M.Sc. in Cognitive Systems

Model Curriculum

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School of Informatics
University of Skövde
Sweden
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1 Core Courses

*Year 1, Semester 1*
- Introduction Cognitive Science
- Cognitive Architectures
- Autonomous Systems
- Empirical Modelling of Human Cognition

*Year 1, Semester 2*
- Embodied Cognition
- Learning, Growth, and Development
- Memory, Prospection, and Internal Simulation
- Knowledge, Representation, and Reasoning

*Year 2, Semester 1*
- Social Cognition and Interaction Dynamics
- Artificial Intelligence
- [Two electives]

*Year 2, Semester 2*
- [Dissertation]

2 Elective Courses

- Distributed Cognition & Adaptive Ecosystems
- Machine Perception
- Human and Computational Models of Attention
- Natural Language Processing
- Industrial, Mobile, and Humanoid Robotics
- Neural Processing
3 Outline Course Syllabi

Introduction Cognitive Science
- Paradigms of cognitive science
- Cognitivism, computationalism, and artificial intelligence
- The emergent paradigm
- Connectionism
- Dynamical systems
- Enaction

Cognitive Architectures
- Role of a cognitive architecture
- Desirable characteristic for cognitivist and emergent architectures
- Cognitive architecture schemas (e.g. Cognitive-Affective; CogAff)
- Example cognitive architectures (e.g. Soar, DARWIN, ACT-R, ISAC, LIDA, CLARION, and others)

Autonomous Systems
- Types of autonomy
- Strength and degree of autonomy
- Robotic autonomy vs. biological autonomy
- Constitutive and behavioural autonomy: homeostasis and allostasis
- Emergence, self-organization, autopoiesis, and organizational closure
- Measures of autonomy

Empirical Modelling of Human Cognition
- Probability concepts, sampling, and expectation
- Factorial mixed model experimental designs
- Confidence intervals and hypothesis testing
- Correlation, single and multiple linear regression
- Bayesian statistics
- Signal detection theory

Embodied Cognition
- Cognitivist and emergent perspectives on embodiment
- The conceptualization, constitution, and replacement hypotheses
- Mutual dependence of perception and action
- Types of embodiment
- Off-line embodied cognition
- Situated, embedded, grounded, extended, and distributed cognition

Learning, Growth, and Development
- Development in natural systems
- Phylogeny and ontogeny
- Developmental psychology
- Imitation
- Value systems and motivation
- Supervised, unsupervised, and reinforcement learning
Memory, Prospection, and Internal Simulation
- Types of memory: declarative, semantic, episodic, procedural, associative
- Self-projection, prospection, and internal simulation
- Prospection, affect, and hedonic experience
- The simulation hypothesis and internal simulation
- Motor, visual, and mental imagery
- Modes of forgetting

Knowledge, Representation, and Reasoning
- Representation and anti-representation
- Weak and strong representation
- Radical constructivism
- The symbol grounding problem
- Joint perceptuo-motor representations
- Sensory-motor theory and Ideo-motor theory
- Acquiring and sharing knowledge

Social Cognition and Interaction Dynamics
- Social interaction
- Reading intentions and theory of mind
- Instrumental helping
- Collaboration
- Joint action, shared intention, and joint attention
- Development and interaction dynamics

Distributed Cognition & Adaptive Ecosystems
- Dynamic self-configuration and coordination of subsystems
- Group cognition
- Social organizations as cognitive architectures
- Cultural factors
- Eco-system dynamics: growth and development

Artificial Intelligence
- Intelligent agents
- Problem solving, search, constraint satisfaction
- Knowledge and reasoning: first order logic, probabilistic reasoning, decision making
- Learning by examples, knowledge, learning probabilistic models
- Natural Language Processing & communication
- Perception
- Robotics

Machine Perception
- Image acquisition, representation, and processing.
- Camera modeling and calibration
- Segmentation: thresholding, edge-, and region-based techniques
- Line and curve detection, Hough transform
- Shape representation and object recognition
- Stereo, motion, and optical flow
- Active vision: overt attention and object tracking
Human and Computational Models of Attention
- Overt and covert attention
- Inhibition of response and habituation
- Pop out, change blindness, and inattentional blindness
- Exogenous and endogenous influences
- Visual search: saccades, scan path patterns, and smooth pursuit
- Prospective control
- Computational models
- The selective routing hypothesis
- The salience map hypothesis
- The temporal tagging hypothesis
- The emergent attention hypothesis

Natural Language Processing
- Regular Expressions and Automata
- N-grams, part-of-speech tagging
- Hidden Markov and maximum entropy models
- Automatic Speech Recognition
- Formal Grammars, Syntactic Parsing, Statistical Parsing
- Computational Lexical Semantics
- Computational Discourse

Industrial, Mobile, and Humanoid Robotics
- Kinematics and dynamics
- Inverse kinematics
- Locomotion
- Mobile robot localization, Kalman filtering
- Planning and navigation
- Grasping
- Bipedal locomotion

Neural Processing
- Artificial neural networks
- Multi-layer perceptrons and back-propagation
- Radial basis functions
- Associative memories
- Adaptive Resonance Theory
- Recurrent networks: Hopfield, Boltzman, Elman and Jordan nets
- Reservoir computing, Echo state networks, Liquid state machines
- Dynamic Field Theory
- Connectionist/symbolic architectures