphne Koller and Nir Friedman. *Probabilistic Graphical Models: Principles and Techniques - Adaptive Computation and Machine Learning*. The MIT Press, 2009. ISBN: 0262013193.

[Mit98] M. Mitchell. *An introduction to genetic algorithms*. The MIT press, 1998.

[Mur12] Kevin P. Murphy. *Machine Learning: A Probabilistic Perspective*. The MIT Press, 2012. ISBN: 0262018020.

[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.