State-of-the-art analysis of the requirements in the field of AAI

Vasyl Martsenyuk (UBB)

FAAI:

The Future is In Applied Artificial Intelligence
WP4 Teacher Training A 4.5,

Podgorica, Montenegro, 15-19.05.2023

(UBB Team)

How do skills and competencies differ?

- **Skills** are the specific learned abilities that you need to perform a given job well. Examples, depending on the specific role, range from handling accounts and coding to welding or writing tenders.

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How do skills and competencies differ?

- There is a distinction, however, to be made between hard skills and soft skills.
- Whereas a **hard skill** is a technical and quantifiable skill that a professional may demonstrate through their specific qualifications and professional experiences, a **soft skill** is a non-technical skill that is less rooted in specific vocations.

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How do skills and competencies differ?

- An **example** of a **hard skill**,
  - then, may be **computer programming** or **proficiency in a foreign language**,
- whereas a **soft skill**
  - may be **time management** or **verbal communication.**

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How do skills and competencies differ?

- **Competencies**, on the other hand, are the person's knowledge and behaviours that lead them to be successful in a job.
- **Examples** of competencies, then, include
  - the **improvement of business processes, strategic planning and data-based decisions**.

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Competence Verbs (ACM/IEEE guide)

Remember – retrieve relevant knowledge from memory				
Define	Duplicate	Find	Identify	Label
List	Locate	Memorize	Name	Recall
Recognize	Retrieve	Select	State	
Understand – construct meaning from instructional messages				
Classify	Convert	Demonstrate	Describe	Differentiate
Discuss	Exemplify	Explain	Infer	Interpret
Paraphrase	Report	Summarize	Translate	
Apply – carry out or use a procedure in a given situation				
Apply	Calculate	Carry out	Diagram	Edit
Execute	Illustrate	Implement	Investigate	Manipulate
Modify	Operate	Perform	Produce	Solve
Use	Write			
Analyse – break material into its constituent parts and determine how the parts relate to one another and to an overall situation				
Analyze	Attribute	Categorize	Compare	Contrast
Decompose	Deconstruct	Deduce	Discriminate	Distinguish
Examine	Integrate	Organize	Outline	Structure
Evaluate – make judgements based on criteria and standards				
Appraise	Argue	Assess	Choose	Critique
Debate	Defend	Estimate	Evaluate	Judge
Support	Test	Value	Verify	
Create – put elements together to form a coherent or functional whole; reorganise elements into a new pattern or structure				
Assemble	Construct	Create	Design	Develop
Devise	Formulate	Hypothesize	Invent	Make
Plan				

Table 3-1 Cognitive Processes and Associated Competence Verbs

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How do skills and competencies differ?

- Competencies effectively explain how an individual's behaviours bring about the desired results in their role.
- As with skills, there are various types of competencies – including core competencies, which are those that any successful employee requires to rise through an organisation.

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How do skills and competencies differ?

- In the words of marketer Aja Davis Isble, "…a core competency is something that is core to you and how you work – so it is something that could potentially set you apart from every other candidate."

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Competency-Based Education

- The **competency-based education** (CBE) approach allows students to advance based on their ability to master a skill or competency at their own pace regardless of environment.
- This method is tailored to meet different learning abilities and can lead to more efficient student outcomes.

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Competency-Based Education

- **Competency-based** or **Outcomes-based**
- Advancement based on mastery of outcomes rather than seat time or credit hours
- Mastery demonstrated through assessments

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Competency-Based Education

- Changing paradigm:
  - Credit hour → **content mastery**
  - Focus on teaching → **focus on learning**
  - Time is constant/learning is variable → **time is variable/learning is constant**
  - **Greater focus on employer input** regarding knowledge, skill, and aptitude (KSA) needs of future employees

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Implementing CBE

- **Identifying outcome competencies** is key – all supporting learning objectives must be identified and sequenced within a program and courses
- **Objectives may be used rather than outcomes** – usually require demonstration of more discrete skills or knowledge

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Implementing CBE

- Identify and **reduce or eliminate ineffective structures, practices, and expectations** that may have been historically justified but are now impeding the efficiency of student learning
  - Minimum hours & unit requirements
  - Minimum internship/externship hours requirements
  - Required skills practice regardless of current competence

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Implementing CBE

- Design classroom and lab experiences with preassessment opportunities
  - Based on outcomes or objectives, determine the appropriate assessment(s) and level of mastery
  - Pre-assessments may be the same as post-assessment, or the two may vary for greater demands on students
  - Pre-assessments may be integrated into early classroom activities or assignments rather than formalized as separate assessment opportunities

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Implementing CBE (continued)

- Design classroom and lab experiences with preassessment opportunities
  - Instruction based on students learning, rather than faculty teaching.
  - Establish achievement benchmarks
  - Establish program exit criteria

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Why CBE and why now?

- For-credit CBE programs are a needed addition to our instructional portfolio
- CBE will help us meet our goals (Vision for Success)
- CBE is an economic mobility lever
- Career preparation is essential to the future of our state and our system
- CBE can flex with changing technologies, employer demands, and unexpected societal shifts

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The Equity Imperative

- We have made substantial progress toward our goals, but gaps remain
- Noncredit serves a high number of students that are disproportionately impacted (DI)
- CBE for-credit opportunities will enhance student outcomes
- Giving students access to significant wage gains with a degree

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CBE Focuses on Mastery of Competencies

- Credit Hour Model… based on seat time originally designed to determine faculty pensions and not as a measure of learning.
- Credit Hour is current basis for awarding financial aid, faculty workload & degree completion.

- Competency Based Education… moves beyond seat-time focusing on mastery of competencies, through learning activities and experiences that align with clearly defined programmatic outcomes.
- Hours will vary, but the learning is fixed.
- Often fully online modules.
- Flexible academic calendar term options.

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Competency-based education is and is not….

CBE is…	CBE is not…
Time is variable with program offered in a flexible, self-paced approach	Learner works at course-set pace with predetermined schedule of assignments, activities, etc. with true beginning and end dates
Learning is fixed requiring demonstration of mastery of each competency	Learning varies with passing course grade (i.e., A, B, C, D)
Determined by rigorous summative authentic assessment focused on meeting core outcomes and competencies	Student evaluation varies based on accumulation of activities, exams, projects, discussion, attendance, etc.
Student learning supported by faculty and staff throughout learning journey	Independent study (i.e., students learn on their own and then take final exam)
Completion of program is based on mastery of intentionally designed scaffold of all competencies	Achievement of credential is based on passing grades and credit-hours (i.e., 60 credit hours=AA/AS)

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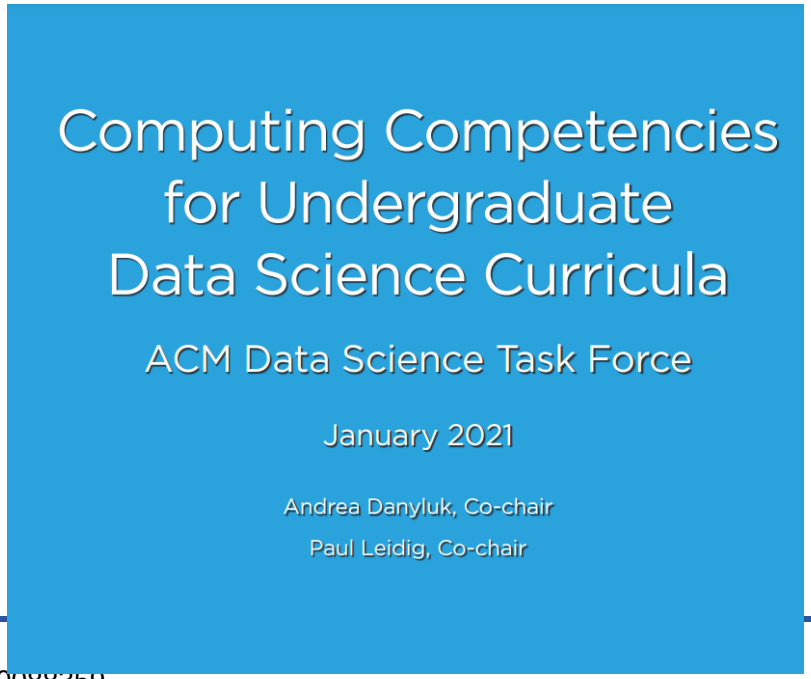
Computing Competencies for Undergraduate Data Science Curricula ACM Data Science Task Force January 2021

- https://www.acm.org/binaries/content/assets/education/curricula-recommendations/dstf_ccdsc2021.pdf



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ACM/IEEE Data Science Competencies

- Artificial Intelligence (p.51)

Scope	Competencies
• Major subfields of AI • Representation and reasoning • Planning and problem solving • Ethical considerations	• Describe major areas of AI as well as contexts in which AI methods may be applied. • Represent information in a logic formalism and apply relevant reasoning methods. • Represent information in a probabilistic formalism and apply relevant reasoning methods. • Be aware of the wide range of ethical considerations around AI systems, as well as mechanisms to mitigate problems.
Sub-domains	

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ACM/IEEE Data Science Competencies

- AI subdomains

AI-General – T1, T2 AI-Knowledge Representation and Reasoning (Logic-based models) – T2, E AI-Knowledge Representation and Reasoning (Probability-based models) – T1, T2, E	AI-Planning and Search Strategies – T2, E

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Subdomain „AI-General”

Knowledge

T1:

- History of AI
- Reality of AI (what it is, what it does) versus perception
- Major subfields of AI: knowledge representation, logical and probabilistic reasoning, planning, perception, natural language processing, learning, robotics (both physical and virtual)

Skills

T1:

- Explain how the origins of AI have led to the current status of AI
- Describe major branches of AI in order to recognize useful concepts and methods when needed in Data Science

T2:

- State *what* AI systems are and that they both collect and use data to implement AI as well as collect and generate data that can be used by data scientists.
- Describe qualitatively *how* robots (physical or virtual), agents, and multi-agent systems collect and use data to embed, deliver, or implement artificial intelligence.
- Describe data collected and produced by AI systems that can be useful for data science applications.

Dispositions

T1:

- Astute to, and respectful of, the fact that AI is not a new field, but rather one with a long and rich history.

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ACM/IEEE Data Science Competencies

- Machine Learning (p.94)

Scope	Competencies
• Broad categories of machine learning approaches (e.g., supervised and unsupervised). • Algorithms and tools (i.e., implementations of those algorithms) for machine learning. • Machine Learning as a set of principled algorithms (e.g., optimization algorithms), rather than as a "bag of tricks." • Challenges (e.g., overfitting) and techniques for approaching those challenges. • Performance metrics. • Training and testing methodology. • Algorithmic and data bias, integrity of data, and professional responsibility for fielding learned models.	• Recognize the breadth and utility of machine learning methods • Compare and contrast machine learning methods • Select appropriate (classes of) machine learning methods for specific problems. • Use appropriate training and testing methodologies when deploying machine learning algorithms. • Explain methods to mitigate the effects of overfitting and curse of dimensionality in the context of machine learning algorithms. • Identify an appropriate performance metric for evaluating machine learning algorithms/tools for a given problem. • Recognize problems related to algorithmic and data bias, as well as privacy and integrity of data. • Debate the possible effects -- both positive and negative -- of decisions arising from machine learning conclusions.

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ACM/IEEE Data Science Competencies

- ML Subdomains

Sub-domains	
ML-General – T1, T2, E ML-Supervised Learning – T1, T2, E ML-Unsupervised Learning – T1, T2, E ML-Mixed Methods – E ML-Deep Learning – T1, T2, E	Note that Reinforcement Learning appears in AI-Knowledge Representation and Reasoning (Probability-based Models)

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State-of-the-art analysis of the requirements in the field of AAI

- Methodology:
  - System analysis
  - Decision making
  - Coping with uncertainties

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Studies based on WP2

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Study of Competencies

- Research 2: job market
- Research 4: academics
- Research 5: students
- Research 6: emploters

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Competencies on AI and ML from ACM/IEEE standards

- C1. Describe major areas of AI as well as contexts in which AI methods may be applied.
- C2. Represent information in a logic formalism and apply relevant reasoning methods.
- C3. Represent information in a probabilistic formalism and apply relevant reasoning methods.
- C4. Be aware of the wide range of ethical considerations around AI systems, as well as mechanisms to mitigate problems.
- C5. Recognize the breadth and utility of machine learning methods.
- C6. Compare and contrast machine learning methods.
- C7. Select appropriate (classes of) machine learning methods for specific problems.
- C8. Use appropriate training and testing methodologies when deploying machine learning algorithms.
- C9. Explain methods to mitigate the effects of overfitting and curse of dimensionality in the context of machine learning algorithms.
- C10. Identify an appropriate performance metric for evaluating machine learning algorithms/tools for a given problem.
- C11. Recognize problems related to algorithmic and data bias, as well as privacy and integrity of data.
- C12. Debate the possible effects -- both positive and negative -- of decisions arising from machine learning conclusions.

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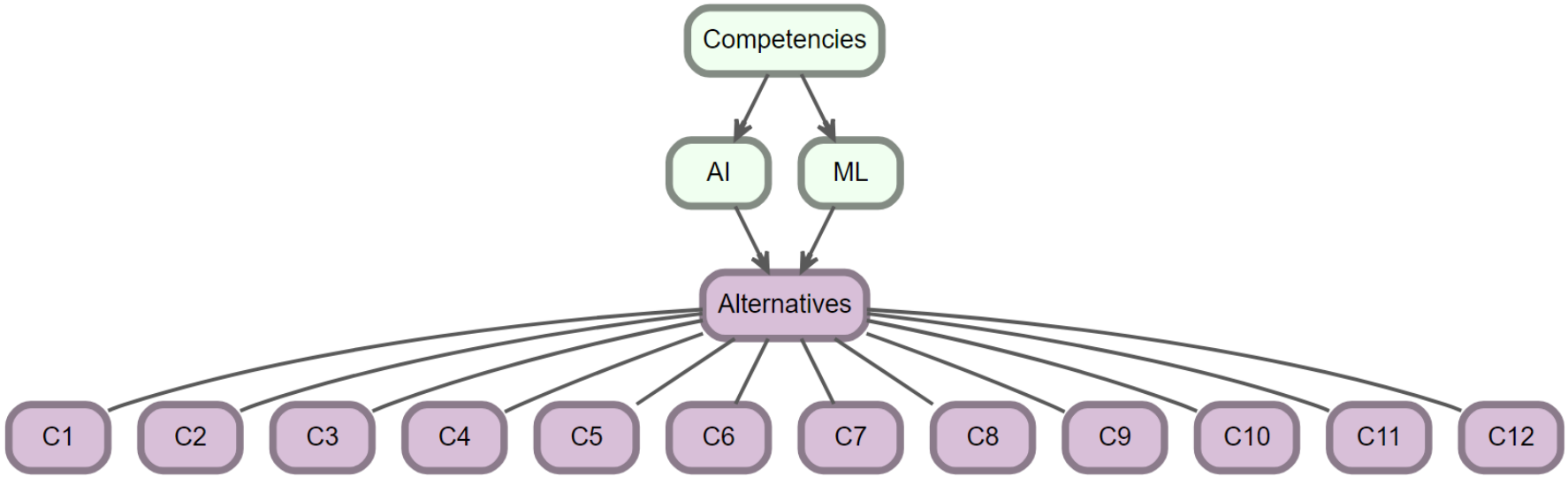
AHP Method for AI+ML competencies



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Decision makers:

- Job market
- Academics
- Students
- Employers

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Decision-makers:

- #optional node, needed only if not all decision-makers have equal voting power
- - Job market: 0.3
- - Academics: 0.2
- - Students: 0.2
- - Employers: 0.3

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Preferences:

- Job market: pairwise:
- - [AI, ML, 1/5]
- Academics: pairwise:
- - [AI, ML, 1]
- Students: pairwise:
- - [AI, ML, 1/3]
- Employers: pairwise:
- - [AI, ML, 1/5]

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AHP Priority Calculation Method: (eigenvalues, total contribution, all DM)

	Weight	C7	C6	C5	C8	C10	C11	C9	C12	C1	C2	C3	C4	Inconsistency
Competencies	100.0%	10.2%	10.0%	9.7%	9.6%	9.6%	9.5%	8.7%	8.3%	6.4%	6.2%	6.1%	5.7%	0.0%
ML	75.0%	9.3%	9.1%	8.7%	8.7%	8.7%	8.6%	7.8%	7.3%	1.7%	1.7%	1.7%	1.7%	0.6%
AI	25.0%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	4.7%	4.6%	4.4%	4.0%	0.0%

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AHP Priority Calculation Method: (eigenvalues, total contribution, DM=job market)

	Weight	C7	C6	C5	C8	C10	C11	C9	C12	C1	C2	C3	C4	Inconsistency
Competencies	100.0%	12.7%	11.5%	10.5%	10.5%	10.2%	9.1%	8.4%	8.0%	5.1%	5.1%	4.6%	4.2%	0.0%
ML	83.3%	12.0%	10.9%	9.9%	9.9%	9.6%	8.5%	7.7%	7.3%	1.9%	1.9%	1.9%	1.9%	0.6%
AI	16.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	3.2%	3.3%	2.7%	2.4%	0.0%

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AHP Priority Calculation Method: (eigenvalues, total contribution, DM=Academics)

	Weight	C7	C6	C5	C8	C10	C11	C9	C12	C1	C2	C3	C4	Inconsistency
Competencies	100.0%	7.6%	7.6%	7.6%	7.6%	7.4%	7.4%	7.3%	7.2%	10.4%	10.0%	10.0%	9.9%	0.0%
AI	50.0%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	9.2%	8.8%	8.9%	8.8%	0.0%
ML	50.0%	5.9%	5.8%	5.8%	5.8%	5.6%	5.6%	5.5%	5.4%	1.1%	1.1%	1.1%	1.1%	0.0%

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AHP Priority Calculation Method: (eigenvalues, total contribution, DM=Students)

	Weight	C7	C6	C5	C8	C10	C11	C9	C12	C1	C2	C3	C4	Inconsistency
Competencies	100.0%	9.5%	9.4%	9.5%	9.6%	9.4%	9.5%	9.1%	9.3%	6.2%	6.2%	6.1%	6.2%	0.0%
ML	75.0%	8.6%	8.5%	8.6%	8.7%	8.5%	8.6%	8.2%	8.4%	1.7%	1.7%	1.7%	1.7%	0.0%
AI	25.0%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	4.5%	4.5%	4.4%	4.5%	0.0%

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AHP Priority Calculation Method: (eigenvalues, total contribution, DM=Employers)

	Weight	C7	C6	C5	C8	C10	C11	C9	C12	C1	C2	C3	C4	Inconsistency
Competencies	100.0%	10.1%	10.6%	10.3%	10.1%	10.6%	11.3%	9.5%	8.3%	5.1%	4.8%	5.0%	4.4%	0.0%
ML	83.3%	9.4%	10.0%	9.7%	9.4%	10.0%	10.7%	8.9%	7.6%	1.9%	1.9%	1.9%	1.9%	0.2%
AI	16.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	3.3%	2.9%	3.1%	2.5%	0.0%

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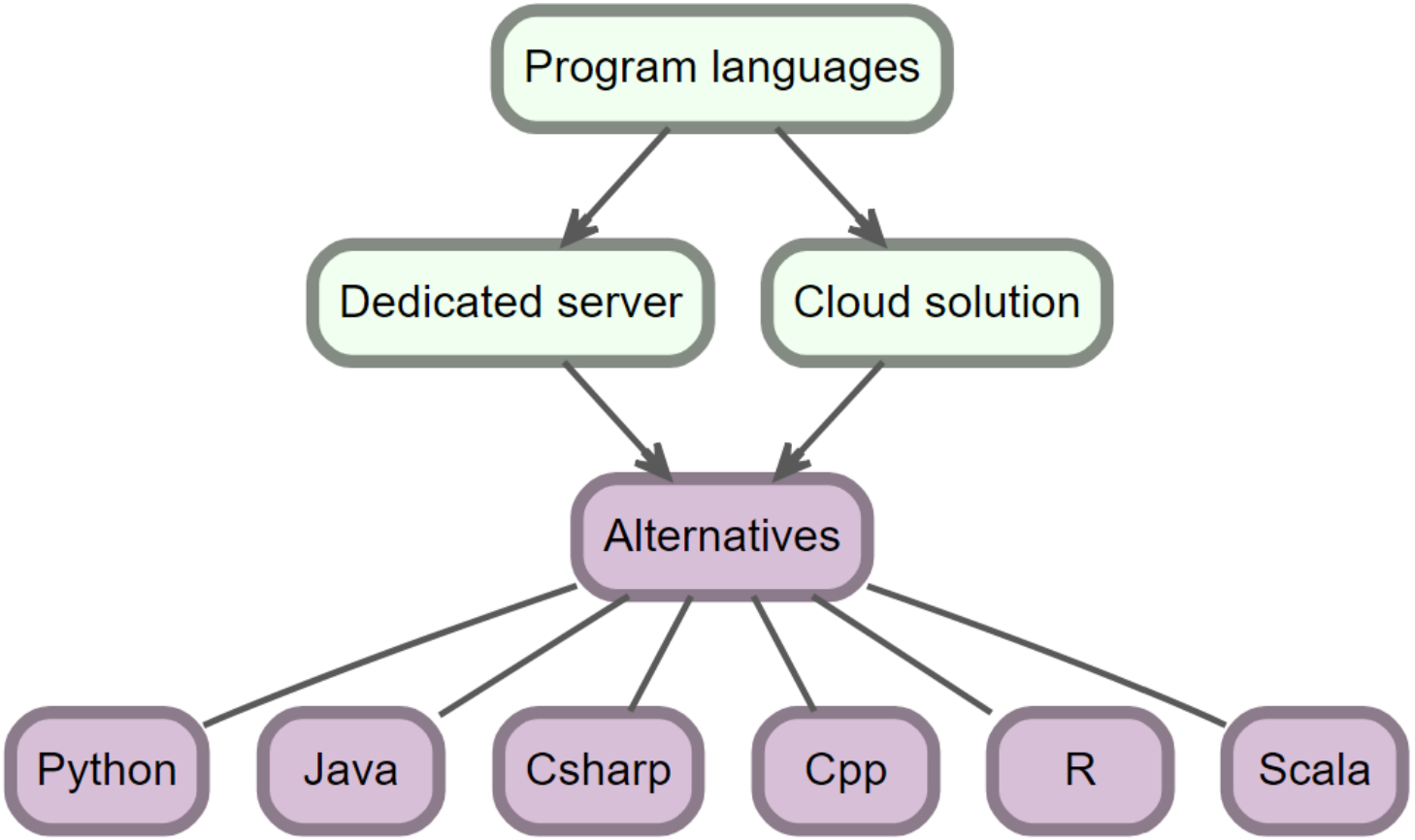
Programming languages relative to dedicated server and cloud solution



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Programming languages relative to dedicated server and cloud solution

- Job Market

	Weight	Python	Java	Csharp	Cpp	R	Scala	Inconsistency
Program languages	100.0%	44.5%	12.0%	14.2%	10.5%	11.3%	7.4%	0.0%
Dedicated server	50.0%	20.7%	4.4%	5.2%	8.0%	8.8%	2.8%	0.6%
Cloud solution	50.0%	23.8%	7.6%	9.0%	2.5%	2.5%	4.6%	4.4%

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Programming languages relative to dedicated server and cloud solution

- Employers

	Weight	Python	Java	Csharp	Cpp	R	Scala	Inconsistency
Program languages	100.0%	34.7%	21.8%	16.1%	12.0%	10.8%	4.5%	0.0%
Dedicated server	50.0%	15.8%	8.9%	5.9%	9.4%	8.1%	1.9%	1.7%
Cloud solution	50.0%	18.9%	12.9%	10.2%	2.6%	2.6%	2.6%	2.9%

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Programming languages relative to dedicated server and cloud solution

- Good Practice

	Weight	Python	Java	Csharp	Cpp	R	Scala	Inconsistency
Program languages	100.0%	42.3%	21.0%	4.8%	10.8%	7.6%	13.5%	0.0%
Cloud solution	54.5%	23.6%	13.2%	3.0%	3.0%	3.0%	8.9%	4.0%
Dedicated server	45.5%	18.7%	7.8%	1.8%	7.8%	4.7%	4.7%	2.8%

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Programming languages relative to dedicated server and cloud solution

- total

	Weight	Python	Java	Csharp	Cpp	R	Scala	Inconsistency
Program languages	100.0%	40.7%	18.6%	11.1%	11.1%	9.6%	9.0%	0.0%
Cloud solution	51.8%	22.2%	11.4%	7.1%	2.7%	2.7%	5.6%	4.4%
Dedicated server	48.2%	18.5%	7.2%	4.0%	8.3%	6.9%	3.3%	2.8%

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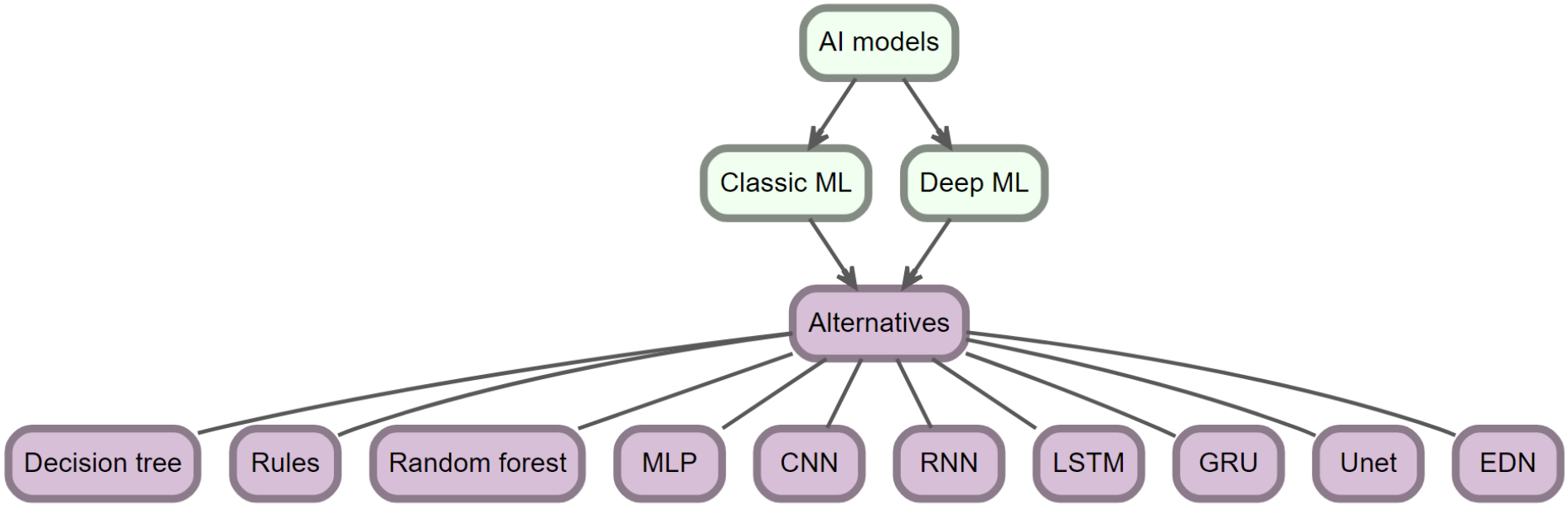
Artificial Intelligence models within the framework of Classic ML and Deep ML



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Artificial Intelligence models within the framework of Classic ML and Deep ML

- Job market

	Weight	CNN	RNN	MLP	Decision tree	Random forest	Rules	EDN	Unet	LSTM	GRU	Inconsistency
AI models	100.0%	13.9%	12.7%	13.4%	12.1%	11.0%	12.5%	8.1%	7.0%	4.4%	5.0%	0.0%
Classic ML	54.8%	2.1%	2.1%	11.7%	10.4%	9.3%	10.8%	2.1%	2.1%	2.1%	2.1%	0.3%
Deep ML	45.2%	11.8%	10.6%	1.7%	1.7%	1.7%	1.7%	6.0%	4.9%	2.3%	2.9%	1.2%

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Artificial Intelligence models within the framework of Classic ML and Deep ML

- Employers

	Weight	CNN	RNN	MLP	Decision tree	Random forest	Rules	EDN	Unet	LSTM	GRU	Inconsistency
AI models	100.0%	13.1%	10.5%	11.3%	11.7%	10.2%	11.3%	9.2%	7.1%	8.7%	7.1%	0.0%
Classic ML	50.0%	1.9%	1.9%	9.8%	10.2%	8.7%	9.8%	1.9%	1.9%	1.9%	1.9%	0.2%
Deep ML	50.0%	11.2%	8.6%	1.5%	1.5%	1.5%	1.5%	7.3%	5.2%	6.8%	5.2%	1.4%

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Artificial Intelligence models within the framework of Classic ML and Deep ML

- Good Practice

	Weight	CNN	RNN	MLP	Decision tree	Random forest	Rules	EDN	Unet	LSTM	GRU	Inconsistency
AI models	100.0%	26.7%	17.2%	9.5%	9.5%	9.5%	5.5%	5.5%	5.5%	5.5%	5.5%	0.0%
Deep ML	77.8%	25.7%	16.2%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	0.6%
Classic ML	22.2%	1.0%	1.0%	5.1%	5.1%	5.1%	1.0%	1.0%	1.0%	1.0%	1.0%	0.0%

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Artificial Intelligence models within the framework of Classic ML and Deep ML

- Total

	Weight	CNN	RNN	MLP	Decision tree	Random forest	Rules	EDN	Unet	LSTM	GRU	Inconsistency
AI models	100.0%	18.2%	13.9%	11.2%	11.0%	10.4%	8.1%	8.0%	6.8%	6.4%	6.0%	0.0%
Deep ML	59.7%	16.6%	12.2%	2.6%	2.6%	2.6%	2.6%	6.3%	5.2%	4.7%	4.4%	1.4%
Classic ML	40.3%	1.7%	1.7%	8.6%	8.4%	7.8%	5.5%	1.7%	1.7%	1.7%	1.7%	0.3%

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Thank you for attention!

Question??

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