Development Team Project:

Academic Paper Search Application

Credits

The template has been provided by slidesgo

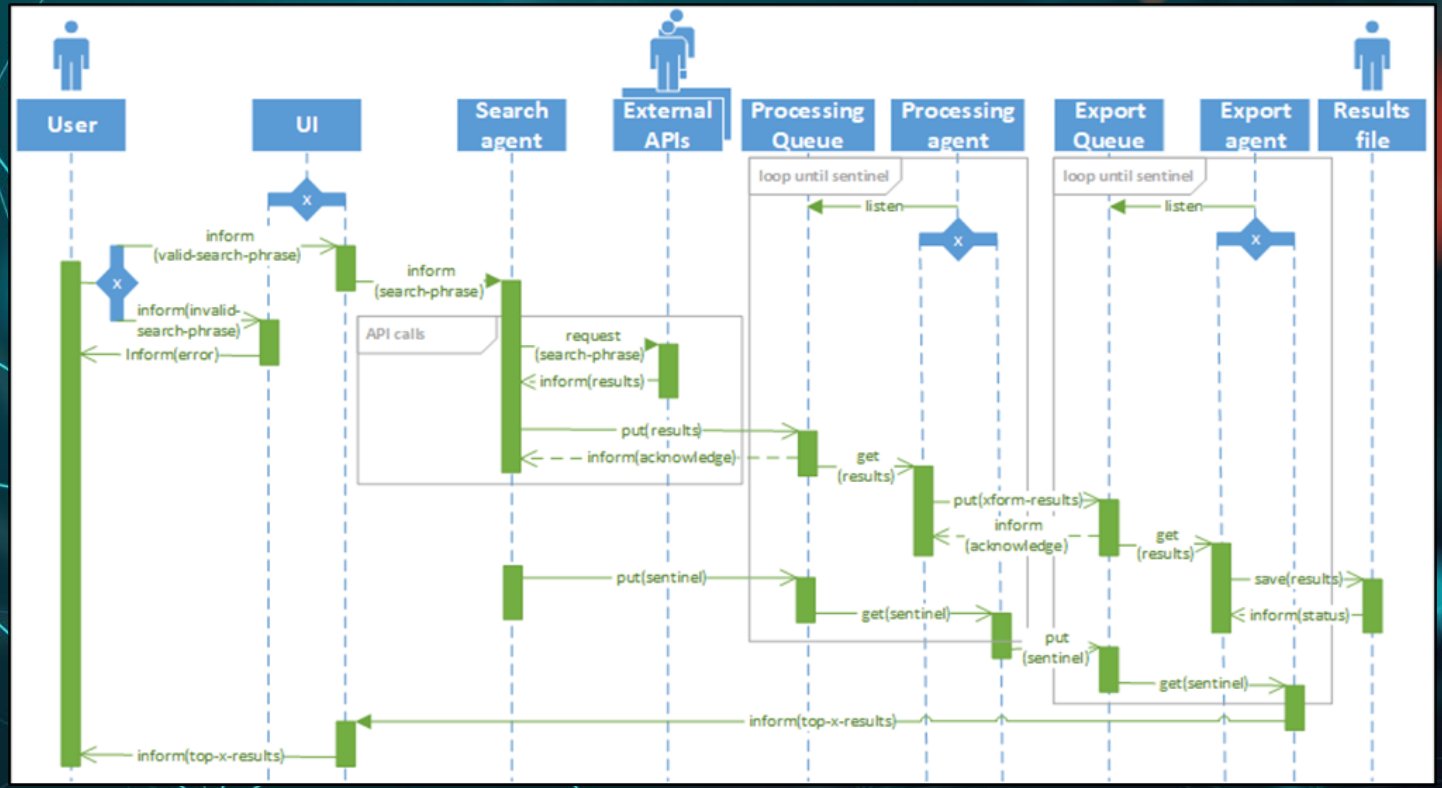
Introduction

- Development of an Academic Paper Search application was chosen because
  - Demonstrates multi-agent application with discrete agents interacting with each other
    - User Interface
    - Search Agents
    - Processing Agent
    - Export Agent
  - Could also be a useful tool for future studies

- During the project we expected to prove
  - Interaction between agents within a single code base to achieve the goal of retrieving academic information based upon search terms

- Out of scope
  - Agents operating in independent code bases, able to start and stop independently
  - Agent communication languages such as Knowledge Query and Manipulation Language (KQML)

Design (from project 1)



APIs implemented

- IEEE Xplore
- arXiv
- PubMed

Development

- Agent autonomy and parallel processing options:
  - Multiprocessing - tested and discounted
  - **Threading** **- tested and used**
  - Asyncio - discounted
- Queues to allow asynchronous communication between agents
- Separate method for each API within search agent and processing agent
- During development: enhanced to search for multiple search terms within a single search
  - Better agent architecture
  - Better user experience
  - Impacted UI responsiveness so implemented PyQt5's QThread and pyqtSignal
- Unexpected error handling meant PyQt5's QThread and pyqtSignal was a better choice anyway

Error handling

```
# perform processing
if dict_data:
    try:
        articles = dict_data['articles']['article']
    except KeyError as e:
        # If `article` is missing from `articles`, then there are no search results
        if str(e) == "'article'":
            # log message
            logger.warning("No search result for this search term for IEEE Xplore",
                           extra={"agent": "PROCESSING AGENT"})
            # emit signal to inform UI about the no result
            agent_signals.no_result_ieee.emit("No search result for this search term for IEEE Xplore")
            return 'IEEE Xplore', 'No search result for this search term'
        # any other KeyError
        else:
            # emit signal to inform UI about the error
            agent_signals.error_ieee.emit("Unexpected response from IEEE Xplore, review app.logs for more info")
            # log message
            logger.error(f"Unexpected response from IEEE Xplore, KeyError: {e}",
                         extra={"agent": "PROCESSING AGENT"})
            return 'IEEE Xplore', 'unexpected response'
else:
    # this should never be hit because the search agent returns an empty xml for "processing" so
    # `dict_data` should never be empty, however putting this here just in case
    # send appropriate signal info message to UI
    agent_signals.error_ieee.emit("Unexpected response from IEEE Xplore, review app.logs for more info")
    # log message
    logger.warning("Empty response from IEEE Xplore", extra={"agent": "PROCESSING AGENT"})
    return 'IEEE Xplore', 'unexpected response'
```

```
Searching for Mechanic banana...

No search result for this search term for IEEE Xplore

Stop signalled,finishing threads...
Search,process,and export agents finished - CSV will be opened
Search complete,CSV will be opened in default .csv extension application.
The file path is: /Users/astrid/Library/Application Support/IntelligentSearchAgent/csv-exports/search-export-43.csv
```

	A	B	C	D	E	F	G	H
1	Search Term	Title	Summary/Abstract	Author(s)	URL			
2	Mechanic banana	Energetic particle loss mechanisms in	Collisionless physics	['E. J. Paul', 'A. Bhatta	http://arxiv.org/abs/2208.02351v2			
3	Mechanic banana	Negative differential resistance: anothe	Just like the artefact found	['J. Li', 'H. -F. Zhang', '	http://arxiv.org/abs/1409.6438v1			
4	Mechanic banana	The nature of the Island and Banana	We propose an	['M. J. Church', 'A. Gib	http://arxiv.org/abs/1312.1823v1			
5	Mechanic banana	Influence of kepok banana bunch as nev	Bioplastics were developed	['Autha Nelga', 'Sireg	https://pubmed.ncbi.nlm.nih.gov/37435944/			
6	Mechanic banana	{'i': 'Triumfetta cordifolia A. rich', '#text	{'i': 'Triumfetta cordifolia',	['Soppie Anny Geraldc	https://pubmed.ncbi.nlm.nih.gov/37408913/			
7	Mechanic banana	Functionality and characterization of m	The objective of this work v	['Aurelio RamV≠rez-H	https://pubmed.ncbi.nlm.nih.gov/37406918/			
8								

The app.log file, debugging, & back-end testing

```
2023-07-15 13:37:34,012 - INFO - INFO - SEARCH TERM: Mechanic banana
2023-07-15 13:37:34,013 - INFO - INFO - NEW CSV: True
2023-07-15 13:37:34,013 - INFO - INFO - NUMBER OF DESIRED SEARCH RESULTS: 3
2023-07-15 13:37:34,016 - INFO - SEARCH AGENT - TRYING ARXIV
2023-07-15 13:37:34,920 - INFO - SEARCH AGENT - arXiv response received, sending to processing queue
2023-07-15 13:37:34,921 - INFO - SEARCH AGENT - TRYING PUBMED
2023-07-15 13:37:34,921 - INFO - PROCESSING AGENT - search_results can be added to logs here if desired (can clog logs with large requests)
2023-07-15 13:37:34,921 - INFO - PROCESSING AGENT - PROCESS IDENTIFIER is arXiv
2023-07-15 13:37:34,922 - INFO - PROCESSING AGENT - Starting arXiv processing...
2023-07-15 13:37:34,929 - INFO - PROCESSING AGENT - arXiv processing finished
2023-07-15 13:37:34,929 - INFO - EXPORT AGENT - Exporting processed arXiv data to CSV...
2023-07-15 13:37:34,930 - INFO - EXPORT AGENT - Processed arXiv data has been written to CSV at location /Users/astrid/Library/Application Suppo
2023-07-15 13:37:35,934 - INFO - PROCESSING AGENT - Search result queue is empty, waiting...
2023-07-15 13:37:35,935 - INFO - EXPORT AGENT - Export queue is empty, waiting...
2023-07-15 13:37:36,119 - INFO - SEARCH AGENT - PubMed records requested Id list: 37435944,37408913,37406918
2023-07-15 13:37:37,167 - INFO - SEARCH AGENT - PubMed response received, sending to processing queue
2023-07-15 13:37:37,169 - INFO - SEARCH AGENT - TRYING IEEE XPLORE
2023-07-15 13:37:37,169 - INFO - PROCESSING AGENT - search_results can be added to logs here if desired (can clog logs with large requests)
2023-07-15 13:37:37,170 - INFO - PROCESSING AGENT - PROCESS IDENTIFIER is PubMed
2023-07-15 13:37:37,170 - INFO - PROCESSING AGENT - Starting PubMed processing...
2023-07-15 13:37:37,178 - INFO - PROCESSING AGENT - PubMed processing finished
2023-07-15 13:37:37,178 - INFO - EXPORT AGENT - Exporting processed PubMed data to CSV...
2023-07-15 13:37:37,179 - INFO - EXPORT AGENT - Processed PubMed data has been written to CSV at location /Users/astrid/Library/Application Supp
2023-07-15 13:37:38,182 - INFO - PROCESSING AGENT - Search result queue is empty, waiting...
2023-07-15 13:37:38,184 - INFO - EXPORT AGENT - Export queue is empty, waiting...
2023-07-15 13:37:39,029 - INFO - SEARCH AGENT - IEEE Xplore response received, sending to processing queue
2023-07-15 13:37:39,187 - INFO - PROCESSING AGENT - search_results can be added to logs here if desired (can clog logs with large requests)
2023-07-15 13:37:39,188 - INFO - PROCESSING AGENT - PROCESS IDENTIFIER is IEEE Xplore
2023-07-15 13:37:39,188 - INFO - PROCESSING AGENT - Starting IEEE Xplore processing...
2023-07-15 13:37:39,188 - WARNING - PROCESSING AGENT - No search result for this search term for IEEE Xplore
2023-07-15 13:37:39,192 - INFO - EXPORT AGENT - No search results for IEEE Xplore, nothing to export - continue
2023-07-15 13:37:40,043 - INFO - SEARCH AGENT - Search term queue is empty, waiting...
2023-07-15 13:37:40,191 - INFO - PROCESSING AGENT - Search result queue is empty, waiting...
2023-07-15 13:37:40,197 - INFO - EXPORT AGENT - Export queue is empty, waiting...
```

```python
# try to make the EFetch request
try:
    raise ValueError("Testing Exception")
```

```
2023-07-07 19:56:47,460 - WARNING - SEARCH AGENT - Request error occurred for PubMed efetch API: Testing Exception
2023-07-07 19:56:47,460 - INFO - SEARCH AGENT - Retrying PubMed...
```

BDD testing

- Behaviour Driven Development test scripts were used to specify positive and negative tests

- Every test from a user perspective:
  - To extend the design with user interactions
  - Serves as maintainable and readable product documentation
  - To provide definitive pass/fail criteria

- Feedback from testing was used to finalise the final solution, including:
  - Enhancement from single search to multi-search capability
  - Additional error handling
  - Renaming of buttons and re-wording of explanatory text for easier understanding
  - Addition of search using “Enter” key as well as “Search” button

- Intermittent issue with arXiv returning no results for search terms that had previously worked. arXiv said they were migrating servers which was probably the cause, so the application was working OK.

Distribution

- Python source code plus executable files for Windows and iOS have been supplied
  - Python:
    - academic_search_ui.py
    - agents_code.py
    - logging_setup.py
  - Windows
    - academic_search_ui_windows.exe
  - macOS (Unix executable file compiled on M1)
    - academic_search_ui_unix
  - Linux (Unix executable file compiled on M1 or directly from the script)
    - academic_search_ui_unix
- All available at:
  - https://github.com/aster-droide/ia-team-project

README

Intelligent Academic Research Tool

This repository contains an Intelligent Academic Research Tool allowing users to search multiple academic databases simultaneously and export the search results to a CSV file. It provides a simple and convenient way to retrieve research articles and relevant information for a given search term.

Features

- Search multiple databases: arXiv, PubMed, and IEEE Xplore (for now).
- Customisable search options, users can:
  - select the desired search engines
  - set max number of results to retrieve
  - retrieve results for unlimited search terms in one CSV export
  - choose a new file or append to existing file
- Data is exported to .csv format for easy access to further analysis.
- User-friendly graphical user interface (GUI) that is intuitive and easy to use.

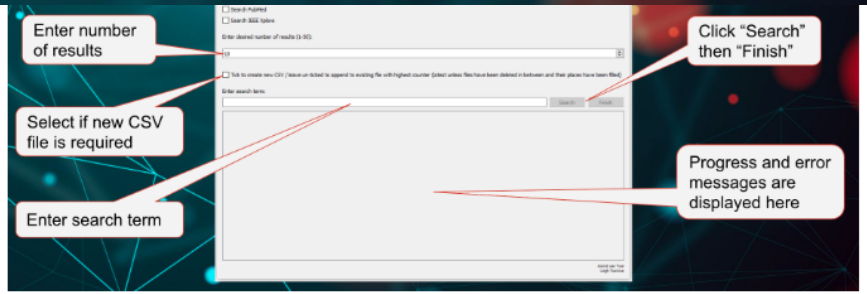
Installation

In this folder two zip files are provided with a compiled version of the application for Mac* and Windows. These applications include all dependencies and can be run directly on respective platforms.

Alternatively, the application can be launched directly by running the academic_search_ui.py file. To run locally, please ensure all three Python files are downloaded and in the same directory.

*Unix executable compiled and tested on Mac M1, it is not guaranteed it will run as expected on intel devices or Linux. In case of failure the code can be run directly. While this has been thoroughly tested on the Mac M1 and Windows, it is not guaranteed it will work on Linux.

Usage



Acknowledgments

This application was developed by Astrid van Toor and Leigh Feaviour as part of a team project for the MSc Intelligent Agents module from the University of Essex. Any questions, feel free to reach out to us.

Relevant sources used during development

Tutorials and forum discussions

https://realpython.com/python-pyqt-qthread/

https://stackoverflow.com/questions/3044580/multiprocessing-vs-threading-python

https://www.pythontutorial.net/python-concurrency/python-threading/

https://stackoverflow.com/questions/27435284/multiprocessing-vs-multithreading-vs-asyncio

Key library documentations

https://docs.python.org/3/library/multiprocessing.html

https://docs.python.org/3/library/threading.html

https://pypi.org/project/PyQt5/

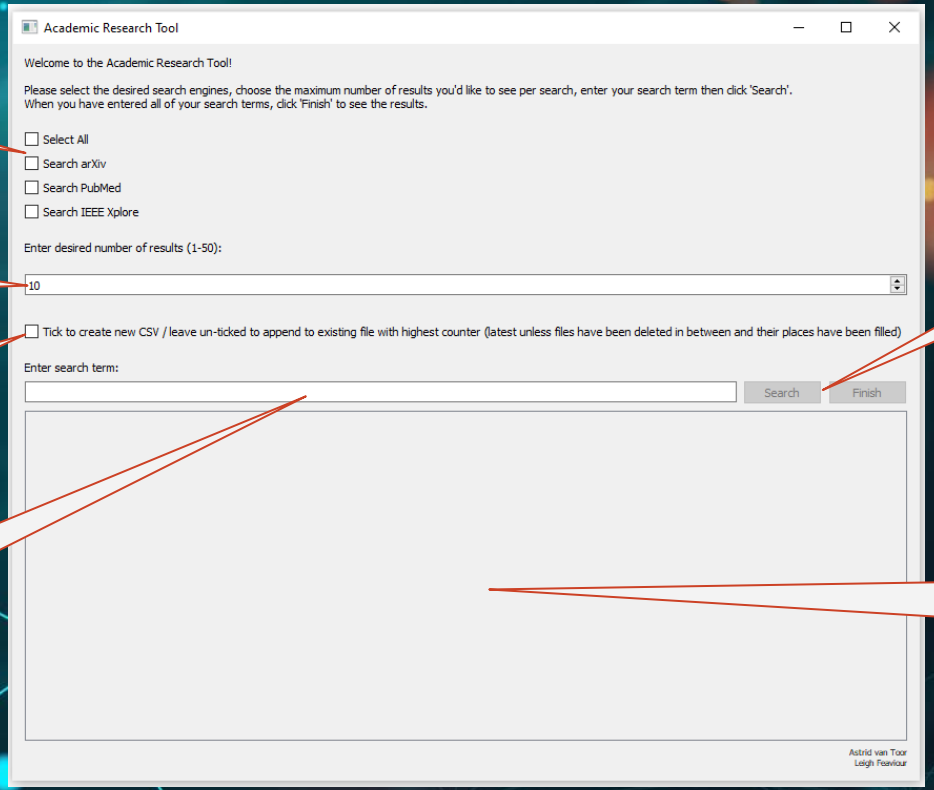
User Interface

Select sources

Enter number of results

Select if new CSV file is required

Enter search term

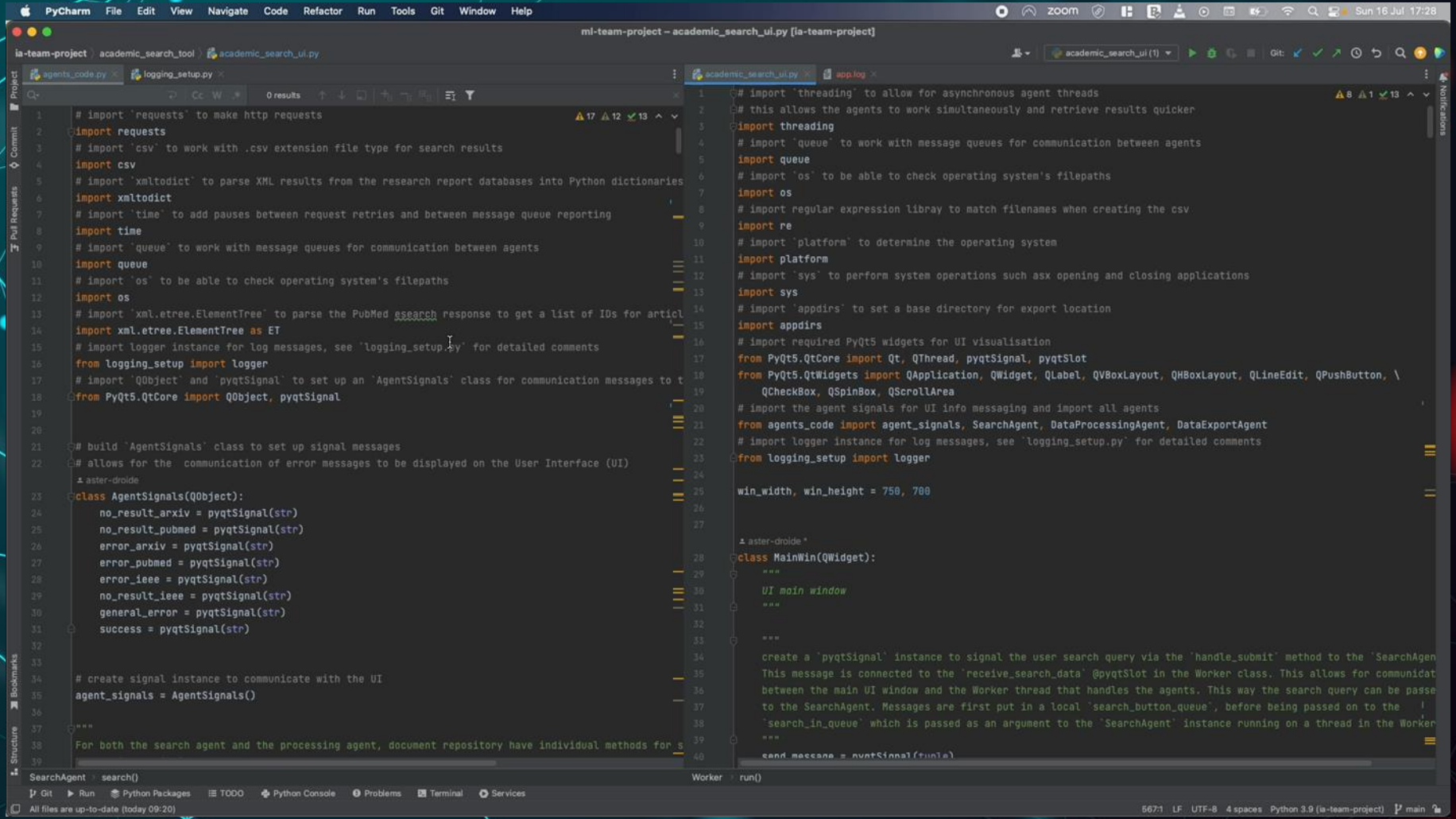


Click “Search” then “Finish”

Progress and error messages are displayed here

CSV example

	A	B	C	D	E
1	Search Term	Title	Summary/Abstract	Author(s)	URL
2	Artificial intelligence	The Governance of Physical Artificial Intelligence	Physical artificial intelligence can prove to be one of the i	['Yingbo Li', 'Anamaria-Beatrice Spulber', 'Yucong Duan']	http://arxiv.org/abs/2304.02924v1
3	Artificial intelligence	Does an artificial intelligence perform market ma	Who should be charged with responsibility for an artificia	['Takanobu Mizuta']	http://arxiv.org/abs/2005.10488v1
4	Artificial intelligence	Impact of Artificial Intelligence on Economic The	Artificial intelligence has impacted many aspects of huma	['Tshilidzi Marwala']	http://arxiv.org/abs/1509.01213v1
5	Artificial intelligence	The case for psychometric artificial general intell	A short review of the literature on measurement and det	['Mark McPherson']	http://arxiv.org/abs/2101.02179v1
6	Artificial intelligence	Proceedings of the Thirteenth Conference on Un	This is the Proceedings of the Thirteenth Conference on U	['Dan Geiger', 'Prakash Shenoy']	http://arxiv.org/abs/1304.3846v1
7	Artificial intelligence	Proceedings of the Ninth Conference on Uncerta	This is the Proceedings of the Ninth Conference on Uncer	['David Heckerman', 'E. Mamdani']	http://arxiv.org/abs/1304.3851v1
8	Artificial intelligence	Proceedings of the Second Conference on Uncert	This is the Proceedings of the Second Conference on Unc	['Laveen Kanal', 'John Lemmer']	http://arxiv.org/abs/1304.3859v1
9	Artificial intelligence	Artificial Intelligence in Humans	In this paper, I put forward that in many instances, thinki	['Michael Swan Laufer']	http://arxiv.org/abs/1311.0716v1
10	Artificial intelligence	AAAI FSS-18: Artificial Intelligence in Governmen	Proceedings of the AAAI Fall Symposium on Artificial Inte	['Frank Stein', 'Alun Preece', 'Mihai Boicu']	http://arxiv.org/abs/1810.06018v1
11	Artificial intelligence	Watershed of Artificial Intelligence: Human Intell	This article reviews the "Once learning" mechanism that	['Li Weigang', 'Liriam Enamoto', 'Denise Leyi Li', 'Geraldo Per	http://arxiv.org/abs/2104.13155v2
12	Artificial intelligence	Human Performance in Competitive and Collabo	In the modern world, many important tasks have become	['Bennett Murray S', 'Hedley Laiton', 'Love Jonathon', 'Houpt	https://pubmed.ncbi.nlm.nih.gov/37439275/
13	Artificial intelligence	Noninvasive In Vivo Thrombus Imaging in Patien	[{'@Label': 'BACKGROUND', '@NlmCategory': 'BACKGROU	['Whittington Beth', 'Tzolos Evangelos', 'Bing Rong', 'Andrew	https://pubmed.ncbi.nlm.nih.gov/37439259/
14	Artificial intelligence	Margin notes from the COVID-19 pandemic for th	The COVID-19 pandemic has been characterized as a "big-	['Bond Andrew']	https://pubmed.ncbi.nlm.nih.gov/37439203/
15	Artificial intelligence	{'i': 'versus', '#text': '[Efficacy of machine learning	[{'@Label': 'OBJECTIVE', '@NlmCategory': 'OBJECTIVE', '#t	['Gao K', 'Wang Y', 'Cao H', 'Jia J']	https://pubmed.ncbi.nlm.nih.gov/37439167/
16	Artificial intelligence	Single-cell transcriptome analysis identifies nov	Hepatocellular carcinoma (HCC) and intrahepatic cholang	['Swain Asish Kumar', 'Pandey Prashant', 'Sera Riddhi', 'Yada	https://pubmed.ncbi.nlm.nih.gov/37438675/
17	Artificial intelligence	Prospective validation of dermoscopy-based ope	The use of artificial intelligence (AI) has the potential to i	['Marchetti Michael A', 'Cowen Emily A', 'Kurtansky Nicholas	https://pubmed.ncbi.nlm.nih.gov/37438476/
18	Artificial intelligence	AI-designed NMR spectroscopy RF pulses for fast	{'sup': ['1', '15'], '#text': 'Nuclear magnetic resonance (NM	['Manu V S', 'Olivieri Cristina', 'Veglia Gianluigi']	https://pubmed.ncbi.nlm.nih.gov/37438347/
19	Artificial intelligence	[Ecological Risk and Health Risk of Heavy Metal P	{'i': 'P', '#text': 'In order to understand the heavy metal co	['Zhang Shu-Min', 'Liu Cui-Ling', 'Yang Gui-Ling', 'Deng Mei-H	https://pubmed.ncbi.nlm.nih.gov/37438312/
20	Artificial intelligence	How much can we rely on artificial intelligence c	[{'@Label': 'UNLABELLED', '#text': 'STATEMENT OF\xa0PRC	['Dashti Mahmood', 'Londono Jimmy', 'Ghasemi Shohreh', 'M	https://pubmed.ncbi.nlm.nih.gov/37438164/
21	Artificial intelligence	The perils and promises of generative artificial in	Generative artificial intelligence (AI) holds great promise	['Ray Tyler R', 'Kellogg Ryan T', 'Fargen Kyle M', 'Hui Ferdinan	https://pubmed.ncbi.nlm.nih.gov/37438101/
22	Artificial intelligence	Optimization Research on Wisdom Tree and Tenc	This paper adopts the hybrid online teaching mode of â€	['Cao Yiwen']	https://ieeexplore.ieee.org/document/9973975/
23	Artificial intelligence	Artificial Intelligence Technology Challenges Pat	The artificial intelligence revolution has brought unprece	['Shuijing Hu', 'Tao Jiang']	https://ieeexplore.ieee.org/document/8669605/
24	Artificial intelligence	IEEE Standard Adoption of Moving Picture, Audio	This standard adopts MPAI AI Framework (MPAI-AIF) Tech	No authors listed	https://ieeexplore.ieee.org/document/10112600/
25	Artificial intelligence	IEEE Approved Draft Standard - Adoption of Movi	This standard adopts MPAI AI Framework (MPAI-AIF) Tech	No authors listed	https://ieeexplore.ieee.org/document/9984142/
26	Artificial intelligence	Goal-oriented requirements analysis and an exte	An artificial intelligence programming contest with game	['Kazunori Sakamoto', 'Hiroaki Hosono', 'Seiji Sato', 'Hironori	https://ieeexplore.ieee.org/document/6632587/
27	Artificial intelligence	On the Emergence of Autonomous Systems towa	Thinking and inference are key essences of human intelli	['Yingxu Wang']	https://ieeexplore.ieee.org/document/9811299/
28	Artificial intelligence	Research on the Application of Artificial Intellige	All articles must contain an abstract. The abstract text sho	['Xianjuan Shang', 'Changhong Zhao']	https://ieeexplore.ieee.org/document/9421442/
29	Artificial intelligence	Artificial Intelligence in the Judiciary System of S	Artificial intelligence (AI) is one of the prominent techno	['Adel Ismail Al-Alawi', 'Albandri Mohammed A-Lmansouri']	https://ieeexplore.ieee.org/document/10050929/
30	Artificial intelligence	On abstract intelligence and brain informatics: M	Summary form only given. A fundamental challenge for a	['Yingxu Wang']	https://ieeexplore.ieee.org/document/6311158/
31	Artificial intelligence	Preliminary Study on Application of Artificial Inte	With the continuous development of social science and t	['Zichen Zhang', 'Shuo Xu', 'Hawking Yan']	https://ieeexplore.ieee.org/document/9148561/
32	Machine learning	Lecture Notes: Optimization for Machine Learnin	Lecture notes on optimization for machine learning, deriv	['Elad Hazan']	http://arxiv.org/abs/1909.03550v1
33	Machine learning	An Optimal Control View of Adversarial Machine	I describe an optimal control view of adversarial machine	['Xiaojin Zhu']	http://arxiv.org/abs/1811.04422v1
34	Machine learning	Minimax deviation strategies for machine learnir	The article is devoted to the problem of small learning sa	['Michail Schlesinger', 'Evgeniy Vodolazskiy']	http://arxiv.org/abs/1707.04849v1
35	Machine learning	Machine Learning for Clinical Predictive Analytics	In this chapter, we provide a brief overview of applying n	['Wei-Hung Weng']	http://arxiv.org/abs/1909.09246v1
36	Machine learning	Towards Modular Machine Learning Solution Dev	Machine learning technologies have demonstrated imme	['Samiyuru Menik', 'Lakshmish Ramaswamy']	http://arxiv.org/abs/2301.09753v1
37	Machine learning	Recent Advances in Optimal Transport for Machir	Recently, Optimal Transport has been proposed as a prob	['Eduardo Fernandes Montesuma', 'Fred NgolÃ¨ Mboula', 'Ar	http://arxiv.org/abs/2306.16156v1
38	Machine learning	Introduction to Machine Learning: Class Notes 67	Introduction to Machine learning covering Statistical Infer	['Amnon Shashua']	http://arxiv.org/abs/0904.3664v1
39	Machine learning	The Tribes of Machine Learning and the Realm of	Machine learning techniques have influenced the field of	['Ayaz Akram', 'Jason Lowe-Power']	http://arxiv.org/abs/2012.04105v1


PyCharm File Edit View Navigate Code Refactor Run Tools Git Window Help
Sun 16 Jul 17:28
ml-team-project – academic_search_ui.py [ia-team-project]
ia-team-project › academic_search_tool › academic_search_ui.py
agents_code.py
logging_setup.py
academic_search_ui.py
app.log
# import `requests` to make http requests
import requests
# import `csv` to work with .csv extension file type for search results
import csv
# import `xmltodict` to parse XML results from the research report databases into Python dictionaries
import xmltodict
# import `time` to add pauses between request retries and between message queue reporting
import time
# import `queue` to work with message queues for communication between agents
import queue
# import `os` to be able to check operating system's filepaths
import os
# import `xml.etree.ElementTree` to parse the PubMed esearch response to get a list of IDs for articl
import xml.etree.ElementTree as ET
# import logger instance for log messages, see `logging_setup.py` for detailed comments
from logging_setup import logger
# import `QObject` and `pyqtSignal` to set up an `AgentSignals` class for communication messages to t
from PyQt5.QtCore import QObject, pyqtSignal
# build `AgentSignals` class to set up signal messages
# allows for the communication of error messages to be displayed on the User Interface (UI)
aster-droide
class AgentSignals(QObject):
no_result_arxiv = pyqtSignal(str)
no_result_pubmed = pyqtSignal(str)
error_arxiv = pyqtSignal(str)
error_pubmed = pyqtSignal(str)
error_ieee = pyqtSignal(str)
no_result_ieee = pyqtSignal(str)
general_error = pyqtSignal(str)
success = pyqtSignal(str)
# create signal instance to communicate with the UI
agent_signals = AgentSignals()
"""
For both the search agent and the processing agent, document repository have individual methods for s
# import `threading` to allow for asynchronous agent threads
# this allows the agents to work simultaneously and retrieve results quicker
import threading
# import `queue` to work with message queues for communication between agents
import queue
# import `os` to be able to check operating system's filepaths
import os
# import regular expression libray to match filenames when creating the csv
import re
# import `platform` to determine the operating system
import platform
# import `sys` to perform system operations such asx opening and closing applications
import sys
# import `appdirs` to set a base directory for export location
import appdirs
# import required PyQt5 widgets for UI visualisation
from PyQt5.QtCore import Qt, QThread, pyqtSignal, pyqtSlot
from PyQt5.QtWidgets import QApplication, QWidget, QLabel, QVBoxLayout, QHBoxLayout, QLineEdit, QPushButton, \
QCheckBox, QSpinBox, QScrollArea
# import the agent signals for UI info messaging and import all agents
from agents_code import agent_signals, SearchAgent, DataProcessingAgent, DataExportAgent
# import logger instance for log messages, see `logging_setup.py` for detailed comments
from logging_setup import logger
win_width, win_height = 750, 700
aster-droide *
class MainWin(QWidget):
"""
UI main window
"""
"""
create a `pyqtSignal` instance to signal the user search query via the `handle_submit` method to the `SearchAgen
This message is connected to the `receive_search_data` @pyqtSlot in the Worker class. This allows for communicat
between the main UI window and the Worker thread that handles the agents. This way the search query can be passe
to the SearchAgent. Messages are first put in a local `search_button_queue`, before being passed on to the
`search_in_queue` which is passed as an argument to the `SearchAgent` instance running on a thread in the Worker
"""
send_message = pyqtSignal(tuple)
SearchAgent › search()
Worker › run()
Git Run Python Packages TODO Python Console Problems Terminal Services
All files are up-to-date (today 09:20)
567:1 LF UTF-8 4 spaces Python 3.9 (ia-team-project) main

Future Enhancements

- Additional document repositories
- Fully constructed Harvard reference for each result (referencing agent)
- Separate search and processing agents for each repository
- Separate programs for each agent
- “Always looking” option to search for new content for existing search terms
- Batch mode

References

Finin, T., Fritzson, R., McKay, D. & McEntire, R. (1994) 'KQML-a language and protocol for knowledge and information exchange' *13th International Distributed Artificial Intelligence Workshop*. Seattle, WA, 28-30 July. Association for the Advancement of Artificial Intelligence (AAAI). 93-103.

Ramos, L.P. (N.D.) Use PyQt's QThread to Prevent Freezing GUIs. Available from: https://realpython.com/python-pyqt-qthread/ [Accessed 13 July 2023].

stackoverflow (2014) multiprocessing vs multithreading vs asyncio. Available from: https://stackoverflow.com/questions/27435284/multiprocessing-vs-multithreading-vs-asyncio [Accessed 13 July 2023].

Wikipedia (N.N.) Zen of Python. Available from: https://en.wikipedia.org/wiki/Zen_of_Python [Accessed 13 July 2023].