

MAI4CAREU

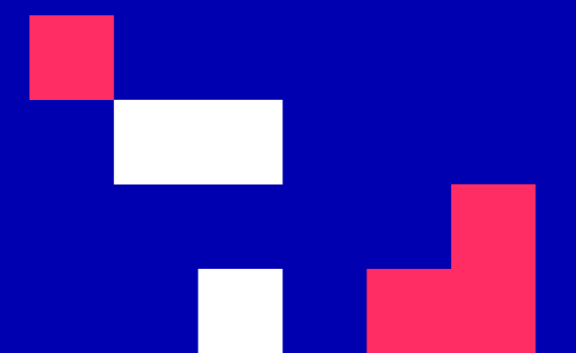
Master programmes in Artificial
Intelligence 4 Careers in Europe

University of Cyprus

MAI613: Research Methodologies and Professional Practices in AI

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Introductions



Course Objectives

- Introduce students to the methods and tools of Artificial Intelligence research, professional practices, and associated technological culture, bearing in mind EC's regulatory framework.
- Familiarization with reading academic papers
- Familiarization with reviewing and presenting of relevant literature
- Familiarization of technical writing and literature surveying

Course Content

- Introduction to the academic research methods and practices
 - Introduction to research and main AI research areas (Week 1)
 - Practical issues of writing academic papers (Week 2)
 - How to give a good talk (Week 4)
 - Introduction to European Commission's regulatory framework for the development of secure, trustworthy and ethical AI. (Week 5)
- 5-6 Seminars from invited researchers/industrialists/entrepreneurs pursuing research/applications in AI (Week 2, 6 – 10)
- Literature review paper. Group presentations of technical study (Week 11 – 13)

Bibliography

- Course's power point slides
- Academic papers
- Course's website

Course Evaluation

- Attendance of the introductory lectures, seminars and final group presentations
- Short summary for one of the invited speakers' seminars (1- 1.5 pages)
 - Research idea
 - Methodology
 - Discussion of results and conclusions
- Group report and presentation of critical review of academic papers on a chosen topic on a particular AI research area.
 - Groups will consist of 2-3 persons
 - Teams will be formed by the course's instructor after completing a Google form
 - Each group should decide a specific research topic, review relevant academic papers and prepare a literature review report (survey) including a critical discussion.

Course Evaluation

Group Literature Review Assignment

- Literature review report (State-of-the-art summary and discussion)
 - Article length: @ 10-15 double-spaced pages in a 12-point font
 - The group should search and collect ~30 related articles on their topic
 - Prepare a report to summarize the main findings of these articles to describe the “start of the art” concerning your topic.
 - The report can be written either in Latex or Word. Examples of templates will be uploaded in Moodle.
- Peer-review of draft reports
 - Each student will be allocated one report to peer-review
 - The final report will be submitted on 01/12 along with the responses to the reviews.
- Group presentation
 - The reports will be presented on Week 11 -13 (16/11, 23/11, 30/11)
 - 25 minutes presentation, ~10 minutes questions/discussion

Course Evaluation

- Attendance 5%
- Individual reports - Summary of one seminar – 15%
- Group research report – Part B, C, F – 40%
 - Individual peer-review – Part D – 20%
 - Group presentation (Part E) – 20%
- Final grade of the course: Pass ($\geq 5/10$) /Fail ($< 5/10$)

Introduction to the course

Research Seminars

- Research seminars related to AI topics from invited speakers from universities in Cyprus, research centres or from industry.
- Each seminar will present a research problem/question in a research topic relevant to AI based on the speaker's research interests.
- The speaker will present their methodology and analysis of solving this problem/answering the question and their results or even any products coming out.
- Some seminars will be based on a single research paper and some others will be more general (but not too technical).
- The research papers will be uploaded in the Moodle before the talk.

Introduction to Research

- Research is not:
 - Information gathering:
 - Gathering information from resources such books or magazines isn't research.
 - No contribution to new knowledge.
 - Transportation of facts:
 - Transporting facts from one resource to another doesn't constitute research.
 - No contribution to new knowledge although this might make existing knowledge more accessible.

Introduction to Research

- Research is:

“...the systematic process of collecting and analyzing information (data) in order to increase our understanding of the phenomenon about which we are concerned or interested.”

Types of Research

- Theoretical
 - It involves the proposition of new theoretical notions, axioms, lemmas, or methods that reside on a higher level of abstraction and generality (theoretical computer science)
- Applied
 - It targets the practical field of research by applying the theory on existing industry problems (e.g. medical informatics – telemedicine)

Research Characteristics

- Research begins with a question in the mind of the researcher
- Requires a plan
- Demands a clear statement of the problem
- Guided by specific problem, question, or hypothesis
- Accepts certain critical assumptions
- Requires collection and interpretation of data
- It is circular

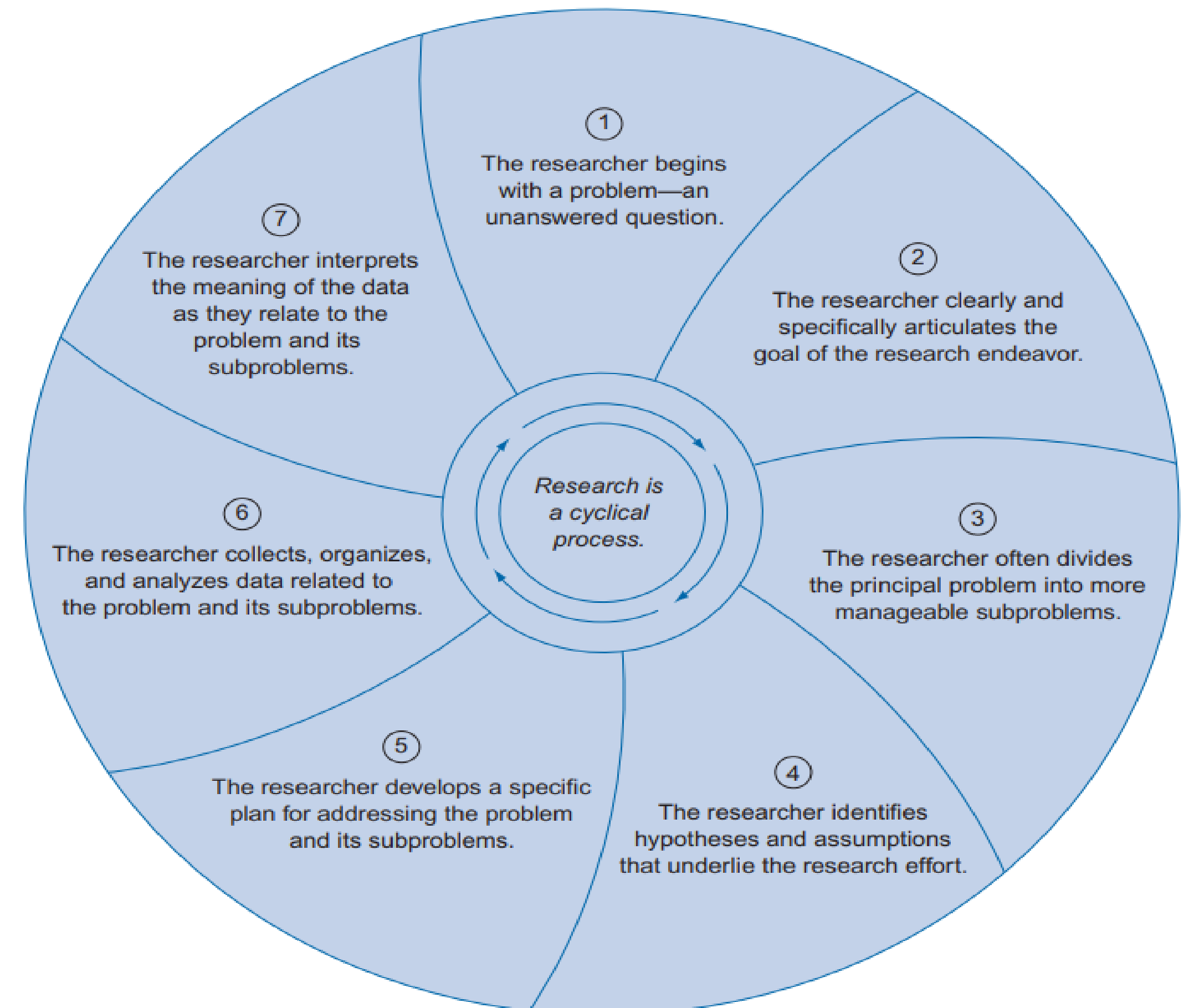
Research Projects

- Research begins with a problem
- This problem need not be Earth-shaking
- Identifying this problem can be the hardest part of research
- In general, good research projects should:
 - Address an important question
 - Advance knowledge

Introduction to Research

Research Cycle

- In general, research involves seven distinct steps, as shown in the next figure.



Sources of Research Problems

- Observation.
- Literature reviews.
- Professional conferences/journals.
- Experts.

Stating the Research Problem

- Once you've identified a research problem:
 - State that problem clearly and completely.
 - Determine the feasibility of the research.
- Identify subproblems:
 - Completely researchable units.
 - Small in number.
 - Add up to the total problem.
 - Must be clearly tied to the interpretation of the data.

Research Skills

- Critical thinking
- Literature searching, summarizing
- Critical reading, evaluation of relevance and value
- Identification of research question and hypotheses
- Recognizing similarities and differences
- Presenting logical and coherent outcome
- Presentation skills – both written and verbal

Literature Review

- Summary and comparative analysis of state of the art related to the research problem
- A literature review is a necessity.
 - Without this step, you won't know if your problem has been solved or what related research is already underway.
- When performing the review:
 - Start searching professional journals.
 - Begin with the most recent articles you can find.
 - Keep track of relevant articles in a bibliography.
 - Don't be discouraged if work on the topic is already underway.

Literature Review Pitfalls

- Be very careful to check your sources when doing your literature review.
- Many trade magazines are not peer reviewed.
 - Professional conferences and journals often have each article reviewed by multiple people before it is even recommended for publication.
 - The IEEE and ACM digital libraries are good places to start looking for legitimate research.

Literature Review Pitfalls

- The Internet can be a good source of information. It is also full of pseudo-science and poor research.
- Make sure you verify the claims of any documentation that has not been peer reviewed by other professionals in the computing industry.

Types of Methodologies

- Methodologies are high-level approaches to conducting research.
- The individual steps within the methodology might vary based on the research being performed.
- Two commonly used research methodologies:
 - Quantitative
 - Qualitative

Methodologies Comparison

Quantitative

- Explanation, prediction
- Test theories
- Known variables
- Large sample
- Standardized instruments
- Deductive

Qualitative

- Explanation, description
- Build theories
- Unknown variables
- Small sample
- Observations, interviews
- Inductive

Research in AI

What is AI?

- “Any set of computer programs able to mimic or even surpass human intelligence”, *Karim Lekadir*
- Systems learning from data
 - Big data
 - Machine learning methods
 - Self-learning
- “AI should be a tool for people and be a force for good in society with the ultimate aim of increasing human well-being”, *European Commission (COM (2021) 206 final)*

Research in AI

AI Techniques

- **Machine learning approaches**, including supervised, unsupervised and reinforcement learning, using a wide variety of methods including deep learning;
- **Logic- and knowledge-based approaches**, including knowledge representation, inductive (logic) programming, knowledge bases, inference and deductive engines, (symbolic) reasoning and expert systems; and
- **Statistical approaches**, Bayesian estimation, search and optimization methods

AI High-Risk Applications

- Biometric identification and categorization of natural persons
- Management and operation of critical infrastructure
- Education and vocational training
- Employment, workers' management and access to self-employment
- Access to and enjoyment of essential private services and public services and benefits
- Migration, asylum and border control management
- Law enforcement, and
- Administration of justice and democratic processes

AI Research Areas

- Natural Language Processing
- Computer Vision
- Recommender Systems
- Artificial Intelligence of Things
- Secure, trustworthy and ethical AI
- Evolutionary AI
- Robotics AI
- AI in specific application domains i.e. medicine, education, banking

AI Research Areas

Machine Learning

- Learning by data models
 - Supervised learning
 - Non-supervised learning
- Traditional ML models vs Deep learning models
- Classification (binary vs multi-label classification) or clustering

AI Research Areas

Natural Language Processing (NLP)

- Techniques for processing natural language
- Text-to-speech recognition
- Speech-to-text
- Sentiment analysis – emotion detection from text
- Examples:
 - Chatbots
 - Voice assistants
 - Google translate

AI Research Areas

Computer Vision

- Another popular AI application
- Connected to face recognition and biometric identification applications
- In general, it is the area that concerns image analysis and processing
- Examples:
 - Biometric identification applications
 - Smart car parking
 - Emotion detection through faces

Recommender Systems

- Use of big data to provide personalized recommendations to the users
- Data can be collected from social networks, search engines, user ratings etc
- Examples:
 - Netflix
 - Amazon

Research in AI

Artificial Intelligence of Things

- Internet of Things (IoT): Physical objects with sensors that connect and exchange data with other devices and systems over the internet or other communications networks.
- Artificial Intelligence with Internet of Things (AIoT): Combination of AI technologies with IoT infrastructure to improve human-machine interaction.
- Use of combination of computer vision, natural language processing, machine learning and other technologies.
- Examples:
 - Smart home
 - Smart cities

Research in AI

Ethical AI

- Discrimination, bias in AI systems
- Transparency and accountability in AI systems
 - Can be achieved through Explainability AI
 - Auditing the systems
- More on this will be discussed on Week 4

Tay the racist chatbot Microsoft released Tay, an AI bot that learnt to chat by analysing and engaging in conversations with humans on Twitter. Within 24 hours, Tay spoke like an angry, confused, racist misogynist. In a way, Tay is a collective failure because it acquired its unpleasantness from how humans tend to interact online. ML algorithms learn the structural biases and inequalities in our societies and find novel ways of discriminating against those that are already most affected by them.

Research in AI

Main Steps

- Research question
- Motivation/Goals - Hypothesis
- Data collection
 - Social media
 - Crowdsourcing
 - Data banks i.e. e-health records, cloud computing
 - Wearable devices
 - Publicly available datasets
 - Surveys

Research in AI

Main Steps (2)

- Data analysis
 - Statistical analysis
 - Build ML models for classification/clustering
 - Transparency of ML systems
- Evaluation of the methodology (AI system)
 - Evaluation metrics
 - Comparison of different models
 - Evaluated by experts (expert systems)
 - Usability evaluation
 - Ethical validation
- Interpretation of the results

Human Judgement (Human-centric AI)
Decision making

References

- Leedy P. D. and Ormrod J. E., Practical Research: Planning and Design, 7th Edition. 2001.

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