> AI and research

(& how to get stuff done)

@ SOLES AI Workshop
Thursday 28th Nov 2024

Dr. Gordon McDonald
Informatics Team Lead,
Sydney Informatics Hub

THE UNIVERSITY OF SYDNEY
—
Sydney Informatics Hub

informatics.sydney.edu.au/

Sydney Informatics Hub

Sydney Informatics Hub is a Core Research Facility within PVC-RI, enabling excellence in computational and data-driven research through advanced digital infrastructure, expert data consultancy and analytics training.

- *Statistics*
- *Data Science, AI & Software*
- *Research Computing*
- *Bioinformatics*

The University of Sydney

informatics.sydney.edu.au

SIH Training

64 Different offerings, in person, online, and hybrid content in a variety of formats from webinars to interactive workshops.

Attendees at all career levels, from undergraduate students to senior professors, and representation from every Faculty and School.

Partnerships with national organisations like Australian BioCommons: biocommons.org.au/training-cooperative.

Find out more on our training calendar: sydney.edu.au/informatics-hub/training. Or stay up to date with our newsletter.

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Statistics	Data Science	Research Computing	Bioinformatics	Events
Fundamentals	Machine Learning	High Performance Computing	'omics Techniques	Hacky Hour
Modelling	Visualisation	Cloud Computing	Reproducible Pipelines	Summer Schools
Specialist	Natural Language Processing	Containers	Data Analytics	Coding Challenges
	Geospatial Analysis	Workflows	National Compute Infrastructure	

What is AI?

Generates…

"A friendly koala cyborg"

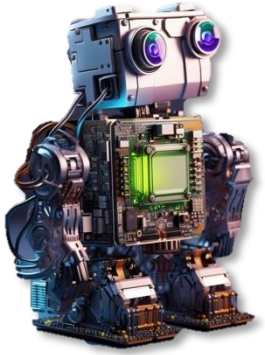
Images, Video

what is the best way to peel a mandarin?

Text

Peeling a mandarin, also known as a clementine or a tangerine, is generally a straightforward process. Here's a simple and efficient method to peel a mandarin:

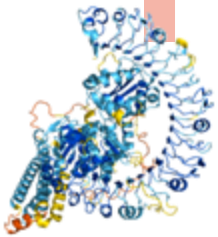
"Hello"



AI

"你好"

Audio

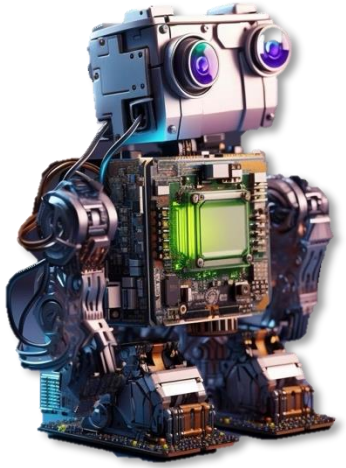


has an internal representation of meaning or content

[0, 1, .5, .2]

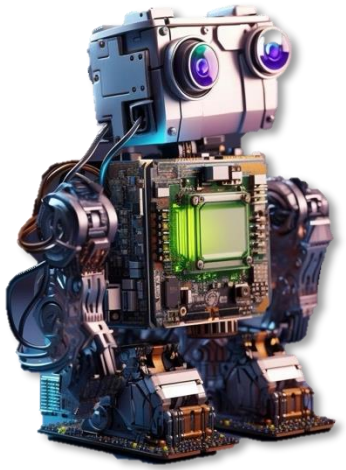
3D structures or molecules

You’re trusting this guy



- He’s doing his best
- But mistakes happen.
- Maybe you should pay him more

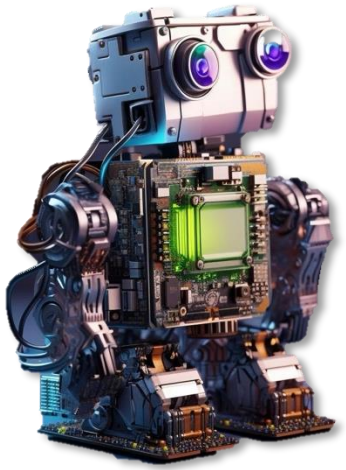
What can he do well?



The boring mindless repetitive bits you give to an RA like

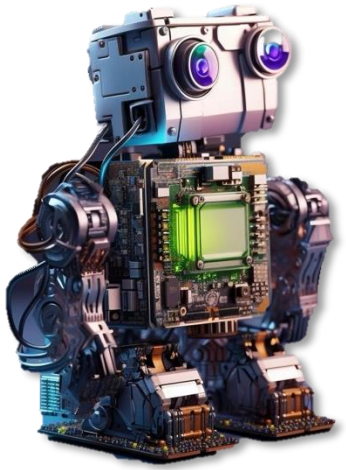
- labelling stuff
- classifying stuff
- turning your vague instructions into concrete actions
- If you can see it, he might. If you can’t, he might have trouble too.

What's going to go wrong?



- Over complication
- Oversimplification
- "best recollection" not absolute truth
- nothing -> average
- lack of diversity of ideas and perspectives

What's not changing?

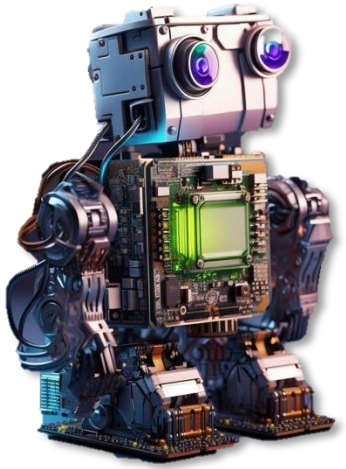


We want to **build** our ideas, **explore** our data, **understand** the world better

We want tools that:

- help us do this efficiently,
- minimize information overload
- don't miss critical parts,
- help us make the important decisions, but not the irrelevant ones.
- let us be the final judge and don't replace our agency

Top tips

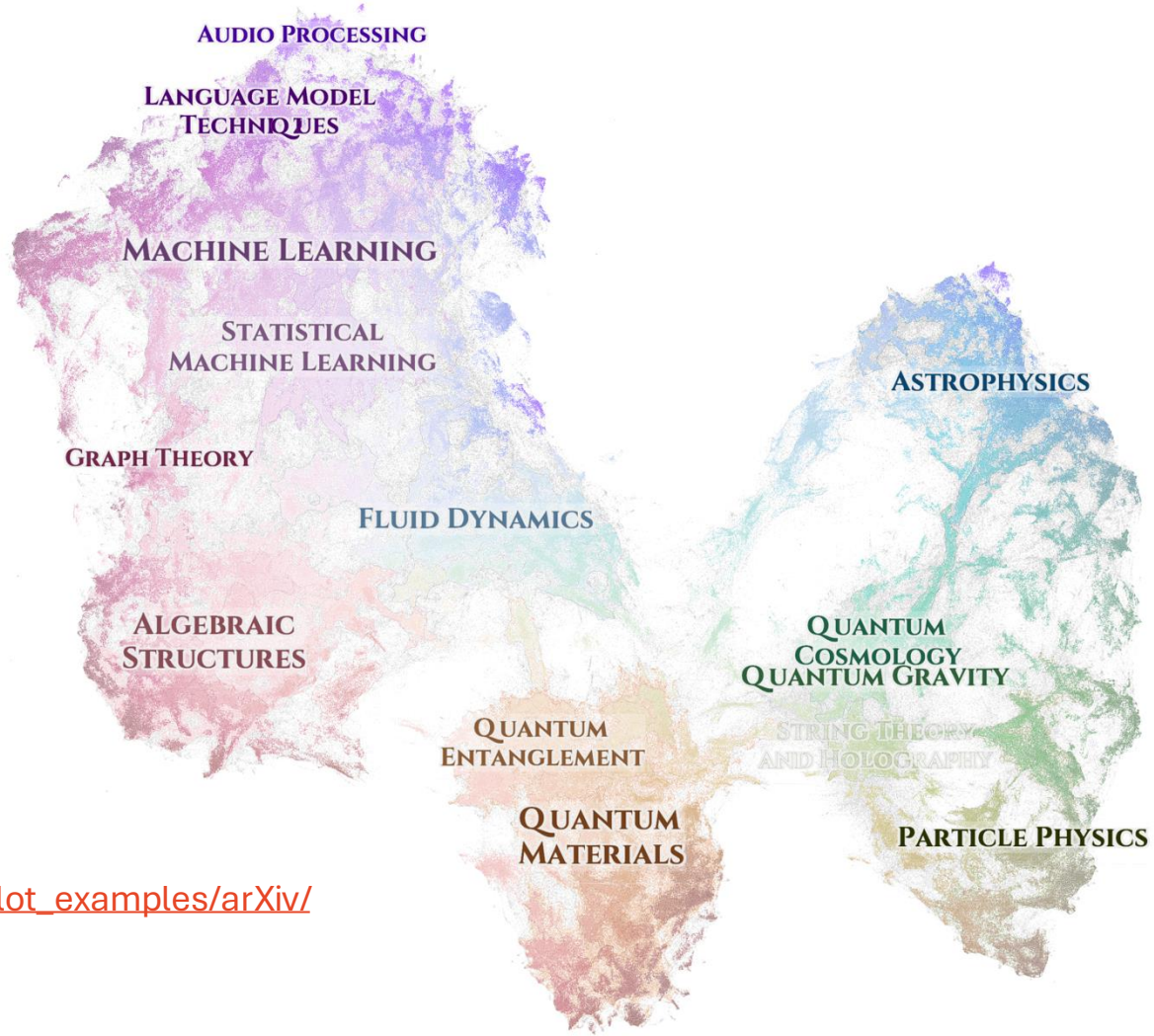


- Be as **specific** as you can about exactly what you want (or ask it to help you refine)
- make sure **private** stuff stays private!
- think carefully about what you **don't** want to automate
- small, **incremental** changes
- **test/check** as you go

Research examples with AI

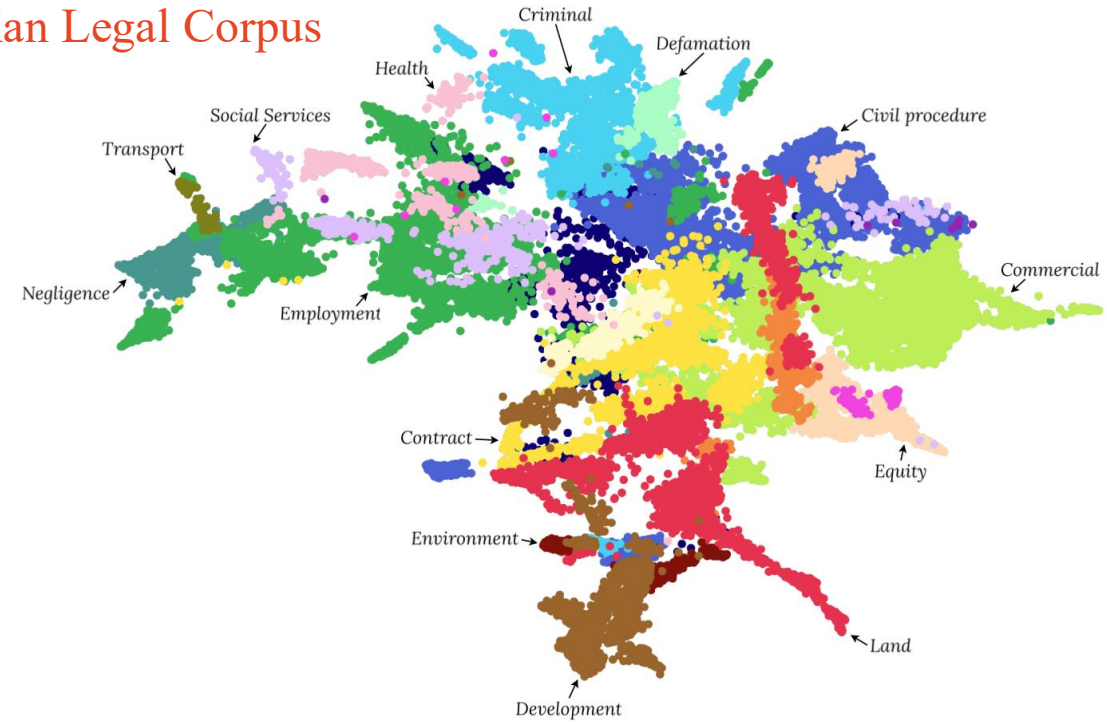
Semantic map of ArXiv

(by the guy who invented UMAP)



lmcinnes.github.io/datamapplot_examples/arXiv/

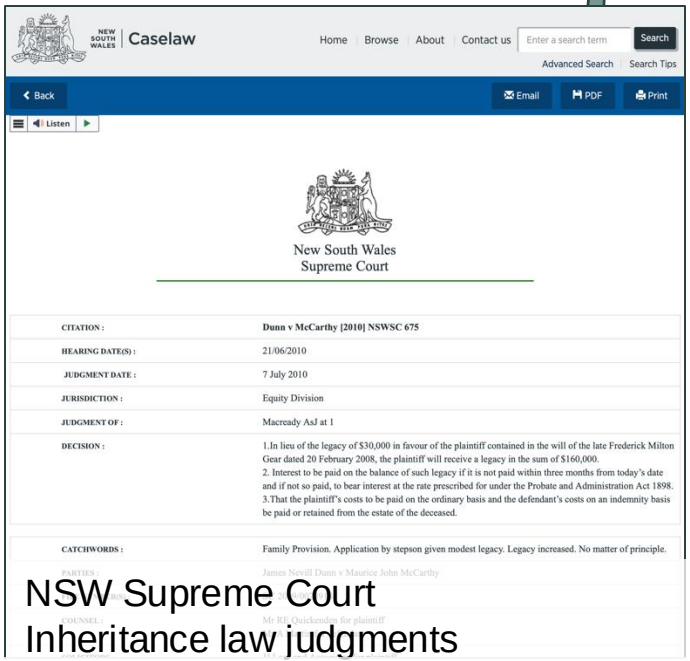
Semantic map of the Open Australian Legal Corpus



umarbutler.com/mapping-almost-every-law-regulation-and-case-in-australia/

Extracting information from text with language models

OpenAI GPT-4o
(May '24)



NSW Supreme Court
Inheritance law judgments

https://www.caselaw.nsw.gov.au/decision/54a004453004262463c948bc

Name	James Nevill Dunn	
Role in trial	Plaintiff	✓
Costs	$40,000 (p6)	✓
Natural person?	true	✓
Relationship to deceased	stepson (p1)	✓
Was dependent on deceased?	partly dependent (p32)	✓
Alleged misconduct?	false	✓
Estranged from deceased?	briefly estranged ~~due to a misunderstanding~~ (p43)	✓ ✗
Financial circumstances	receives a pension of $520 per fortnight, wife earns $800 per fortnight, owns a house with a $15,000 mortgage (p39-40)	✓

Inheritance Case Law – Dr. Ben Chen
SIH: Mike Lynch, Xinwei Luo

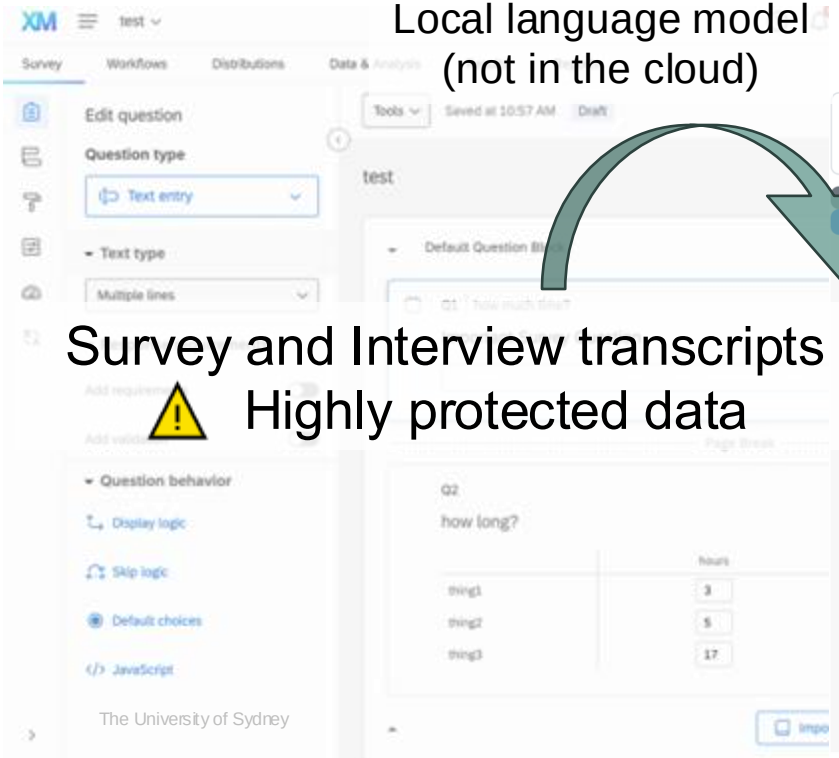
Semantic search on private data

Digital Criminal Justice Project–
Dr. Carolyn McKay

SIH: Nathaniel Butterworth,
Gordon McDonald, Marius Mather
bit.ly/sih_search

Local language model
(not in the cloud)

Survey and Interview transcripts
⚠ Highly protected data



Semantic Query
food

Find

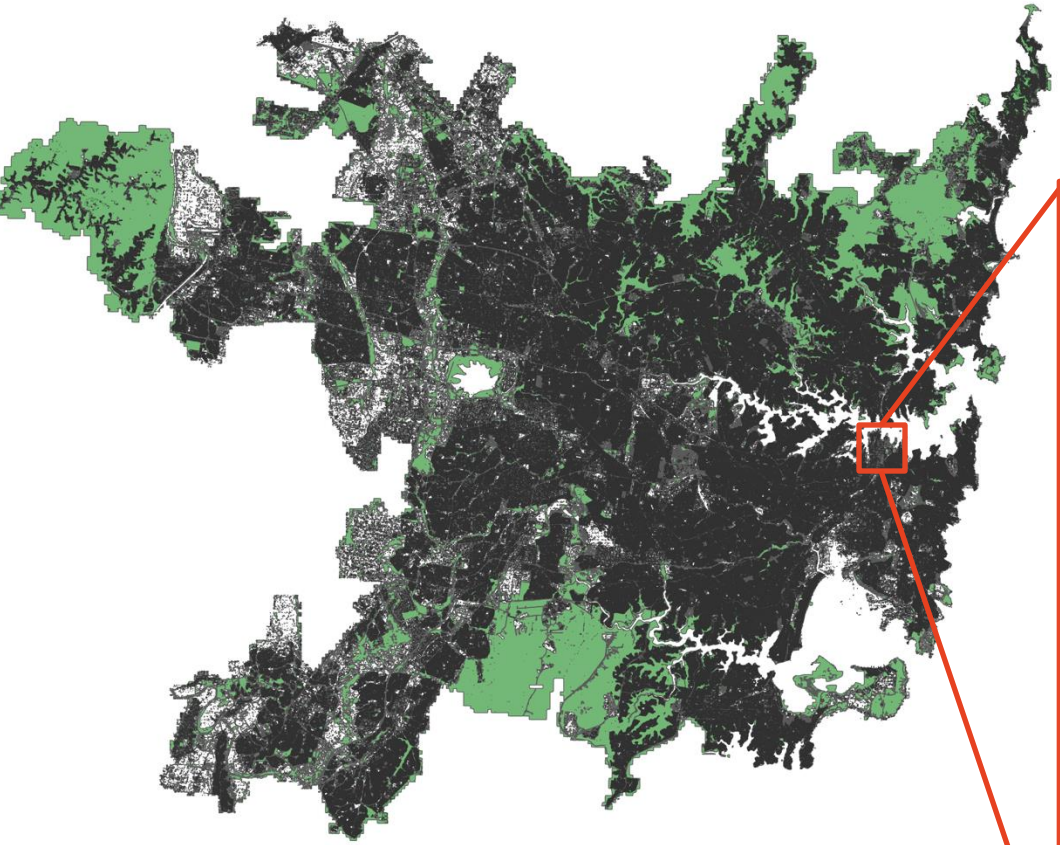
100%

bones; we are going into the forest to cut wood." Then she gave each of them a piece of bread, and said, "That is for dinner, and you must not eat it before then, for you will get no more." Grethel carried the bread under her apron, for Hansel had his pockets full of the flints. Then they set off all together on their way to the forest. When they had gone a little way Hansel stood still and looked back towards the house, and this he did again and again, till his father said to him, "Hansel, what are you looking at? take care not to forget your legs."

"O father," said Hansel, "Iam looking at my little white kitten, who is sitting up on the roof to bid me good-bye." - "You young fool," said the woman, "that is not your kitten, but the sunshine on the chimney-pot." Of course Hansel had not been looking at his kitten, but had been taking every now and then a flint from his pocket and dropping it on the road. When they reached the middle of the forest the father told the children to collect wood to make a fire to keep them, warm; and Hansel and Grethel gathered brushwood enough for a little mountain; and it was set on fire, and when the flame was burning quite high the wife said, "Now lie down by the fire and rest yourselves, you children, and we will go and cut wood; and when we are ready we will come and fetch you."

So Hansel and Grethel sat by the fire, and at noon they each ate their pieces of bread. They thought their father was in the wood all the time, as they seemed to hear the strokes of the axe: but

Greater Sydney Dataset



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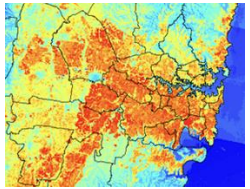
>2 million tree patches
1 million buildings

Understanding cities with computer vision

Prof. Ben Eggleton, NSW Smart Sensing, SIH: Henry Lydecker, Sahand Vahidnia, Thomas Mauch, Xinwei Luo

NSSN
NSW Smart Sensing Network

Urban Heat ML Model



Geospatial Features

Local Climate Zone = “2: Compact Midrise”

(49% class confidence)

Input Image

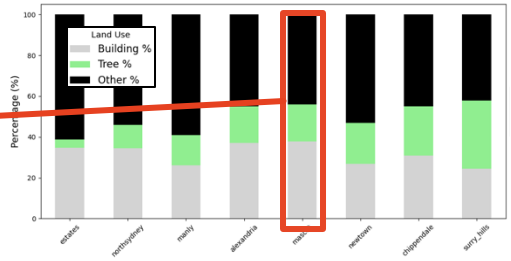
RGB Visual Light Satellite Imagery
Aerial Imagery (Best)

Computer Vision

bit.ly/aigis

Insights, ML, Analysis

Compare neighborhoods

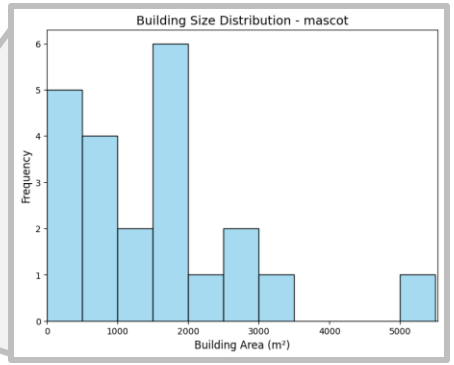


Tree Patches

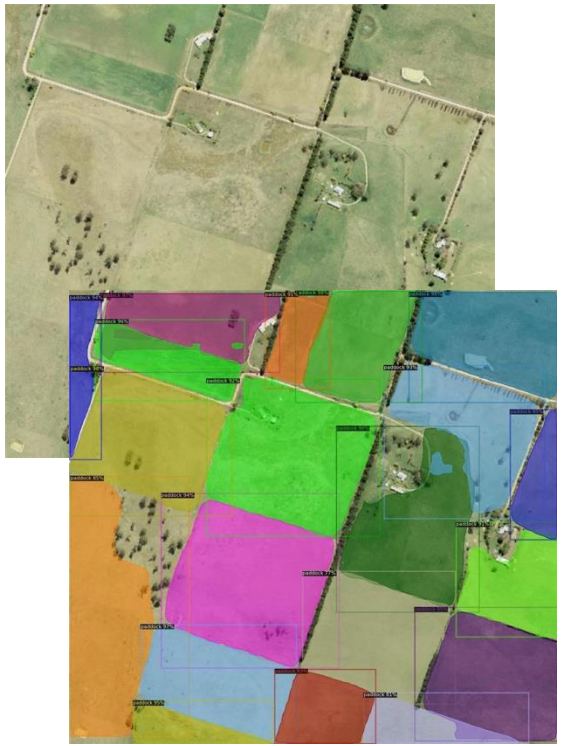
- 101 tree patches
- 15% coverage

Building Outlines

- 22 buildings
- 38% coverage
- building footprint area distribution



Agricultural land use models, urban ecology



Detecting wildlife with NSW National Parks

SIH: Henry Lydecker, Nathaniel Butterworth, Gordon McDonald

Key Highlights

Fine-tuned family of YOLOv5 models on **2.16 million** camera trap images.

Detect and identify up to **72 different species**, with **94% precision** and **95% recall** on the top 33 most common.

GPU-accelerated prediction pipeline **1371x faster** than manual labeling.

Ecological researchers like Dr. Aaron Greenville, conservation agencies, and governments make extensive use of camera traps to monitor wildlife. Processing this data requires an immense amount of time.

We implemented an AI pipeline for automatically detecting & identifying animals in camera trap images, dramatically speeding up speed of data processing.

MICROSCOPY AUSTRALIA

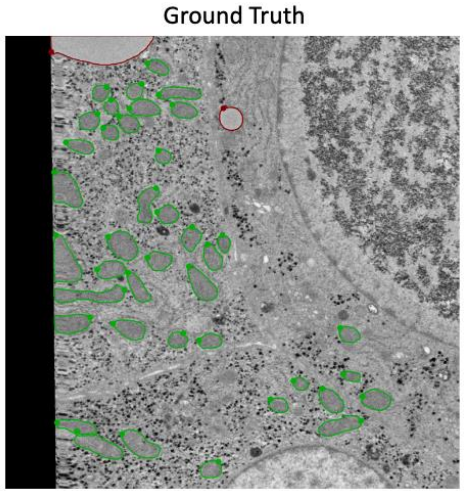
Speeding up microscopy data processing

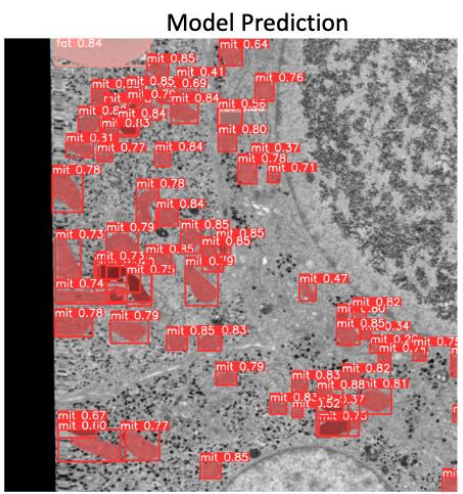
SIH: Sebastian Haan, Nathaniel Butterworth

bit.ly/sih-micro

Key highlights

- Sped up annotation process by up to 10x existing approaches
- Full technology review of existing solutions with best practice solutions provided to clients
- Strategic collaboration between SIH and SMM





Sydney Microscopy & Microanalysis collects immense amounts of data at the micro, nano, & atomic scales. We developed AI pipelines to speed up cell segmentation in electron microscopy images, automating 3D cell tomography.

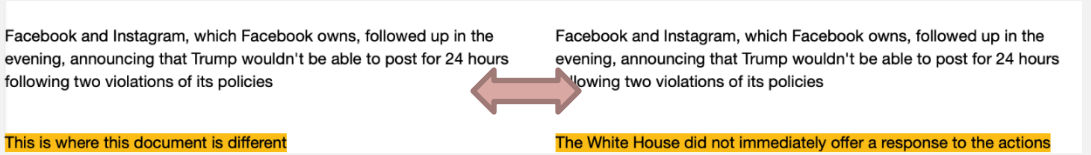
The University of Sydney

SMM: Gerry Shami, Chad Moore, Andre Venne, Eleanor Kable, Prof. Filip Braet

Australian Text Analytics Platform

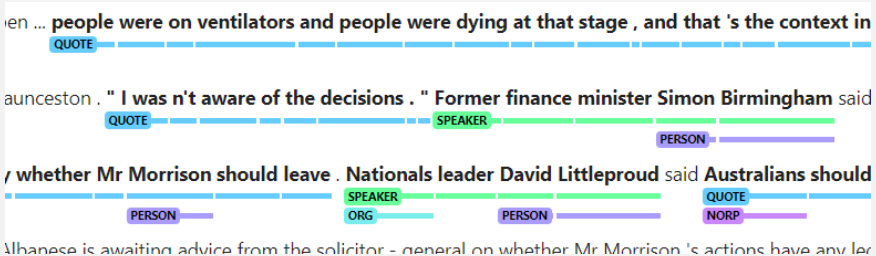
Text analysis tools for all researchers

www.atap.edu.au



Some tools on the platform:

Document and corpus similarity tool
- Compare differences between documents, e.g. to eliminate near-duplicates.



Quotation tool and semantic tagging
- Extract quotes from text e.g. news articles
- www.atap.edu.au/posts/quotation-tool/

Discursis
- An analysis and visualisation tool for conversational data
  www.atap.edu.au/posts/discursis/

Linguistics: Prof. Monika Bendarek
SIH: Dr. Chao Sun, Hamish Croser, Jack Chan, Sony Jufri

Australian Research Data Commons

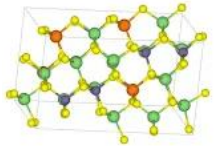
Generative X

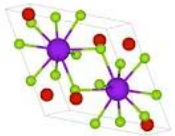
Drug discovery
Design your own chemicals

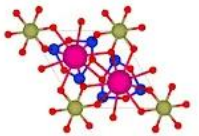
Biology
Design your own protein
synthetic biology

Manufacturing
Design me a diffraction grating / micro resonator / widget with these properties…

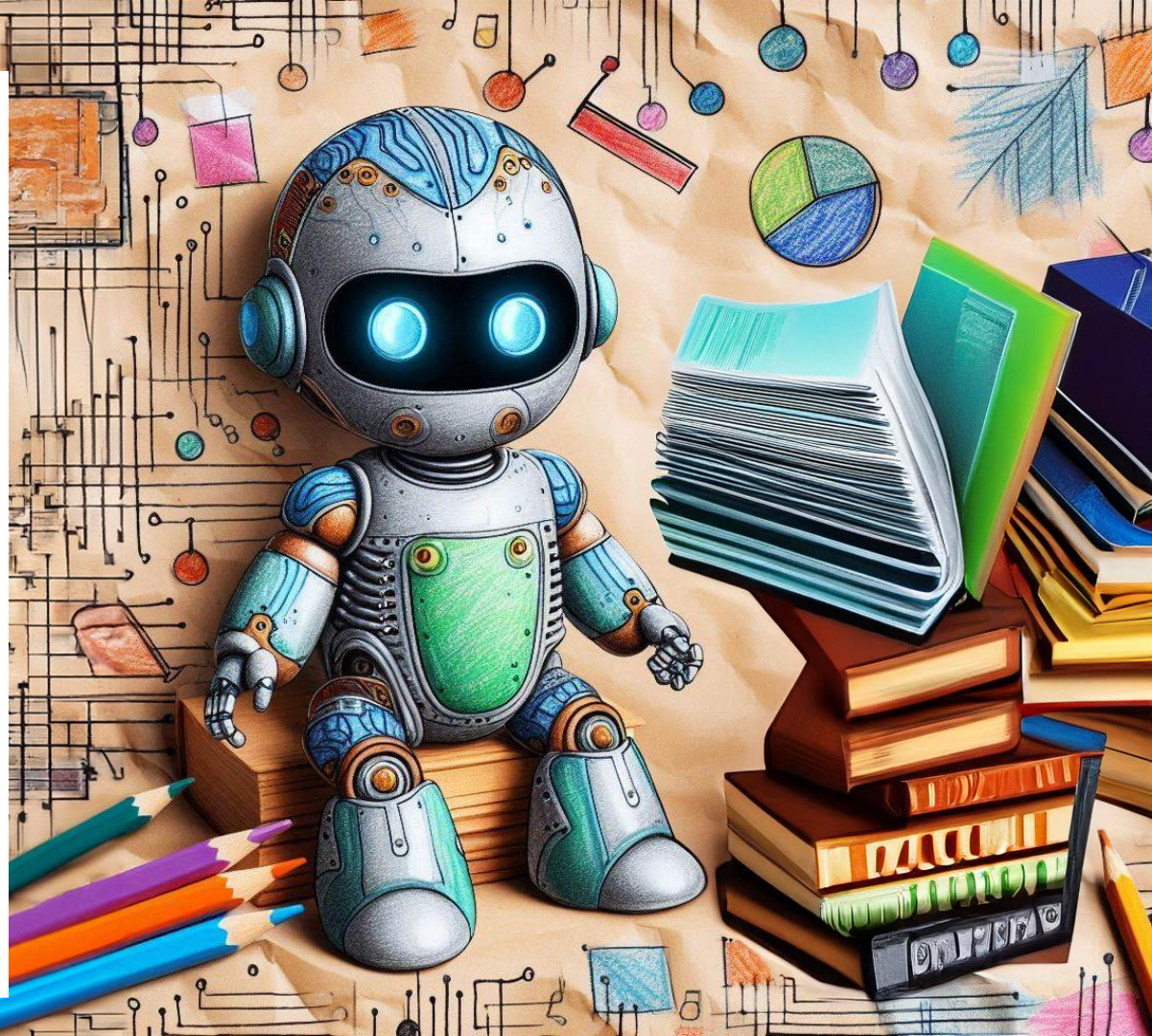
Material discovery
AI mineral discovery and autonomous material synthesis







Source: https://deepmind.google/discover/blog/millions-of-new-materials-discovered-with-deep-learning/



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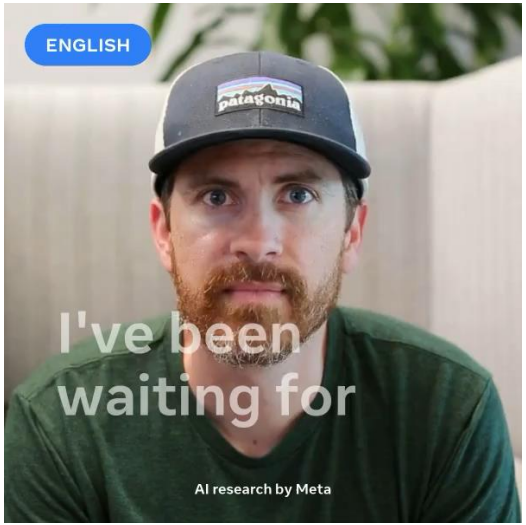
Some Tools and Platforms

Audio

Translate audio between different languages, keeping your tone of voice
https://seamless.metademolab.com/expressive

Generate Speech
https://elevenlabs.io

Generate Music
https://suno.com



On-device video transcription

If you’re on a mac
sindresorhus.com/aiko

Data and model runs in your browser – word level timestamps
huggingface.co/spaces/Xenova/whisper-word-level-timestamps

Data and model runs in your browser – speaker diarization
huggingface.co/spaces/Xenova/whisper-speaker-diarization

If you’re ok with code and installs
github.com/ggerganov/whisper.cpp

(Not on device) Sharepoint automatic video transcription

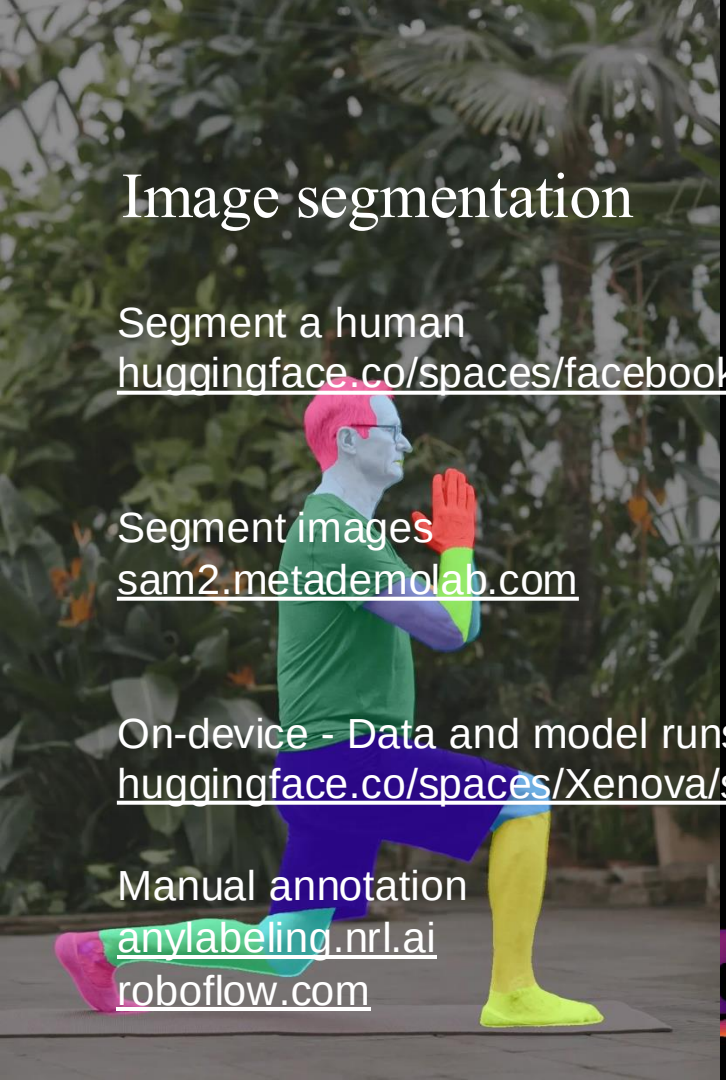
Image segmentation

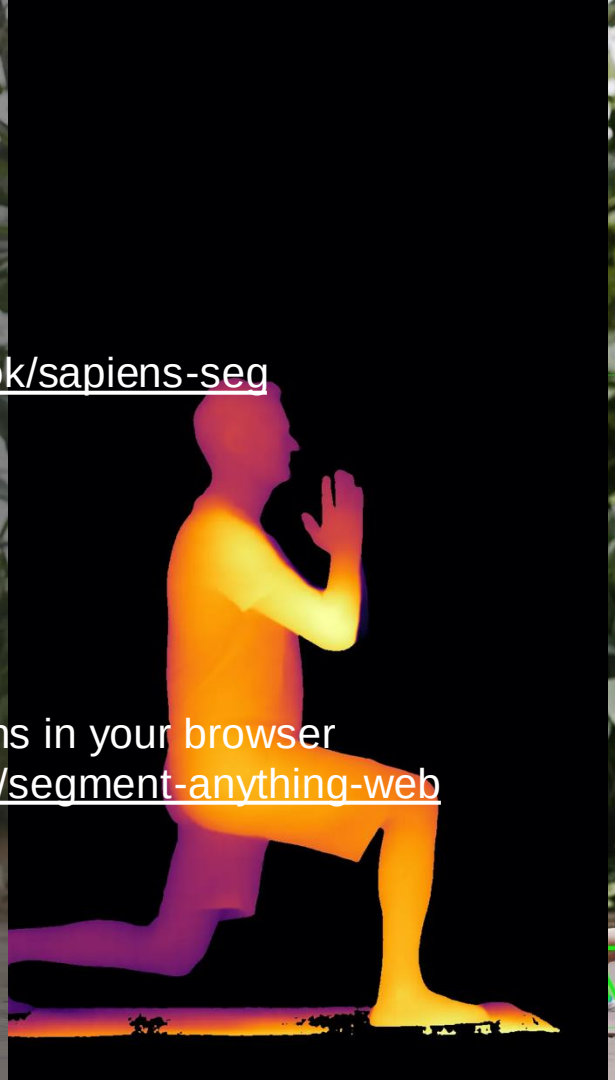
Segment a human
huggingface.co/spaces/facebook/sapiens-seg

Segment images
sam2.metademolab.com

On-device - Data and model runs in your browser
huggingface.co/spaces/Xenova/segment-anything-web

Manual annotation
anylabeling.nrl.ai
roboflow.com





Platforms & Tools

- Huggingface – Open & free tools for AI proof of concepts
- Papers with code – compare state of the art models' performance
- Colab – free Jupyter notebook interface from Google
- Weights & Biases – Model training and evaluation diagnostics
- Roboflow – Very easy to use dataset utilities
- PaddlePaddle - frameworks for AI use cases

Literature Search

Research Rabbit – free for researchers, operates on donation model
Elicit free trial, then $10/month
Rayyan $8/month researcher, $4/month student
Scite Free trial then $13-$22/month
SciSpace
Scopus-AI

Coding assistance

Free (ish)

Aider
Jupyter-AI
Open Interpreter
MetaGPT
Copilot

Paid

ChatGPT
Github Copilot

Best language models to use with these tools now (10-09-24):

- claude-3.5-sonnet (via API)
- gpt-4o (via API)
- DeepSeek 2.5 (via API)
- Local models? (none of them are quite good enough yet to be useful) ☹

Agent building

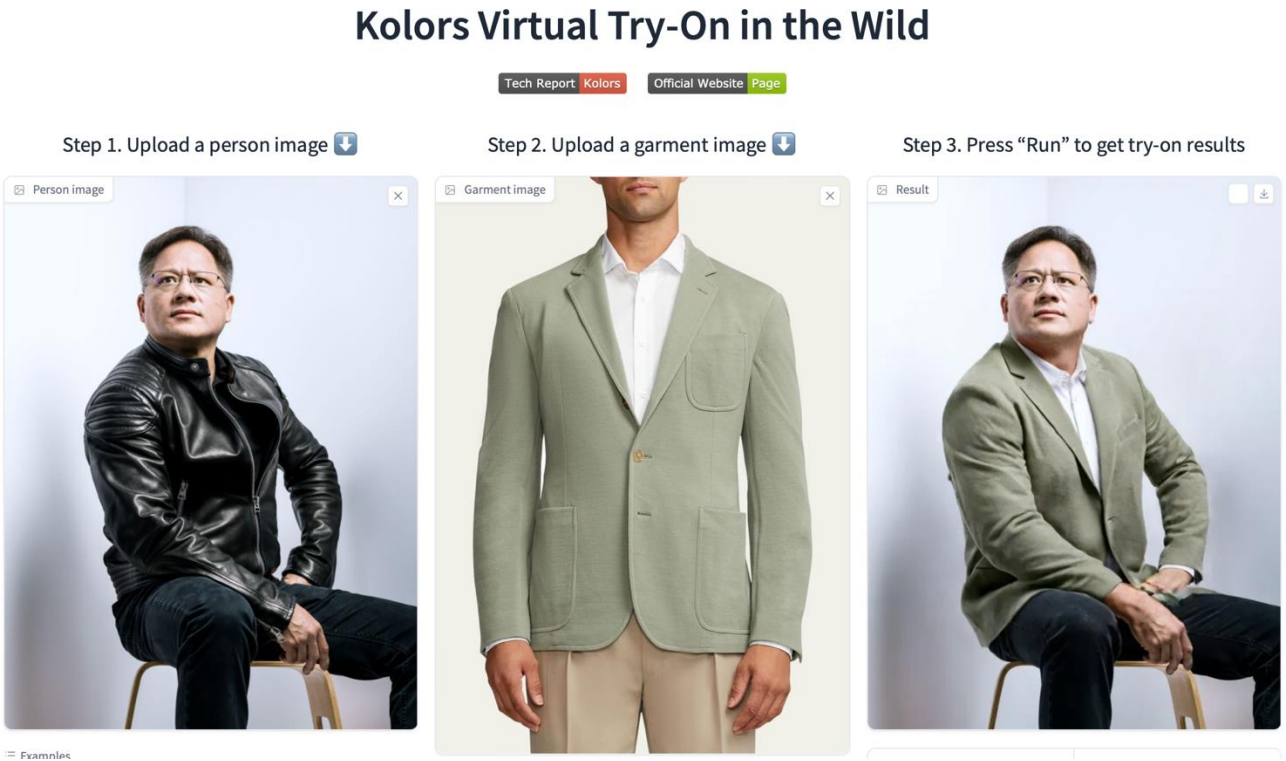
Agents
to reduce
time to science

Free (ish)
Cogniti
Flowise
MetaGPT

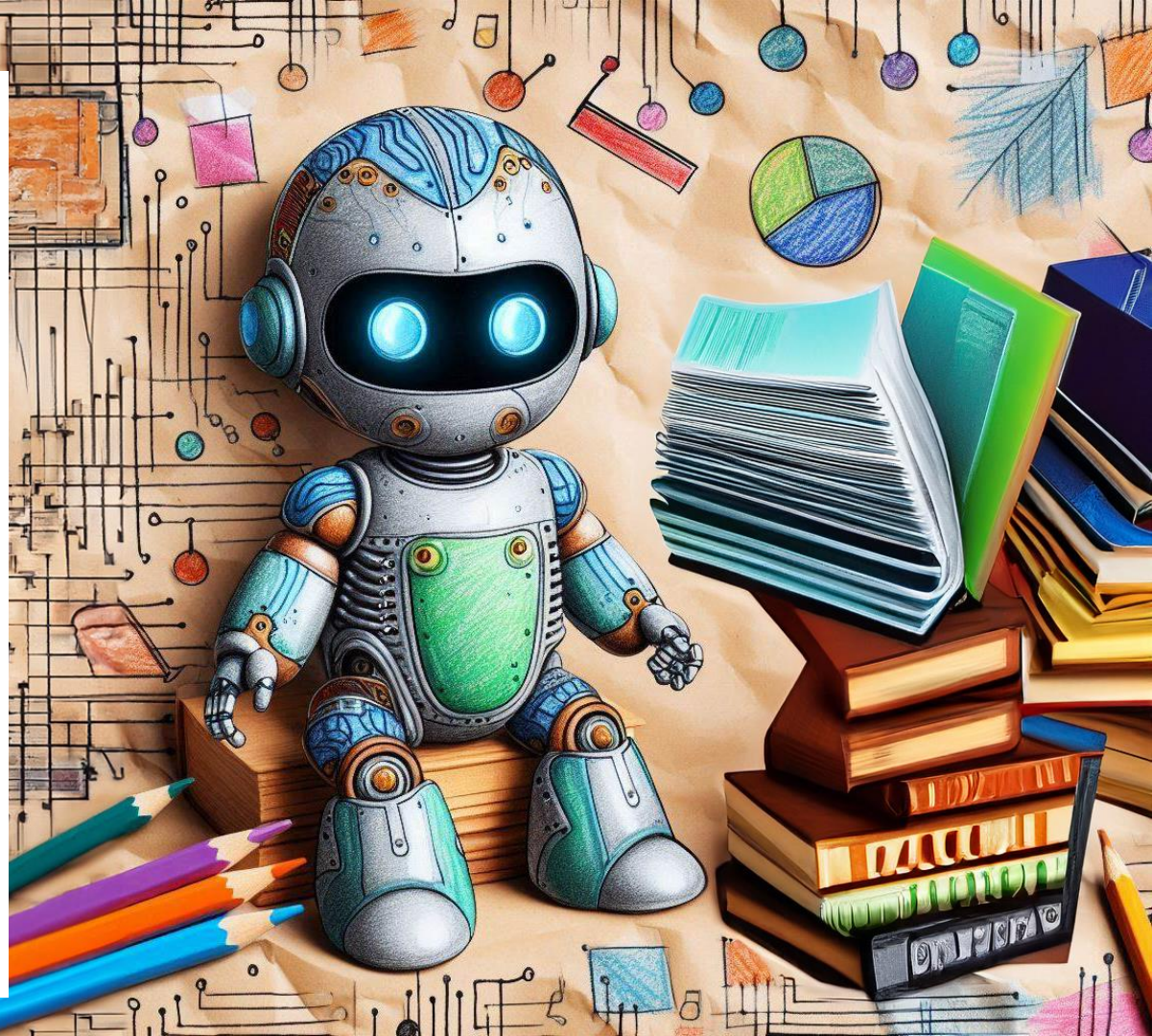
Paid
ChatGPT Custom GPTs
Azure Promptflow

Try on virtual clothes!

To find more new models as they are released:
https://huggingface.co/spaces



https://huggingface.co/spaces/Kwai-Kolors/Kolors-Virtual-Try-On



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