Introduction to the Student Projects

IE686 Large Language Models and Agents

UNIVERSITY OF MANNHEIM
Data and Web Science Group

Student Projects

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- **Goals**
  - Gain practical experience with developing multi-agent LLM applications for a specific problem
  - Learn about problem domain
    - What domain-specific problems exist and make the task hard
    - Come up with ways to try to solve them with agents
- **Expectation**
  - You explore your assigned topic area and its problems with data/benchmarks/LLMs of your own choosing
  - You solve the problem by
    - Building on the general methods we have seen in the course
    - Exploring additional methods that may be specific to the domain
    - Comparing multiple approaches using some form of evaluation

Procedure

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Teams of four to five students
  - realize a project using LLMs as agents
  - write a 12-page summary of the project and the methods employed in the project
  - present the project results to the other students
    - 10 minutes presentation + 5 minutes discussion

- Final mark for the course
  - 70 % written final report about the project
  - 30 % project presentation

Exam Registration

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- There is no “real” exam at the end of this course
- You still need to formally register with the Prüfungsamt separate of your course registration
- The general registration period starts on **02.04.2025** and continues until **16.04.2025**
- Make sure to **register**!

Course Schedule

You are here

Day	Topic
20.03	**Project:** Introduction to Student Projects
27.03	**Exercise:** Introduction to LangGraph 2
03.04	**Exercise:** Introduction to AutoGen
Sunday, April 6th, 23:59 Submission of Project Outlines	
10.04	**Project:** Project Coaching
30.04	**Project:** Project Coaching
08.05	**Project:** Project Coaching
15.05	**Project:** Project Coaching
22.05	**Project:** Project Coaching
Sunday, May 25th, 23:59 Submission of Project Report	
28.05	**Project:** Presentation of Project Results
Wednesday, May 28th, 23:59 Submission of Presentation Slides	

Team Formation

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Team formation is already done based on your preferences
  - You have been assigned to your team in ILIAS with your team number and assigned topic
  - It was difficult to satisfy everyone's wishes at once, so receiving the top priority topic area was not always possible
- Now it is time to define your own project in your assigned area!
- Meet with your team after the session to organize your work!
  - Decide project specifics
  - Organize writing of project outline

Topic 1: Multi-Agent Gaming

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- **Task:** Build a Multi-Agent gaming application.
  - Have teams of agents cooperate to solve a game or play against each other
  - Seminar student in last semester tried playing Dungeons and Dragons with Agents with good success
  - Can be explorative or you use an existing agent benchmark
- **Dataset/APIs:**
  - https://github.com/THUDM/AgentBench
  - https://github.com/microsoft/SmartPlay
- **Evaluation:**
  - Existing evaluation when using agent benchmark
  - Otherwise depends on game, could be win rate, ELO ranking, …

Topic 2: Online Shopping Assistant

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- **Task:** Build a (Multi-)Agent system that supports a user in making shopping decisions, e.g. for a new TV.
  - Search and present relevant products
  - Based on the users wishes
  - Present in structured format or directly perform the transaction
- **Dataset/APIs:**
  - Use existing benchmarks and relevant metrics
  - https://github.com/THUDM/AgentBench
  - https://webarena.dev/
  - https://webshop-pnlp.github.io/
- **Evaluation:**
  - Relevant evaluation metrics in used benchmarks

Topic 3: Text to SQL

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- **Task:** Build a (Multi-)Agent system that converts natural language queries to SQL.
  - Convert query
  - Query database
  - Refine based on result/errors
- **Dataset/APIs:**
  - https://paperswithcode.com/task/text-to-sql
  - https://github.com/THUDM/AgentBench
- **Evaluation:**
  - Relevant evaluation metrics in used benchmarks

Topic 4: Text-to-BPMN

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- **Task:** Build a (Multi-)Agent system that can create a business process model given a natural language description
- **Dataset/APIs:**
  - Use existing benchmarks and relevant metrics
  - Select a representative set of description-process pairs
- **Evaluation:**
  - Relevant evaluation metrics in the field
  - Human Evaluation

Topic 5: Browser Interaction

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- **Task:** Build a (Multi-)Agent system that can perform various tasks on websites.
  - Site search/link following/extraction of relevant info
  - Identify problems with each approach
- **Dataset/APIs:**
  - Use existing benchmarks and relevant metrics
  - Or define your own tasks in the real web
  - https://github.com/THUDM/AgentBench
  - https://webarena.dev/
- **Evaluation:**
  - Relevant evaluation metrics in used benchmarks
  - Measure task fulfillment

Where to find Datasets/Benchmarks?

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Agent Benchmarks
  - AgentBench
  - WebShop
  - WebArena
  - Meta RAG KDD Cup
  - SmartPlay
  - EvalPlus
- General Task Benchmarks
  - Papers with Code Datasets (filter by task)
  - Huggingface Datasets

Even More Benchmarks

UNIVERSITY OF MANNHEIM
Data and Web Science Group

Method	Evaluation	Model Types	Abilities/Domain	Data Source
Benchmark	MMLU [364]	Base/Fine-tuned/Specialized	General	Human exam/practice
	BIG-bench [70]	Base/Fine-tuned/Specialized	General	Human annotation
	HELM [520]	Base/Fine-tuned/Specialized	General	Benchmark collection
	Open LLM Leaderboard [707]	Base/Fine-tuned/Specialized	General	Benchmark collection
	AGIEval [708]	Base/Fine-tuned/Specialized	General	Human exam/practice
	MMCU [709]	Base/Fine-tuned/Specialized	General	Human exam/practice
	M3KE [710]	Base/Fine-tuned/Specialized	General	Human exam/practice
	C-Eval [711]	Base/Fine-tuned/Specialized	General	Human exam/practice
	Xiezhi [712]	Base/Fine-tuned/Specialized	General	Human exam/practice
	OpenCompass [713]	Base/Fine-tuned/Specialized	General	Benchmark collection
	Chain-of-Thought Hub [714]	Base/Fine-tuned	General	Benchmark collection
	KoLA [715]	Base/Fine-tuned	Knowledge utilization	Web
	ARB [716]	Fine-tuned	Complex reasoning	Human exam/practice
	APIBench [717]	Base/Fine-tuned	Tool manipulation	Web
	APIBank [718]	Fine-tuned	Tool manipulation	Synthesis
	ToolAlpaca [719]	Base/Fine-tuned	Tool manipulation	Synthesis
	T-Bench [720]	Fine-tuned	Tool manipulation	Synthesis
	ToolBench [721]	Fine-tuned	Tool manipulation	Synthesis
	BOLAA [722]	Base/Fine-tuned	Environment interaction	Benchmark collection
	AgentBench [723]	Base/Fine-tuned	Environment interaction	Human annotation/Synthesis
	HaluEval [602]	Base/Fine-tuned	Human alignment	Human annotation/Synthesis
	PromptBench [724]	Base/Fine-tuned	Robustness	Benchmark collection
	HumanEval [105]	Base/Fine-tuned/Specialized	Code synthesis	Human annotation
	MultiMedQA [356]	Specialized	Healthcare	Benchmark collection
	FLUE [725]	Specialized	Finance	Benchmark collection
	LegalBench [726]	Specialized	Legal	Human annotation
Human	Chatbot Arena [727]	Base/Fine-tuned/Specialized	Human Alignment	Human annotation
	SciBench [728]	Fine-tuned	Complex reasoning	Human exam/practice
Model	AlpacaEval [729]	Fine-tuned	Instruction following	Synthesis
	MT-bench [727]	Fine-tuned	Human alignment	Human annotation
	TrustGPT [730]	Base/Fine-tuned	Human alignment	Benchmark collection
	LMExamQA [731]	Base/Fine-tuned	Knowledge utilization	Synthesis
	ChatEval [732]	Base/Fine-tuned	Knowledge utilization	Benchmark collection

Zhao et al.: A Survey of Large Language Models. 2024. arXiv:2303.18223

Where to Find Additional Information

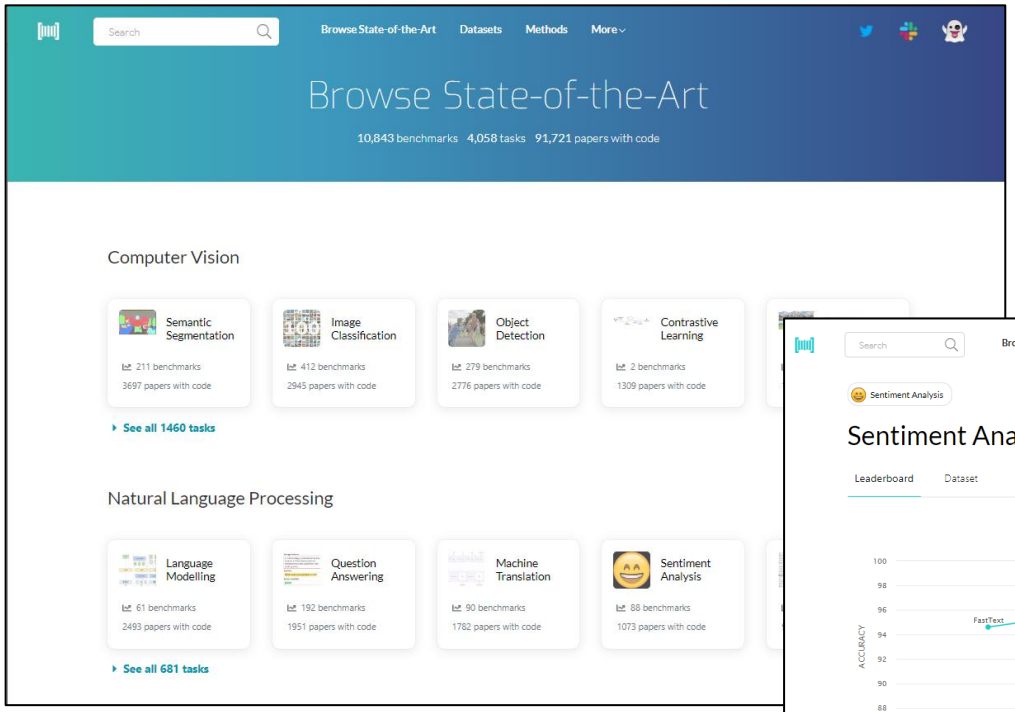
UNIVERSITY OF MANNHEIM
Data and Web Science Group

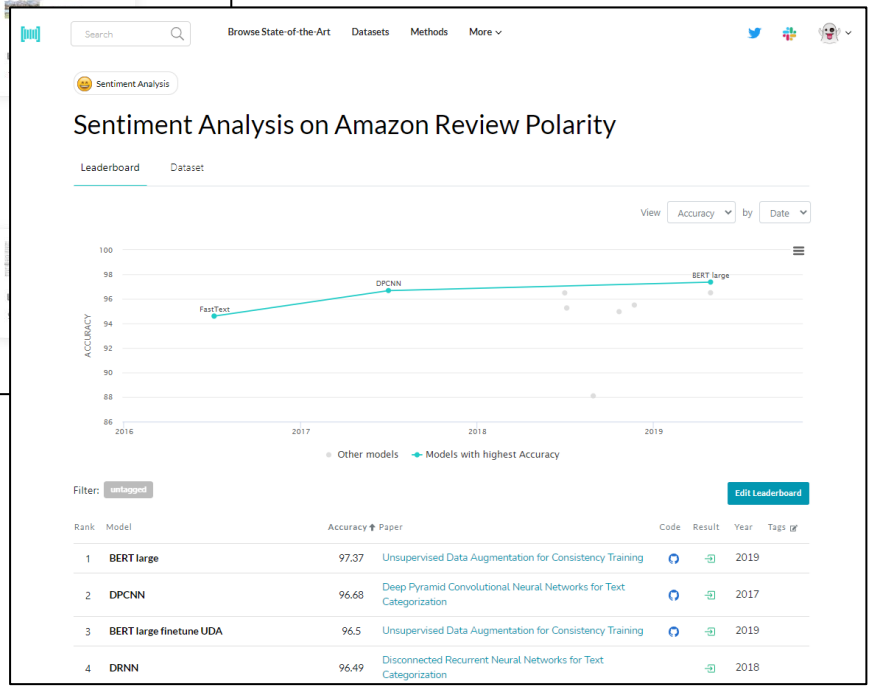
- Check out the LLMs/solutions to your problem that other people have tried.
  - by looking at leaderboards of the relevant benchmarks
  - by investigating the state-of-the-art for your your task on Papers with Code
  - or search for relevant scientific papers using Google Scholar
- Use them for inspiration and/or comparison

Google

Papers With Code

State-of-the-Art for Specific Tasks





https://paperswithcode.com/sota

Suggestions for APIs/Tools

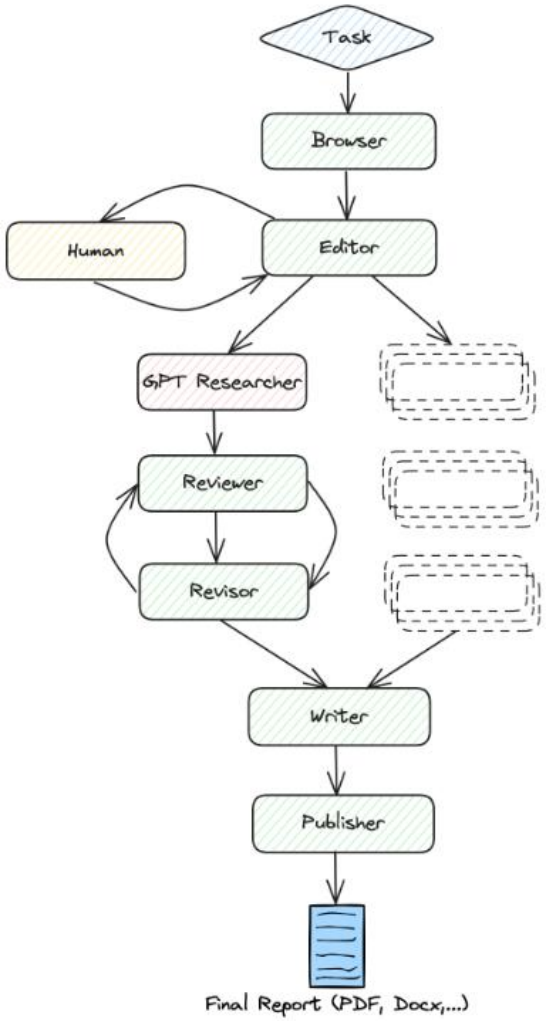
UNIVERSITY OF MANNHEIM
Data and Web Science Group

- For finding relevant APIs to query: https://apislist.com/
- Tavily search tool: https://tavily.com/
  - 1000 free requests per month (*5 team members = 😊 + free student tier)
  - Also possible to just use search engine
  - then find and extract relevant info from HTML
- Unstructured data transformation tool: https://unstructured.io/
  - Offer many open-source libraries to prepare data for LLMs you can use for free (https://github.com/Unstructured-IO)
- Groq LLM inference API: https://groq.com/
  - Let's you query some powerful open-source models for free
  - May run into rate limit or unavailability due to traffic
- OpenAI: gpt4o-mini (or similar Google/Anthropic/Mistral offering)
  - Quite powerful and successfully used last semester
  - Comparably cheap

GPT-Researcher

UNIVERSITY OF MANNHEIM
Data and Web Science Group

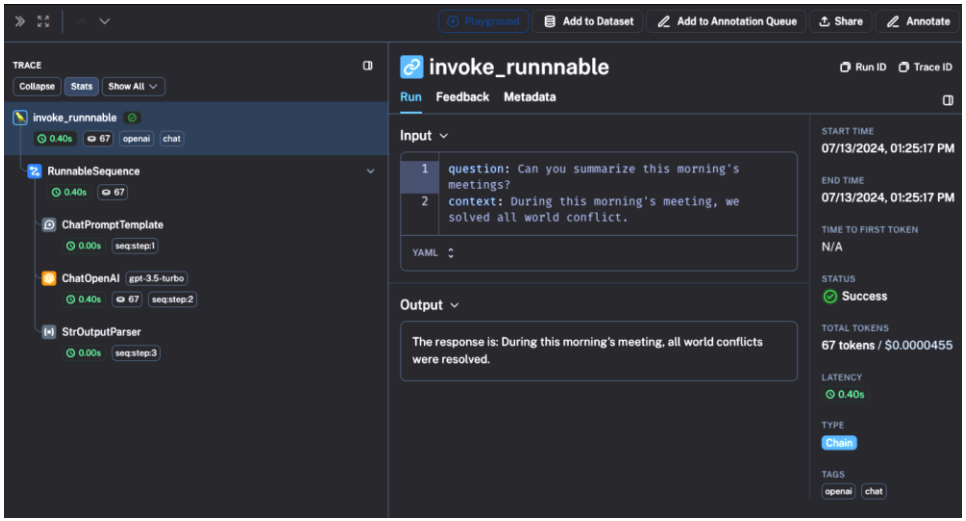
- Multi-agent system for online research
- Uses “Plan-and-Solve” prompting to divide task into subtasks…
- Which are carried out by multiple agents in parallel using web crawling as a tool.
- Written in LangGraph
- Can be used as inspiration

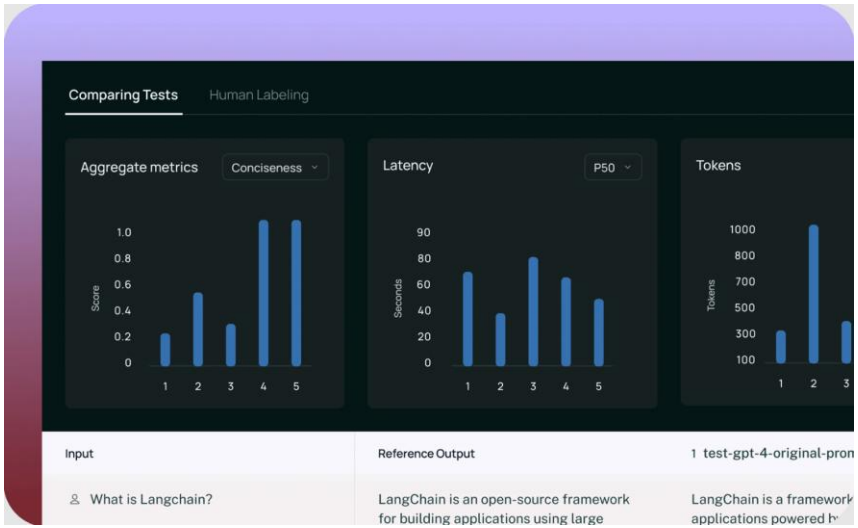


https://docs.gptr.dev/blog/building-gpt-researcher
https://github.com/assafelovic/gpt-researcher/tree/master/multi_agents

Tracking your Experiments

UNIVERSITY OF MANNHEIM
Data and Web Science Group





- Print to console and save to logfiles, or…
- Use LangSmith
  - Commercial offering by LangChain
  - Let's you track and save what's happening during your workflow executions (traces)
  - Easy way to review what's happening and where things go wrong
  - 5000 free traces per month (*5… 😊)

Project Outlines

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Maximum 4 pages (sharp!) including title page
  - Using DWS Seminar thesis layout (PDF!)
  - Include a project name, your team number and name on the first page!
- Due **Sunday, April 6th, 23:59**
- Upload to ILIAS submission (Every team member can submit, last submission will be evaluated)
- Feedback about your project outlines if required: Thursday, 10.04.2025, lecture time (15:15-17:00)
  - We will inform you Wednesday, 09.04.2025 with some feedback via mail and let you know if you need to attend the session on Thursday
  - Then the projects start!

Project Outlines

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Answer the following questions:
  1. What is the problem you are solving?
  2. What data will you use?
     - Where will you get it?
     - How will you gather it?
  3. How will you solve the problem?
     - What LLMs do you plan to use?
     - Which methods do you plan to apply? Be as specific as you can!
     - What is your idea for a multi-agent workflow for your task?
  4. How will you measure success? (Evaluation method)

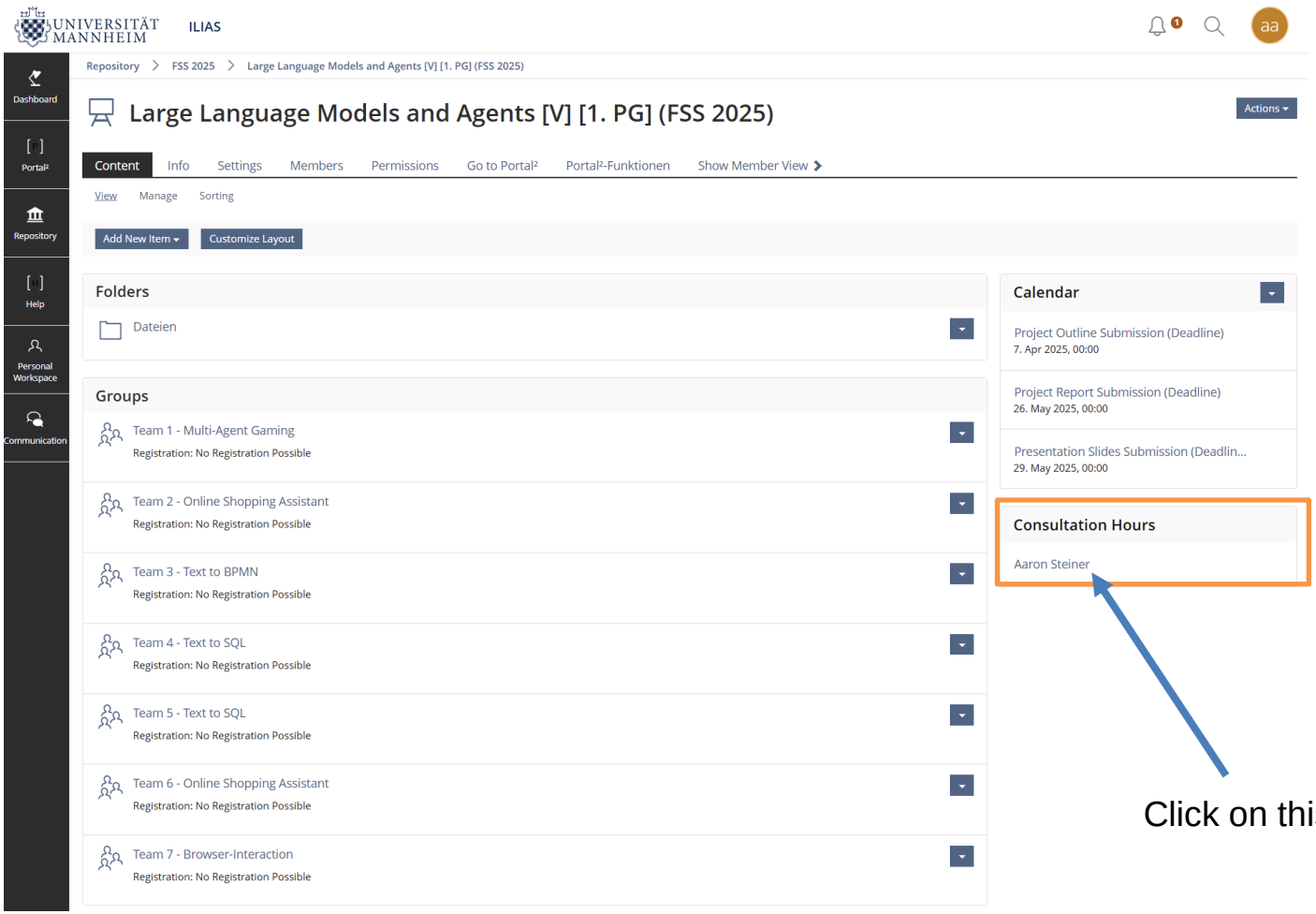
Coaching Sessions

UNIVERSITY OF MANNHEIM
Data and Web Science Group

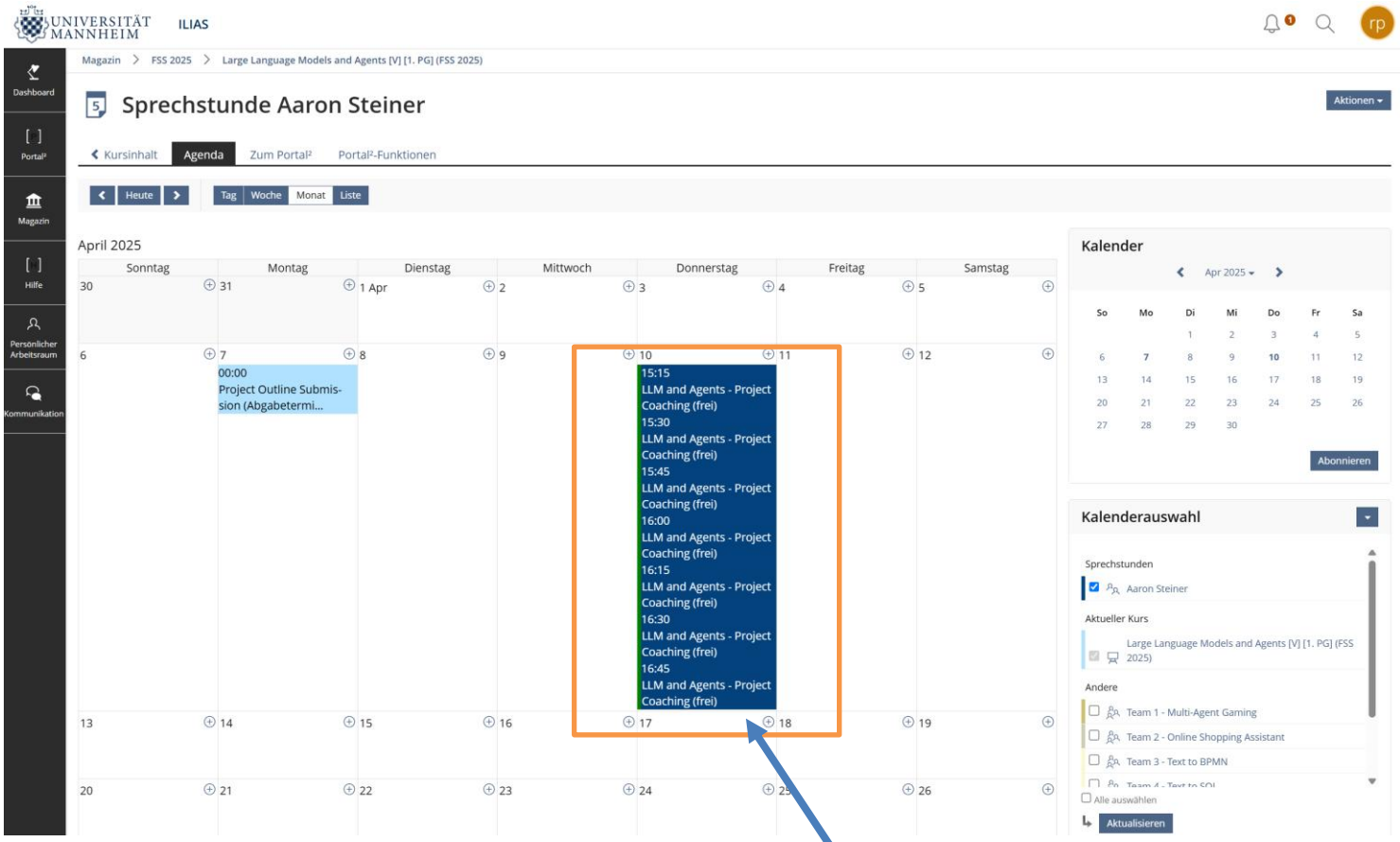
- We give you tips and answer questions about your project.
- At the time of the lecture (Thursdays 15:15-17:00)
- **Registration** is mandatory if you want coaching!
- Make sure to register until Monday (23:59) of the week you want to attend the coaching session
- Each coaching session lasts for 15 minutes
  - Include your questions when booking the session, so we can prepare!
  - Most time efficient use of the session
  - We will of course also answer any question you pose directly in the session

Booking Coaching Sessions: How-to

UNIVERSITY OF MANNHEIM
Data and Web Science Group



Booking Coaching Sessions: How-to

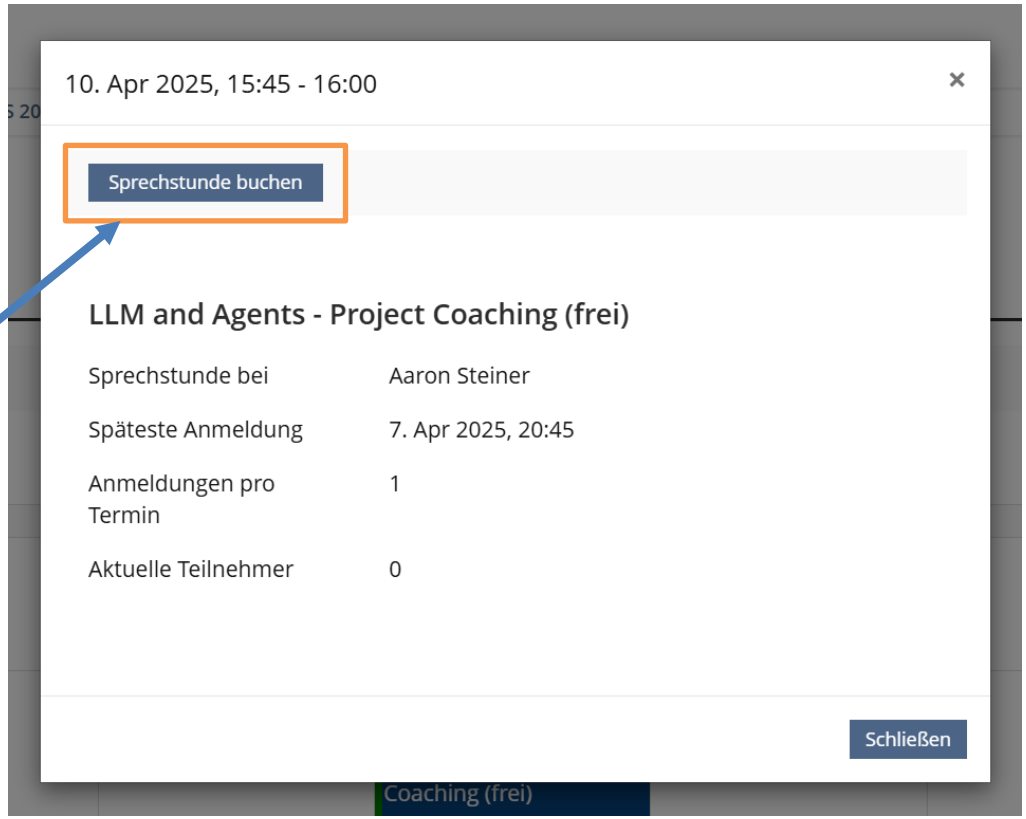


Choose and click the slot you want to attend (as long as it is still free)

Booking Coaching Sessions: How-to

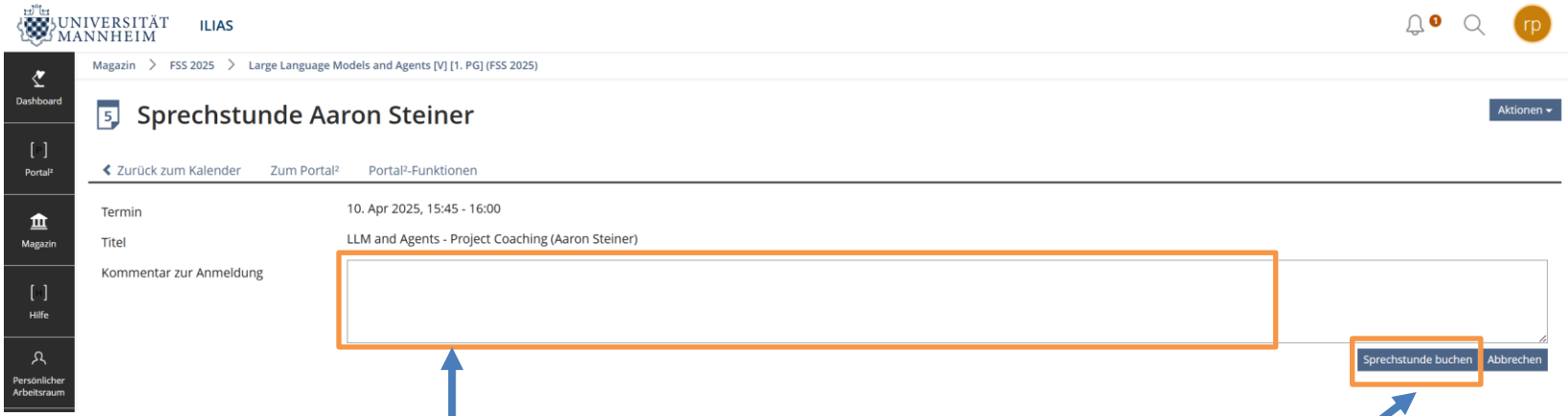
UNIVERSITY OF MANNHEIM
Data and Web Science Group

Click to book



Booking Coaching Sessions: How-to

UNIVERSITY OF MANNHEIM
Data and Web Science Group



1. Enter your questions and topics to discuss during the session

2. Finalize the booking of the coaching session

Some Project Management Hints

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Organize your project in **multiple iterations**
  - Every artefact will be improved over time!
- Get a **simple process running early** on to have a baseline
- **Parallelize tasks** while keeping centrally track of results
  - e.g. one central document with results plus reference to exact version of the notebooks/datasets that produced these results
  - sub-groups should explore specific ideas for a specified amount of time

Some Project Management Hints

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- **Define concrete milestones**: When should what be finished?
  - e.g. 20.04.25 Data exploration done and first simple baseline implemented
  - e.g. 26.04.25 Subgroup using decentralized agent communication adds results to central document

- **Infrastructure**
  - use shared folder for result document, versions of data, processes, slideset (e.g. MS Teams, Google Drive, GitHub)
  - use LLMs for inspiration about additional methods as well as for coding support

Tasks within the Iterations of the Project

UNIVERSITY OF MANNHEIM
Data and Web Science Group

1. Data Exploration
2. Establish/update baseline (simple LLM agent(s) based method or non LLM baseline)
3. Try different methods for applying agents using different LLMs
   - Iteratively improve on methods…
   - solving problems as they come up
   - Track your experiments and all the things you did!
4. Perform error analysis in order to understand what is going on!
   - Stream the outputs, see whats going on and going wrong!
   - Analyse mistakes and reason about why system fails

Project Presentation

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Present the project results to the other students
  - 10 minutes presentation + 5 minutes discussion
  - Everyone must attend as its part of your grade

- Upload your presentation in **PDF format**
  - Via your ILIAS Group
  - Until **Wednesday, May 28th, 23:59**

Project Report

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Max. 12 pages including title/toc page and reference page
  - max. 10 pages content, no appendix
  - Each extra page and each day of late submission downgrades your mark by 0.3!
- Due **Sunday, May 25th, 23:59**
- Upload in **PDF format** via your ILIAS group

Project Report

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Outline for project report:
  - Application area and goals (0.5 pages)
  - Profile (structure and size) of your data (minimum 1 page)
  - Approaches to solving the problem with LLM Agents
    - Describe different approaches that you tried
  - Evaluation
    - Results
    - Including problems that you faced with each approach and what steps you took to fix them
    - Including an analysis of the errors still made, a discussion of the results, and a comparison to state-of-the-art results (together: minimum 2 pages)

Project Report

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Requirements
  - You have to use the latex template for DWS Seminar Theses
  - Please cite sources properly and use your references page
  - Also submit your Python code and (a subset) of your data
  - Also submit a **who-did-what table** together with your report/code!
  - Include your names and your team number on the first page!
- Usage of additional AI Tools for non-method specific tasks needs to be declared in a separate table

Declaration of Used AI Tools

Tool	Purpose	Where?	Useful?
ChatGPT	Rephrasing	Throughout	+
DeepL	Translation	Throughout	+
ResearchGPT	Summarization of related work	Sec. 2.2	-
Dall-E	Image generation	Figs. 2, 3	++
GPT-4	Code generation	functions.py	+
ChatGPT	Related work hallucination	Most of bibliography	++

Get Additional Advice from a Stanford Professor

UNIVERSITY OF MANNHEIM
Data and Web Science Group

Christopher Potts

- How to evaluate your model?
  - https://www.youtube.com/watch?v=TxTblROT9lY
- How to structure your project report?
  - https://www.youtube.com/watch?v=DZNwO-p5PGY
- How to present the results of your project?
  - https://www.youtube.com/watch?v=GGx7klcahzY

Deadlines - Overview

UNIVERSITY OF MANNHEIM
Data and Web Science Group

- Project outline until **Sunday, April 6th, 23:59**
- Coaching Sessions
  - Every week
  - Registration for coaching must be done by Monday 23:59 of that week the latest!
- Project report as PDF until **Sunday, May 25th, 23:59**
- Project presentation as PDF until **Wednesday, May 28th, 23:59**

Questions?

UNIVERSITY OF MANNHEIM
Data and Web Science Group

Thank you

UNIVERSITY OF MANNHEIM
Data and Web Science Group