Professorship for Computer Science Education

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

FACULTY OF ENGINEERING

Designing a Teacher PD Programme for AI – First Steps

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Research Questions

1. Which central concepts and topics of AI should be introduced in a professional development (PD) measure for teachers about artificial intelligence?
2. Which format should be used for an extensive PD programme?
3. Which aspects of the teachers' pedagogical content knowledge (PCK) need to be developed further in a PD measure to successfully teach AI?

Overall goal: AI Literacy and AI-teaching competency for CS teachers

Course Development Process

Content Analysis

- Russell/ Norvig: AIMA 3
- Görz et al.: Handbuch der Künstlichen Intelligenz
- ACM Classification System (Areas: Artificial Intelligence & Machine Learning)
- ACM/ IEEE Computer Science Curricula 2013 (Area: Intelligent Systems)
- ACM Taskforce Data Science Curriculum 2021 (Area: Artificial Intelligence & Machine Learning)
- AI4K12: Big Ideas of AI
- Long/ Magerko 2020: What is AI Literacy?

Content Framework

Introduction
- Definitions of AI
- Topics, paradigms and typical problems of AI
- History
- Definitions of intelligence
- AI Education, student pre-concepts

GOFAI
- Search: informed vs uninformed, heuristics, local search, constraint satisfaction problems, adversarial search
- Knowledge Representation: problem representation, logic, expert systems, logical programming, vagueness & insecurity, reasoning mechanisms
- Planning

Machine Learning
- Paradigms: supervised, unsupervised & reinforcement learning
- Typical tasks of ML: classification, regression, clustering, dimensionality reduction
- Training & test, performance evaluation
- ML-algorithms & methods: decision tree learning, neural networks etc.
- Connection to Data Science

Applications of AI
- NLP: information extraction, text classification, machine translation, voice recognition
- Perception/ Computer Vision: representation of perception, recognition tasks, pattern recognition
- Robotics: sensor data, movement, multi-agents

Ethics and Society
- Can machines think?: Turing test, Chinese Room
- Strong vs Narrow AI
- Explainability, socially acceptable AI, questions of responsibility
- Bias
- Chances, limits & risks of AI
- Human role in AI
- Future developments

Teachers are able to…

Introduction	GOFAI (Good old-fashioned AI)	Machine Learning	Applications of AI	Ethics and Society
• recognise applications that are using AI. • define AI and describe sub-fields, paradigms and the interdisciplinary nature of the topic. • describe the issue of defining natural intelligence and what that means for AI. • name key milestones in AI history. • identify central characteristics and challenges of AI problems.	**Search** • describe the difference between informed and uninformed search methods focusing on heuristics (cost vs benefit) and the problem of combinatorial explosion. • implement selected informed and uninformed search algorithms. • describe the functioning of local search algorithms. • compare common search problems with adversarial search and explain how a respective algorithm, e.g. Minimax, works. • implement constraint satisfaction problems using backtracking. **Knowledge Representation** • formulate a suitable problem representation for a search problem (start/goal state, operators, etc.). • describe general possibilities for digitally representing complex real-life contexts and how these can be used for reasoning and decision-making processes. • explain how an expert system works. • translate natural language statements into logic. • implement a closed set of facts using logic programming, e.g. in PROLOG. • discuss the limitations and problems of logic representation. • reason with probabilities based on a real-world problem, e.g. using Bayes' theorem. • describe and compare different approaches to reasoning. **Planning** • describe the difference between a planning system and classical search strategies. • explain how forward & backward search work. • implement a simple planning algorithm, e.g. a simple version of STRIPS.	• define machine learning and distinguish it from classical approaches to AI (GOFAI). • describe central paradigms of machine learning and explain the differences between them. • identify different types of tasks in machine learning, describe examples of applications of these (e.g. their input features, output, goals) and the limitations of machine learning. • explain the core steps of machine learning (training, testing, evaluation, etc.) and the importance of data and its responsible use (including potential problems, e.g. overfitting, bias). • explain how different machine learning methods work (e.g. decision trees, neural networks, Bayes' classifier, GAN) and analyse their strengths and weaknesses in concrete application situations. • implement specific machine learning algorithms from different paradigms (e.g. linear regression/ classification, k-means, Q-learning, etc.). • explain exemplary mathematical and statistical backgrounds of machine learning (e.g. of neural networks).	• describe the properties of an intelligent agent and possible realizations, highlighting the aspect of programmability. • explain the importance of speech and vision recognition (perceptual abilities) in AI and describe key applications that implement these aspects (e.g. face recognition, speech recognition, preferably by example). • explain concrete techniques AI systems can use to perceive and interpret the world (e.g. sensors & sensor data, CNNs, text classification algorithms). • identify the challenges of processing and extracting information from natural language (e.g. meaning, dialect, background noise). • implement a procedure for feature extraction in images and use it in a classification algorithm. • explain the use of AI in robotic systems and how these applications differ from robotics without AI (e.g. learning, interaction with the environment). • describe an approach to coordinating the actions and perceptions of different robots.	• explain the difference between strong and weak AI and give examples of the two concepts. • evaluate opportunities and risks of AI, identify strengths and limitations. • analyze the development of AI and assess the probability of possible future scenarios. • describe thought experiments such as the Chinese Room or the Turing Test and thus shed light on the question of whether machines can think. • explain aspects necessary for socially acceptable, ethical AI (e.g. explainability, transparency, trustworthiness) and potential implementation options. • identify sources of bias and discuss how to avoid it. • define the role of humans in the process of developing and using AI systems.

PCK

- identify student pre-concepts about AI and align their teaching to them.
- appropriately select AI contexts and applications for class based on the students' identity, values and social backgrounds.
- describe different perspectives on AI (application/ social/ technical orientation) and address them in class.
- create AI activities encouraging students to participate.
- use different approaches and tools to teach AI based on their appropriateness for the students.

Drafting of Learning Objectives

Course Structure & Material Development

- clarification of organizational conditions
- search for and development of appropriate material
- didactic preparation and reflection

(in progress)

AI-PD Prototype Course

Pilot / 1st Iteration

- Day 1: Introduction (90 min), GOFAI (270 min)
- Online component
- Day 2: Machine Learning (360 min)
- Online component
- Day 3: Applications of AI (180 min), Ethics and Society (180 min)

Evaluation

- Pre-/Post-Survey of each day: PCK, content knowledge, self-efficacy
- Validation of Learning Objectives

Enhancement according to Design-Based Research

Adjustment of Learning Objectives

Adaptions of PD format and material

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