Concept: SE with AI (Jack Heseltine, concept document)

Content:

- SE note (skills)
- AI curricula and content (core content and theoretical)
- Symbolic Computation course list (long and deep direction)
- note

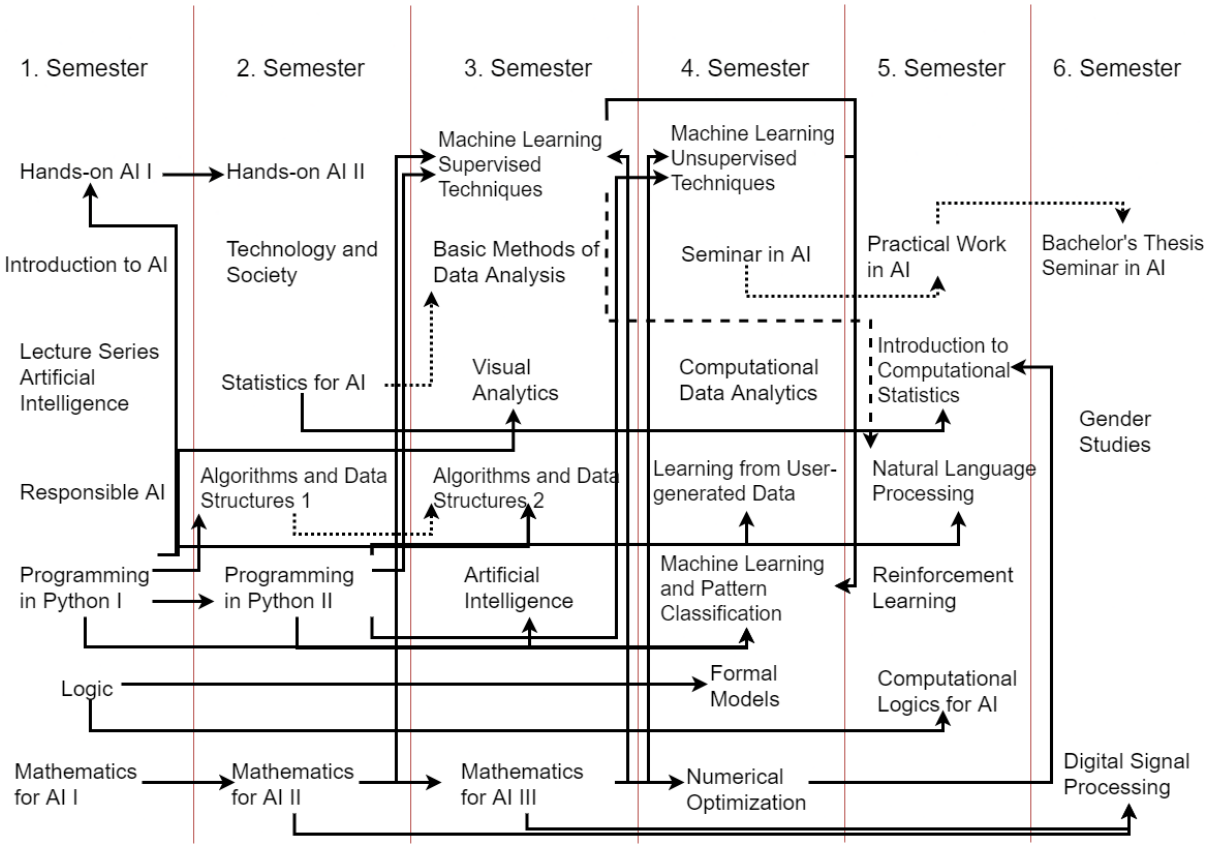
The skills focus (and basis) for this self-designed curriculum in the JKUniverse (Johannes Kepler Universität (JKU) in Linz and Hagenberg Campus, Fachhochschule Upper Austria, possibly in the future: Institute of Digital Sciences Austria) is the Hagenberg Software Engineering (SE) curriculum, see Software Engineering Studies Documentation and Research-Projects/Interests - heseltime with a personal focus of Software for Math (as thesis project), which makes sense especially in this context.

Overlapping or building on SE, at JKU, the AI curriculum to Masters level is:

1st Semester (WS)		2nd Semester (SS)		3rd Semester (WS)		4th Semester (SS)		
Subject/Course	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	
Machine Learning and Perception Computer Vision (4.5 KV) Deep Learning and Neural Nets I (3 VL) Deep Learning and Neural Nets I (1.5 UE) LSTM and Recurrent Neural Nets (3 VL) LSTM and Recurrent Neural Nets (1.5 UE)	13.5	**Machine Learning and Perception** Deep Learning and Neural Nets II (3 VL) Deep Learning and Neural Nets II (1.5 UE) Deep Reinforcement Learning (4.5 KV) Theoretical Concepts of Machine Learning (3 VL) Theoretical Concepts of Machine Learning (1.5 UE)	13.5	**Machine Learning and Perception** Explainable AI (3 KV) Probabilistic Models (3 VL) Probabilistic Models (1.5 UE)	7.5			**34.5**
AI and Society AI and Law I (3 VL) Artificial Intelligence in Society (1.5 KV)	4.5	**AI and Society** AI and Law II (1.5 VL) Robopsychology (3 KV)	4.5	**AI and Society** Communicating AI (1.5 KV)	1.5			**10.5**
				Seminar and Practical Training Seminar in AI (Master) (3 SE) Practical Work in AI (Master) (7.5 PR)	10.5			**10.5**
Elective Track: Reasoning and Knowledge Representation Computer Algebra (3 VL) Computer Algebra (1.5 UE) Model Checking (4.5 KV)	9.0	**Elective Track: Reasoning and Knowledge Representation** Symbolic AI (3 VL) Symbolic AI (1.5 UE)	4.5	**Elective Track: Reasoning and Knowledge Representation** Automated Reasoning (3 VL) Automated Reasoning (1.5 UE)	4.5			**18.0**
Area of Specialization	1.5	**Area of Specialization**	4.5	**Area of Specialization**	3.0			**9.0**
Free Electives	1.5	**Free Electives**	3.0	**Free Electives**	3.0	**Free Electives**	4.5	**12.0**
						Master's Thesis Seminar	3.0	**3.0**
						Master's Examination	1.5	**1.5**
						Master's Thesis	21.0	**21.0**
	30.0		**30.0**		**30.0**		**30.0**	

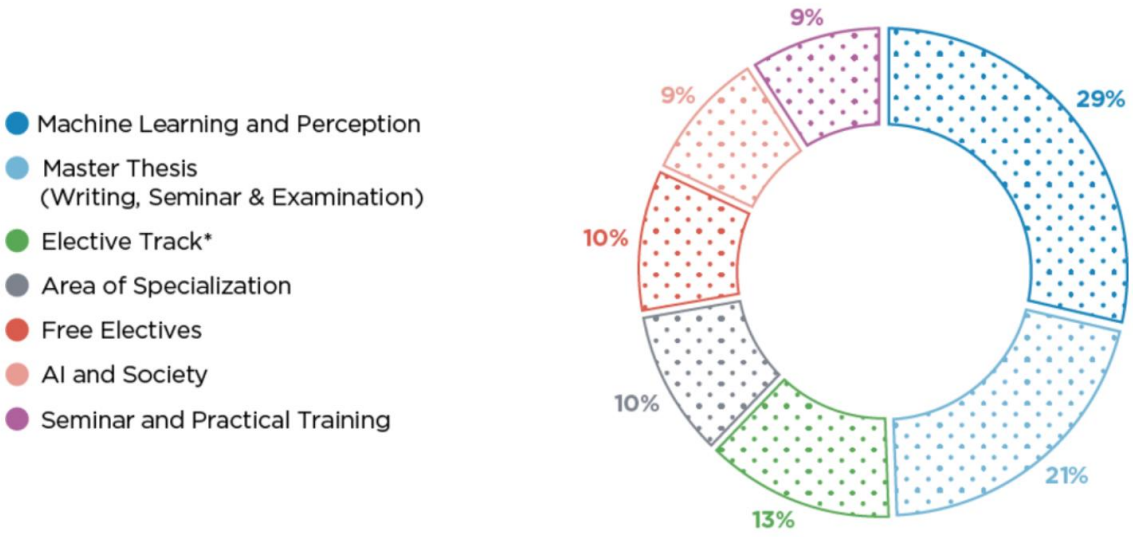
Total ECTS: 120.0

SE should be finished as far as possible to start on this track (symbolic and math version, in terms of JKU tracks). Theoretical and especially math background needs building in the SE phase as well as on an as-needed basis in the Masters:

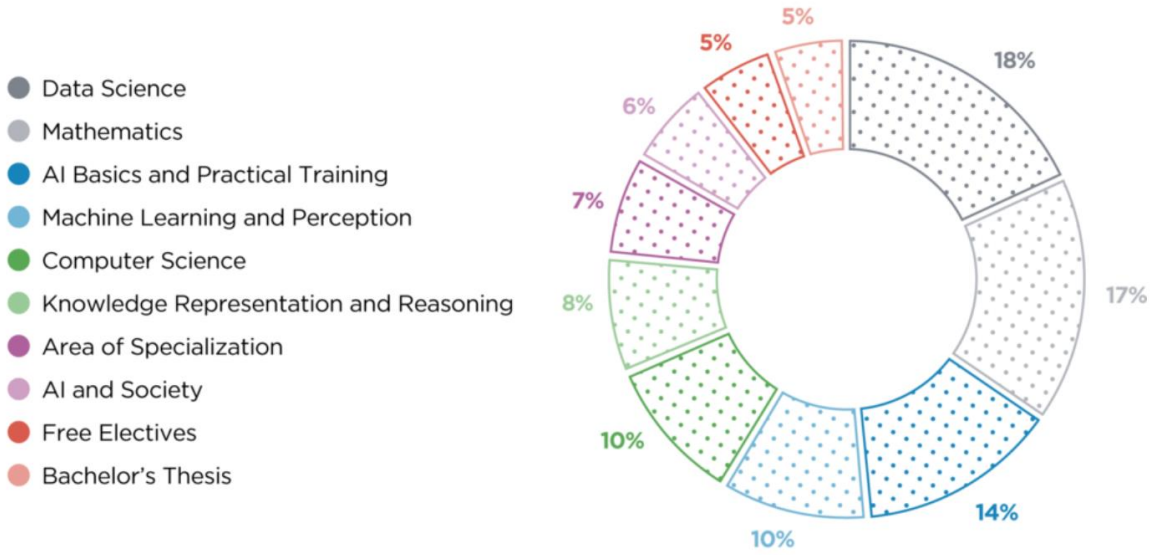


The Masters surely similarly follows a dependency graph, both within itself but also wrt the Bachelor's.

In terms of content, both levels of the JKU degree are distributed as follows.

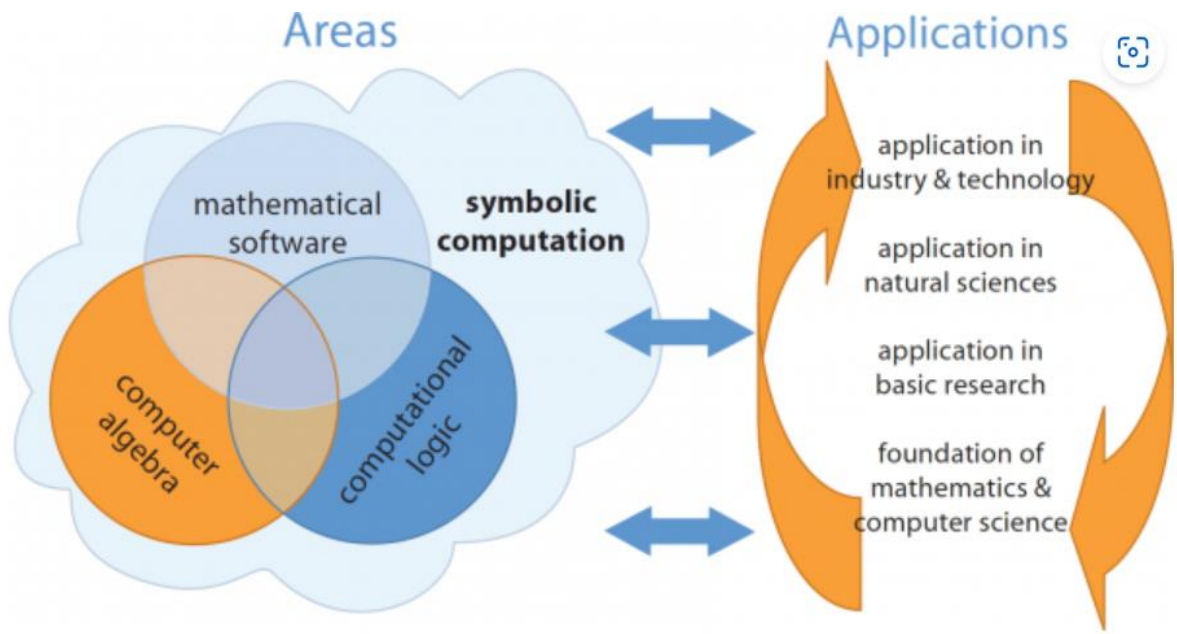


This was the Masters, where the focus is on independent work and the area of specialization – core content in the Bachelors:



For an AI-SE integration, a Masters Thesis that builds on the SE thesis is preferable, where the JKU-track (symbolic/math) should be respected.

The motivation for this studies should lie in the content and its application themselves, but also a view to the following doctoral level studies at RISC (or another institute) but where this institute is certainly notable within the JKUniverse, see the following PhD overview and course list for Symbolic Computation to wrap.



The following is copied from [Studying Symbolic Computation - RISC - Johannes Kepler University (jku.at)] – without course descriptions, my italics.

RISC offers three kinds of courses:

Curriculum Courses

These are the core courses of the curriculum; every Ph.D. student performs course work in the amount of at least 30 ECTS points. The curriculum courses are offered annually or biennially; additionally Special Topics courses with varying content may be offered.

Seminars

In seminars, the RISC faculty discusses the state of the art in research and ongoing project work. In the first year, every Ph.D. student attends (as a listener) several seminars; later the student attends (as an active participant) *at least one seminar per semester.* Seminar topics vary from semester to semester, the ones listed below are just examples.

Standard Courses

These are courses offered by RISC for *bachelor/master* students in mathematics or computer science. They are actually not part of the RISC curriculum *but they may help in exceptional cases to supplement the education of new Ph.D. students*.

According to the general working areas of RISC, the courses are structured into three categories. Short course descriptions are given in the appendix.

Computer **Algebra**

Curriculum Courses

Title

Computer Algebra

Gröbner Bases

Fast Arithmetic and Factorization

Elimination Theory

Commutative Algebra and Algebraic Geometry

Algorithmic Algebraic Geometry

Computer Analysis

Symbolic Linear Algebra

Computer Algebra for Concrete Mathematics

Algorithmic Combinatorics

Symbolic Summation and Special Functions 1

Symbolic Summation and Special Functions 2

Category Theory for Symbolic Computation

Algebraic Methods in Kinematics

Algebraic Topology

Homological Algebra

Special Topics in Computer Algebra

Seminars (Examples)

- Seminar “Computer Algebra”
- Seminar “Algorithmic Algebra”
- Seminar “Algorithmic Combinatorics
- Seminar “Algebraic Geometry”
- Seminar “Symbolic Summation for Particle Physics”
- Seminar “Symbolic Summation and Special Functions”
- Seminar “Fundamentals of Numerical Analysis and Symbolic Computation”

Standard Courses

- Algebra
- Analysis
- Linear Algebra 1 and 2
- Linear Algebra for Physicists 1 and 2
- Linear Algebra and Analytic Combinatorics 1 and 2
- Linear Algebra and Analytic Geometry 1 and 2
- Ordinary Differential Equations and Dynamical Systems 1

- Algebraic and Discrete Methods for Biology
- Preparatory Course Mathematics for Beginners of Business Informatics

Computational **Logic**

Curriculum Courses

Title

Thinking, Speaking, Writing 1+2

Mathematical Logic

Topics in Mathematical Logic

Automated Reasoning

Advanced Automated Reasoning

Computability Theory

Decidability and Complexity Classes

Decidable Logical Theories

Rewriting in Computer Science and Logic

Unification Theory

Gödel's Incompleteness Theorems

Formal Methods in Software Development

Formal Semantics of Programming Languages

Formal Specification of Abstract Datatypes

Formal Models of Parallel a. Distributed Systems

Formal Languages and Formal Grammars 1

Formal Languages and Formal Grammars 2

Fixpoint Theory of Functional Programs

Special Topics in Computational Logic

Seminars (Examples)

- Seminar “Automated Reasoning (Theorema)”
- Seminar “Set Theory and Logical Foundations”
- Seminar “Formal Methods”

Standard Courses

- Logic as a Working Language
- Logic for Computer Science
- Mathematics and Logic
- Computability and Complexity
- Formal Foundations in Business Informatics

Mathematical **Software**

Curriculum Courses

Title

Programming Project Symbolic Computation 1+2

Design and Analysis of Algorithms

Introduction to Parallel and Distributed Computing

Logic Programming

Functional Programming

Programming in Mathematica

Chess Programming

Computer Algebra Systems

Automated Reasoning Systems

Computer-based Working Environments

Special Topics in Mathematical Software

Seminars (Examples)

- Bachelor Seminar “Selected Algorithms in Symbolic Computation”

Standard Courses

- Practical Software Technology
- Software Engineering
- Project Engineering
- Algorithms and Data Structures
- Information Systems
- Computer Systems
- Algorithmic Methods 1

As a personal side, I think this concept and PhD can accommodate varied backgrounds and interests, managing to strike a balance between applied skills and theoretical and math background, with flexibility to allow math content and proving later in one’s studies as well, which actually is of interest to lots of different people coming to this kind of studies.

I think the particular Masters combination allows for taking SE in an AI direction, with enough depth, and to integrate math and symbolic approaches as an application direction in the long and deep run.

Finally, the course, especially at PhD level and once a certain cruising altitude has been reached, might allow for math or computer science/software exchanges or intercalations externally from the JKUniverse/abroad as well (incl. summer schools). Accommodation for the JKUniverse content in Linz/Hagenberg mit make sense, at least some of the time. The distance learning mode for JKU AI studies and the part-time “berufsbgegleitend” mode for SE in Hagenberg are worth mentioning, for further flexibility, to the point of allowing work during studies: Software Engineering work would be the obvious choice.

But of course also: potential long/deep topics? For me: Symbolic/connectionist theme, LLMs in Theorema and similar applications, symbolic verification of LLM output, natural language to theorem to proof. To be determined.