New Ways of Understanding the Past with Generative AI

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Using AI in Historical Fur Trade Research

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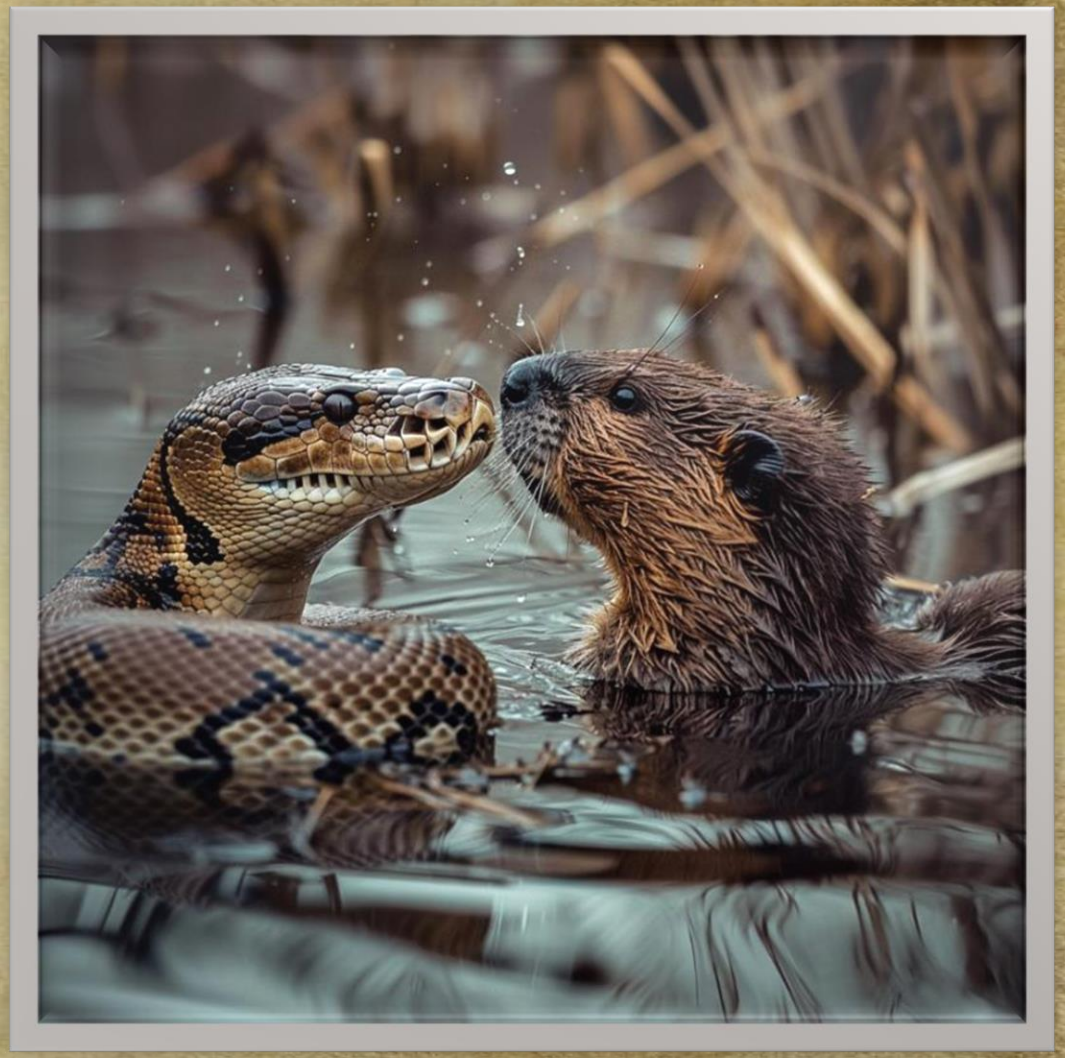

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Canada Research Chair Program Funding
(Dr. Lianne Leddy)

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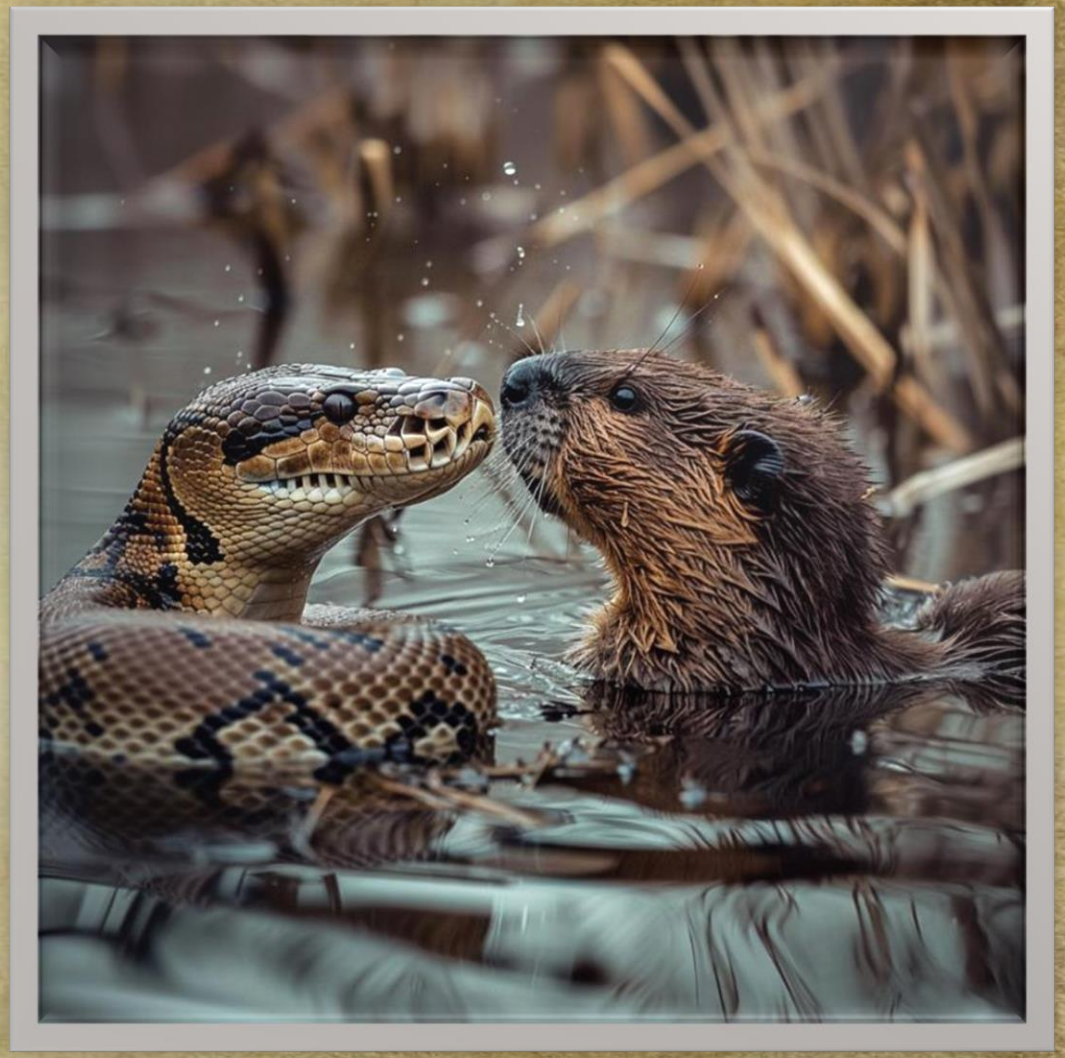
Outline

Brief overview of the historical project and problem

How LLMs Are Trained and Work

Demonstration of PearlBot: The AI Research Assistant

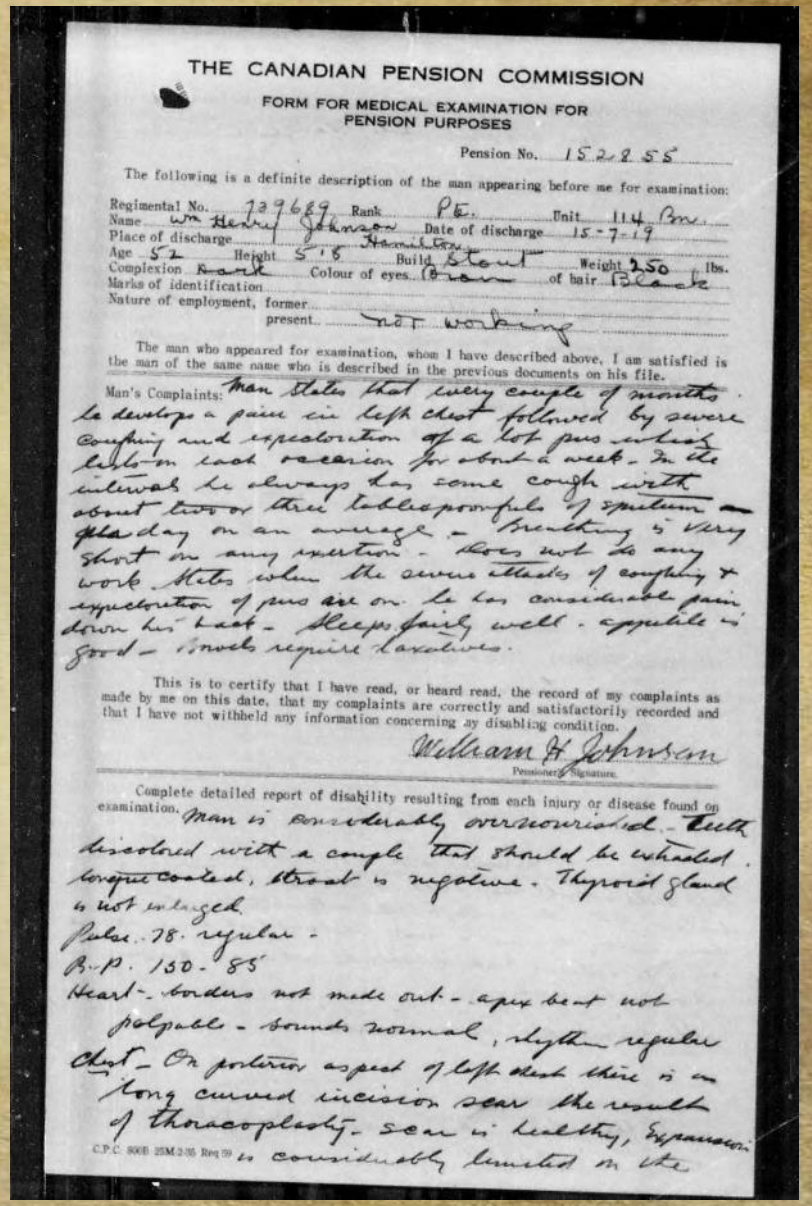
Issues, lessons, and thoughts on AI in historical research



Ordinary People in History

The documents we use to reconstruct the lives of ordinary people are often widely dispersed and perfunctory.

This limits the questions we can feasibly investigate so we develop imperfect workarounds like samples, case studies, etc.



THE CANADIAN PENSION COMMISSION

FORM FOR MEDICAL EXAMINATION FOR PENSION PURPOSES

Pension No. 152255

The following is a definite description of the man appearing before me for examination:

Regimental No. 739689 Rank Pte. Unit 114 Bn.
Name Wm Henry Johnson Date of discharge 15-7-19
Place of discharge Hamilton
Age 52 Height 5'6 Build Stout Weight 250 lbs.
Complexion Dark Colour of eyes Brown of hair Black
Marks of identification
Nature of employment, former
present Not working

The man who appeared for examination, whom I have described above, I am satisfied is the man of the same name who is described in the previous documents on his file.

Man's Complaints: Man states that every couple of months he develops a pain in left chest followed by severe coughing and expectoration of a lot pus which lasts on each occasion for about a week. In the interval he always has some cough with about two or three tablespoonfuls of sputum a day on an average. Breathing is very short on any exertion. Does not do any work. Notes when the severe attacks of coughing & expectoration of pus are on he has considerable pain down his back. Sleeps fairly well. Appetite is good. Bowels require laxatives.

This is to certify that I have read, or heard read, the record of my complaints as made by me on this date, that my complaints are correctly and satisfactorily recorded and that I have not withheld any information concerning my disabling condition.

William H Johnson
Pensioner's Signature

Complete detailed report of disability resulting from each injury or disease found on examination. Man is considerably overnourished. Teeth discolored with a couple that should be extracted. Tongue coated, throat is negative. Thyroid gland is not enlarged.
Pulse 78. regular -
B.P. 150-85
Heart - borders not made out - apex beat not palpable - sounds normal, rhythm regular
Chest - On posterior aspect of left chest there is a long curved incision scar the result of thoracoplasty. Scar is healthy, Expansion is considerably limited on the

C.P.C. 8008 25M 2-35 Req 59

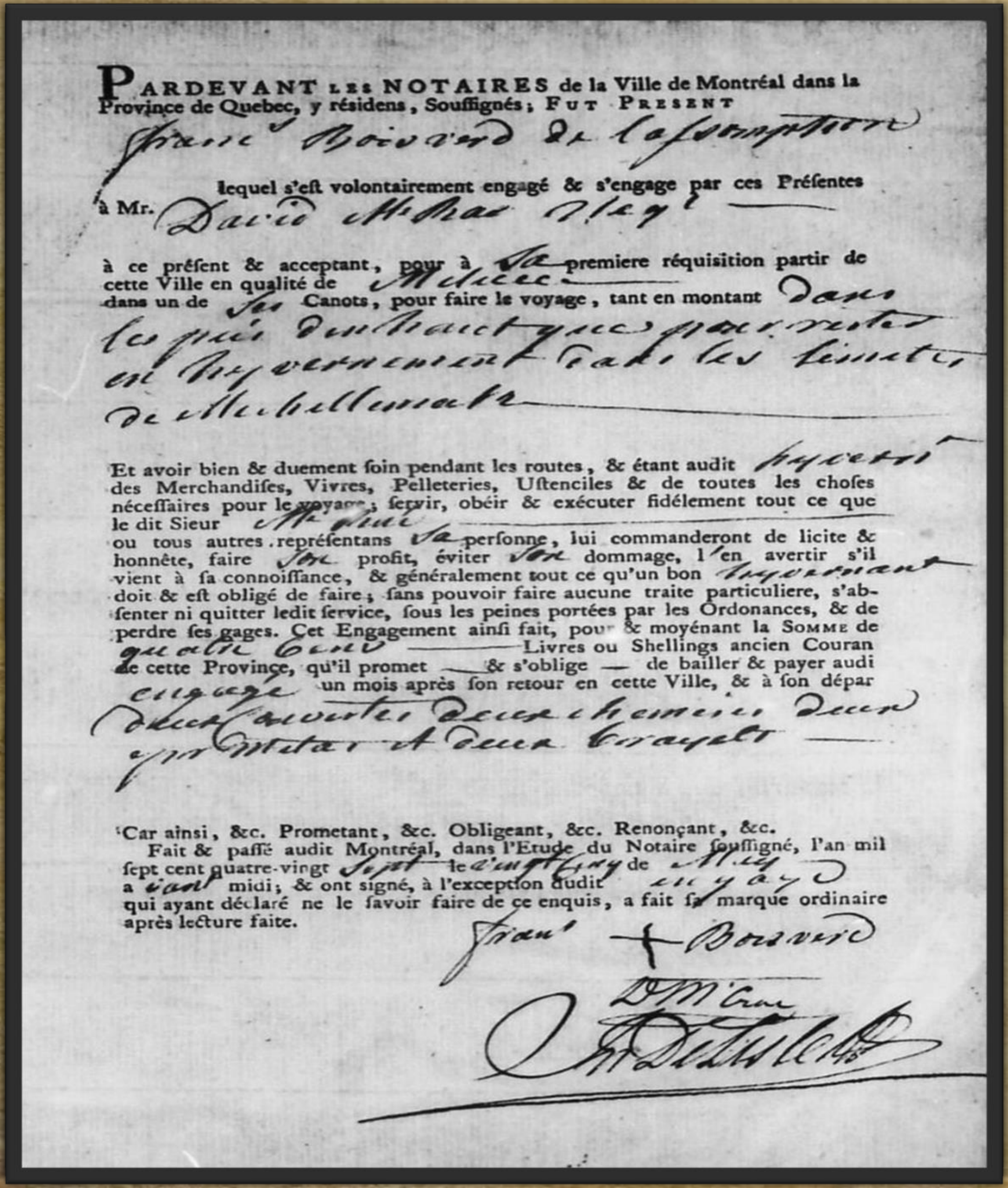
Pension Medical Record, Pte. William Johnson, First World War Pension Files, Veterans Affairs Canada/Laurier Centre for the Study of Canada Archives

Life Histories of Voyageurs

Paul Kane, Encampment, River Winnipeg, 1849, Royal Ontario Museum,

A study of 350 St-Benoit parish voyageurs involving parish records, fur trade contracts, notarial records, post journals, and merchant account books took more than a year of repetitive research.

Alexander Henry biography poses similar challenges.


PARDEVANT les NOTAIRES de la Ville de Montréal dans la Province de Quebec, y résidens, Souffignés; Fut Present

lequel s'eft volontairement engagé & s'engage par ces Préfentes à Mr.

à ce préfent & acceptant, pour à sa premiere réquisition partir de cette Ville en qualité de dans un de ses Canots, pour faire le voyage, tant en montant

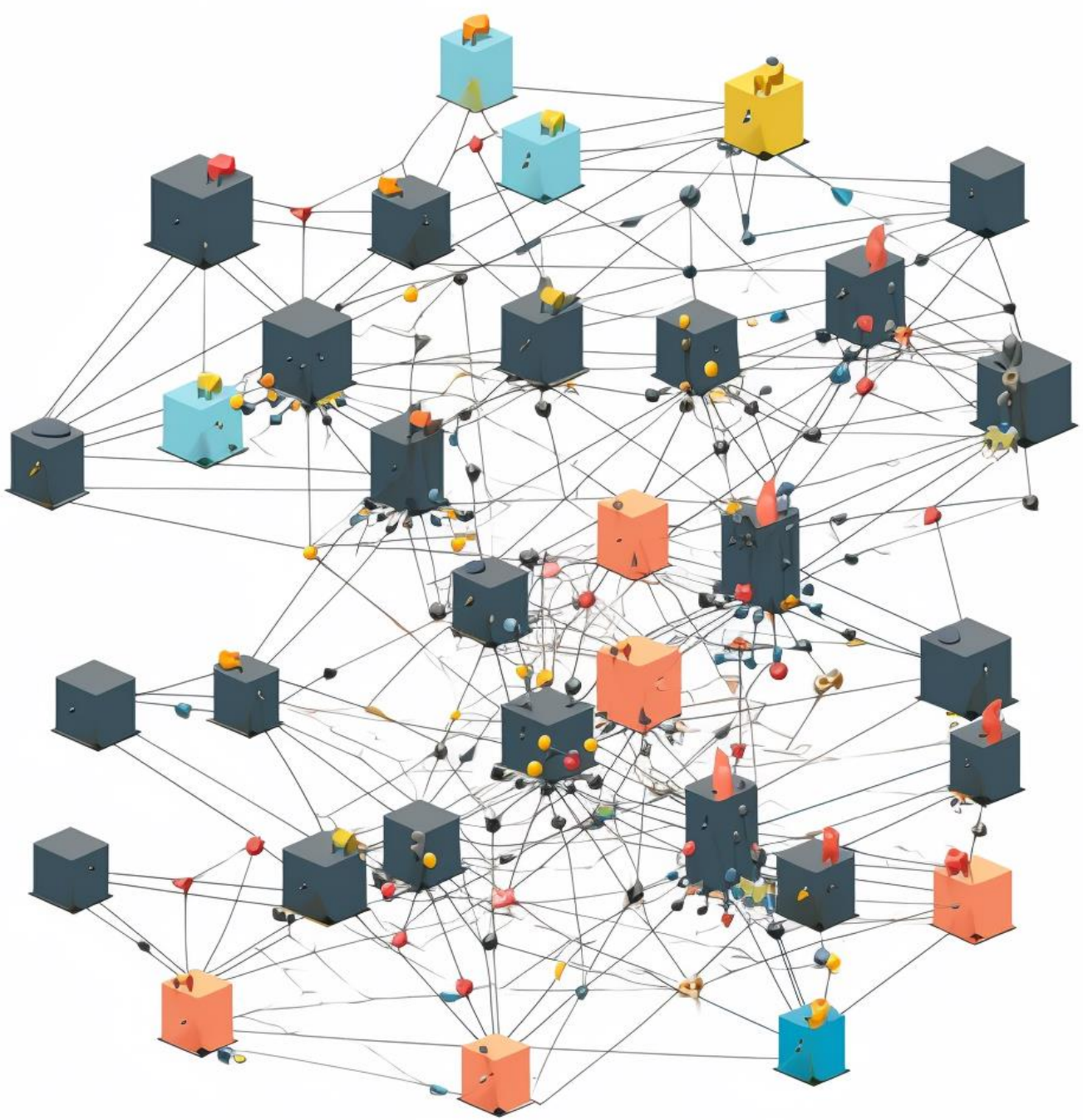
Et avoir bien & duement foin pendant les routes, & étant audit des Merchandifes, Vivres, Pelleteries, Uftenciles & de toutes les chofes néceffaires pour le voyage; fervir, obéir & exécuter fidélement tout ce que le dit Sieur ou tous autres repréfentans sa perfonne, lui commanderont de licite & honnête, faire son profit, éviter son dommage, l'en avertir s'il vient à fa connoiffance, & généralement tout ce qu'un bon doit & eft obligé de faire; fans pouvoir faire aucune traite particuliere, s'abfenter ni quitter ledit fervice, fous les peines portées par les Ordonances, & de perdre fes gages. Cet Engagement ainfi fait, pour & moyénant la Somme de Livres ou Shellings ancien Courant de cette Province, qu'il promet & s'oblige de bailler & payer audi engagé un mois après fon retour en cette Ville, & à fon dépar

Car ainsi, &c. Prometant, &c. Obligeant, &c. Renonçant, &c.
Fait & paffé audit Montréal, dans l'Etude du Notaire fouffigné, l'an mil fept cent quatre-vingt Sept le vingt cinq de May a midi; & ont signé, à l'exception dudit engagé qui ayant déclaré ne le favoir faire de ce enquis, a fait fa marque ordinaire après lecture faite.

<u>Voyageurs & Fur Trade Families</u>

Lianne Leddy (PI) and I are investigating and tracing the lives and kinship networks of large numbers of voyageurs and Indigenous women mentioned in post journals, ledgers, parish records, and fur trade contracts.

Can we use AI to speed up the research process, allowing us to ask new and exciting questions?



Large Language Models (LLMs)

LLMs are transformer based **neural networks** which use extremely complicated statistical processes to generate outputs (called **inference**) in response to user prompts.

Modelled on the human brain, neural networks are arranged in layers of weighted, artificial neurons which process information flowing through the network.

The **weights** are like adjustable knobs which, in combination, control the output.

Modelling Language

Large Language Models (LLMs) are trained on vast amounts of textual data, but contrary to popular belief this is not to learn the actual contents of a text, but to **create a statistical model of the relationships between the components of language** in those texts.

"The best thing about AI is its ability to…"

learn	4.5%
predict	3.5%
make	3.2%
understand	3.1%
do	2.9%

From: Stephen Wolfram, "What Is ChatGPT Doing … and Why Does It Work?", 14 Feb 2023.

Probabilities and Language

If one were to try to build a sentence one word or part of a word—called a **token** (about 4-5 characters)—at a time, we could use our knowledge of existing English texts to calculate the probability that a given word is likely to come next.

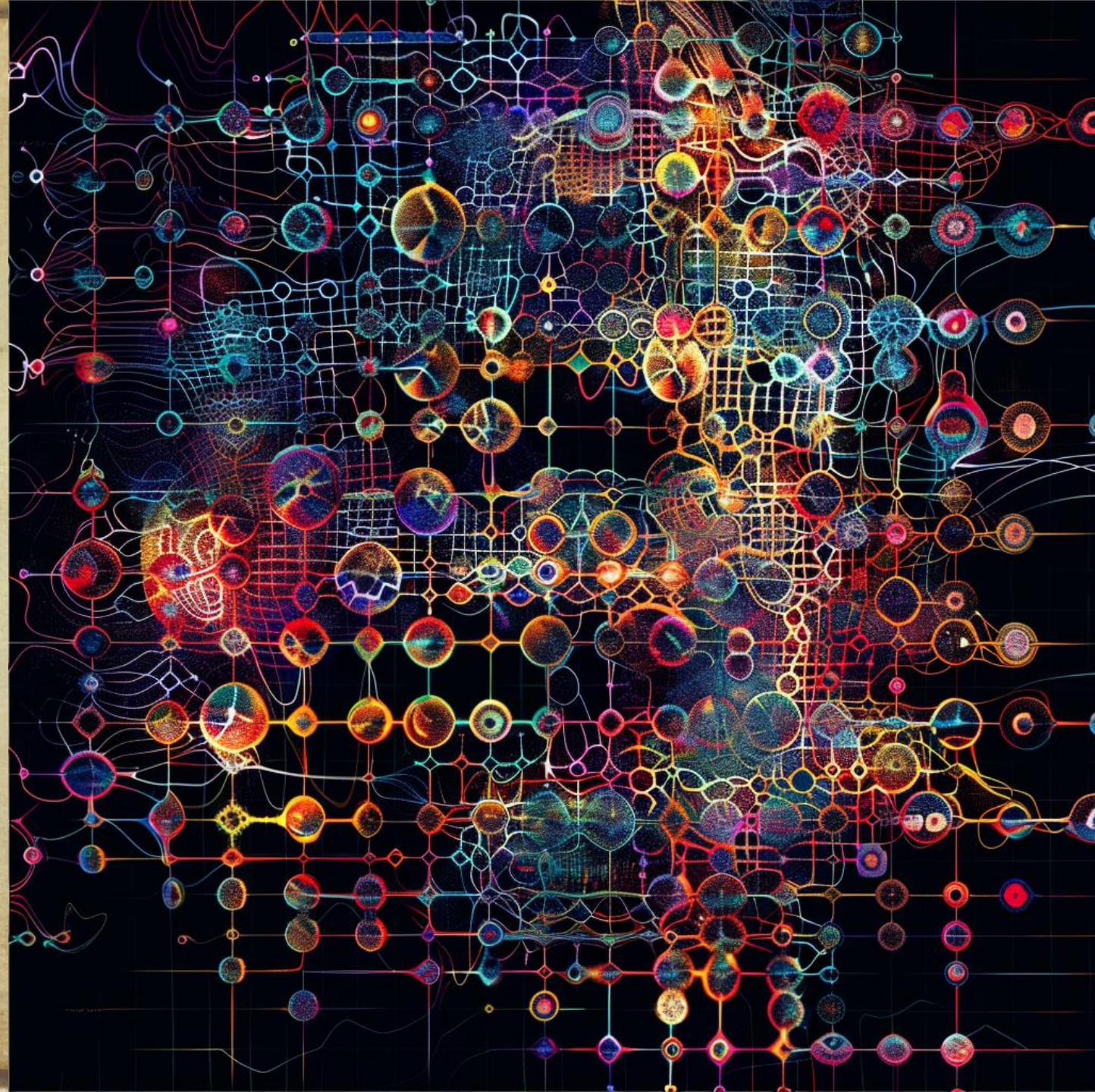
This is how autocomplete works.

Representing Semantic Meaning

But if we want to understand how language actually works, we also need to understand how context can change the meaning of words.

LLMs use numerical representations called **vectors** (embeddings) to graph the relative meaning of words in a multidimensional space.

They learn to “think” about language in numbers



The Training Process

1. Data Collection
2. Model Architecture
3. Initialisation of the Weights
4. Pre-Training Phase
5. Alignment Phase (Fine-Tuning)
6. Safety Testing
7. Deployment

Training Data

GPT-3.5 has 175 billon parameters and took roughly 355 GPU years to train.

Its training data consisted of a combination of a proprietary dataset called WebText2, the Common Crawl dataset, digitized books, and Wikipedia.

The use of some of this data, in WebText2 and Book2 has sparked lawsuits and allegations of copyright infringement.

GPT-3 training data[1]:9

Dataset	# tokens	Proportion within training
Common Crawl	410 billion	60%
WebText2	19 billion	22%
Books1	12 billion	8%
Books2	55 billion	8%
Wikipedia	3 billion	3%

An illustration of how gradient descent and backpropagation might be used to find your way to the lowest point in a hilly landscape

Training LLMs

In training, the LLM is given the task of successfully predicting the next word. Data (text, images, video, etc) is passed through the layers of the model with the final word masked.

At the end of the training run, the prediction is compared to the actual text and an error rate is calculated.

The error rate is then used to adjust the weights in the model (think of making tiny adjustments to a tuning knob) and the process is repeated until the error rate gets acceptably low.

Eugène Delacroix - Lycurgus Consulting the Pythia

All-Knowing-Oracle?

The problem is that this makes the process inherently opaque—we simply don't know what is going on inside of these models.

We can see why people might think that ChatGPT and other **Large Language Models** (LLMs) are all knowing oracles after interacting with them for the first time.

Stochastic Parrots

In once sense, ChatGPT is just a really big, expensive, and fancy version of the autocomplete on your phone.

In essence, it was trained to generate text by adding words (or parts of words called tokens), one bit at a time based on the probabilities it learned during training.

MidJourney's image for the prompt: "a historical photograph of fur traders portaging a canoe".

Limitation of LLMs

Confabulations (Hallucinations)

Biased training data

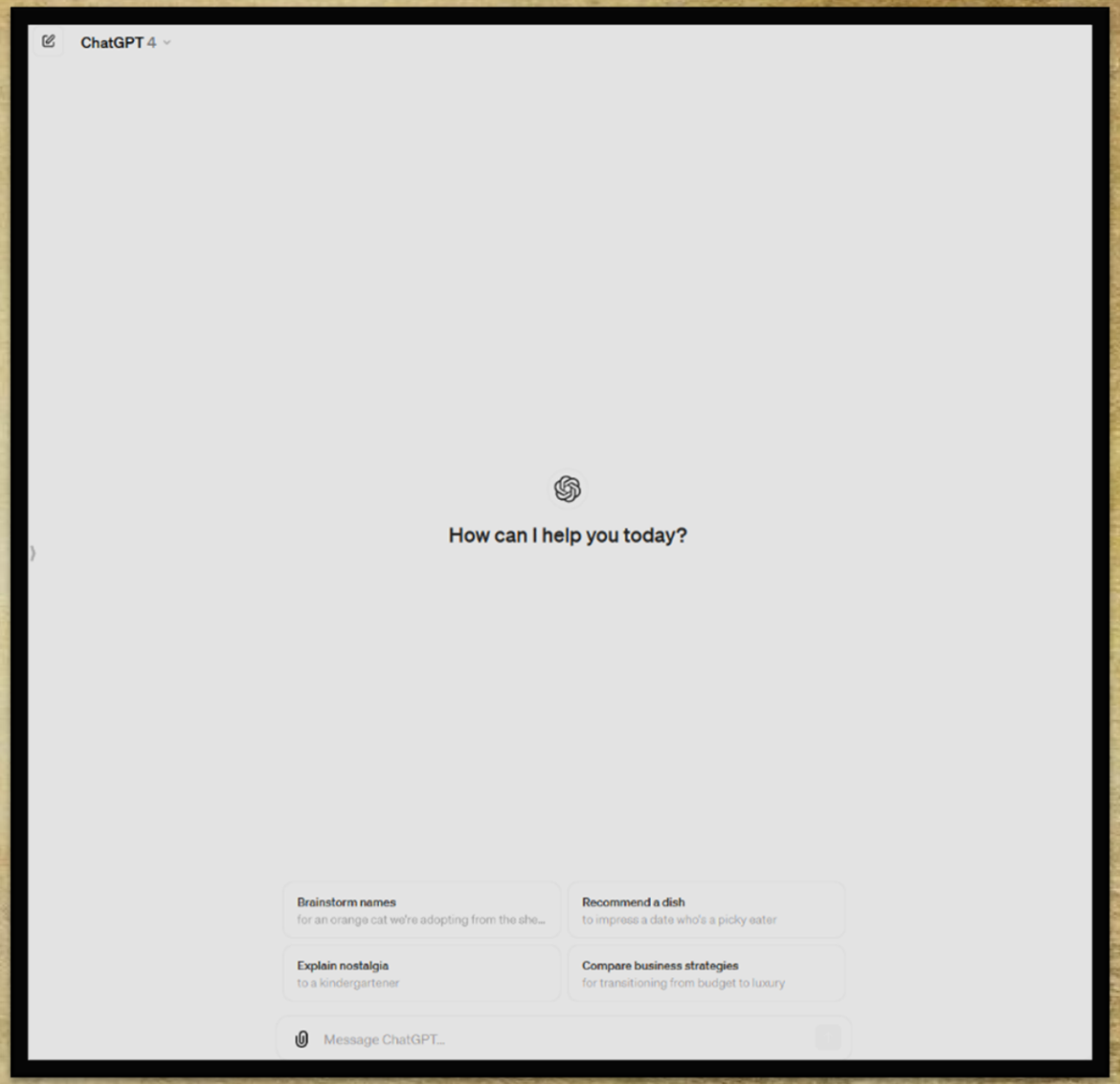
Data security / Copyright

(among others)

ChatGPT vs AI at Scale

Media attention has focused on chatbots like ChatGPT which are powered by LLMs.

Many people don't realize that we can also get LLMs to automatically do all sorts of informational tasks really quickly without ever opening a web browser.



AI in History

AI can be helpful in two main ways:

1. *As a teacher and coder able to assist in the development of Python scripts to automate the linkage and processing of data*

2. *As a virtual research assistant capable of doing a number of time consuming, repetitive tasks.*

PearlBot: Protype AI Historical Research Assistant

A database of roughly a million words of digitized North West Company fur trade journals with plans to significantly expand its scope in the coming months.

Uses GPT-4o and Claude-3.5 to answer questions, individually or automatically.

Works via Retrieval Augmented Generation (RAG) with Hybrid Keyword-Semantic search and re-ranking via fine-tuned GPT-3.5 models…in other words, an elaborate system to give the LLM the right information to answer the question.

Coded in Python.

Building an AI Research Assistant (RAG Pipeline)

1. *Digitize and transcribe sources*
2. *Store information in both conventional and vector databases*
3. *Fine-tune models for coding and retrieving sources*
4. *Find a way to validate the results (both automatically and manually)*

Transcription Pearl

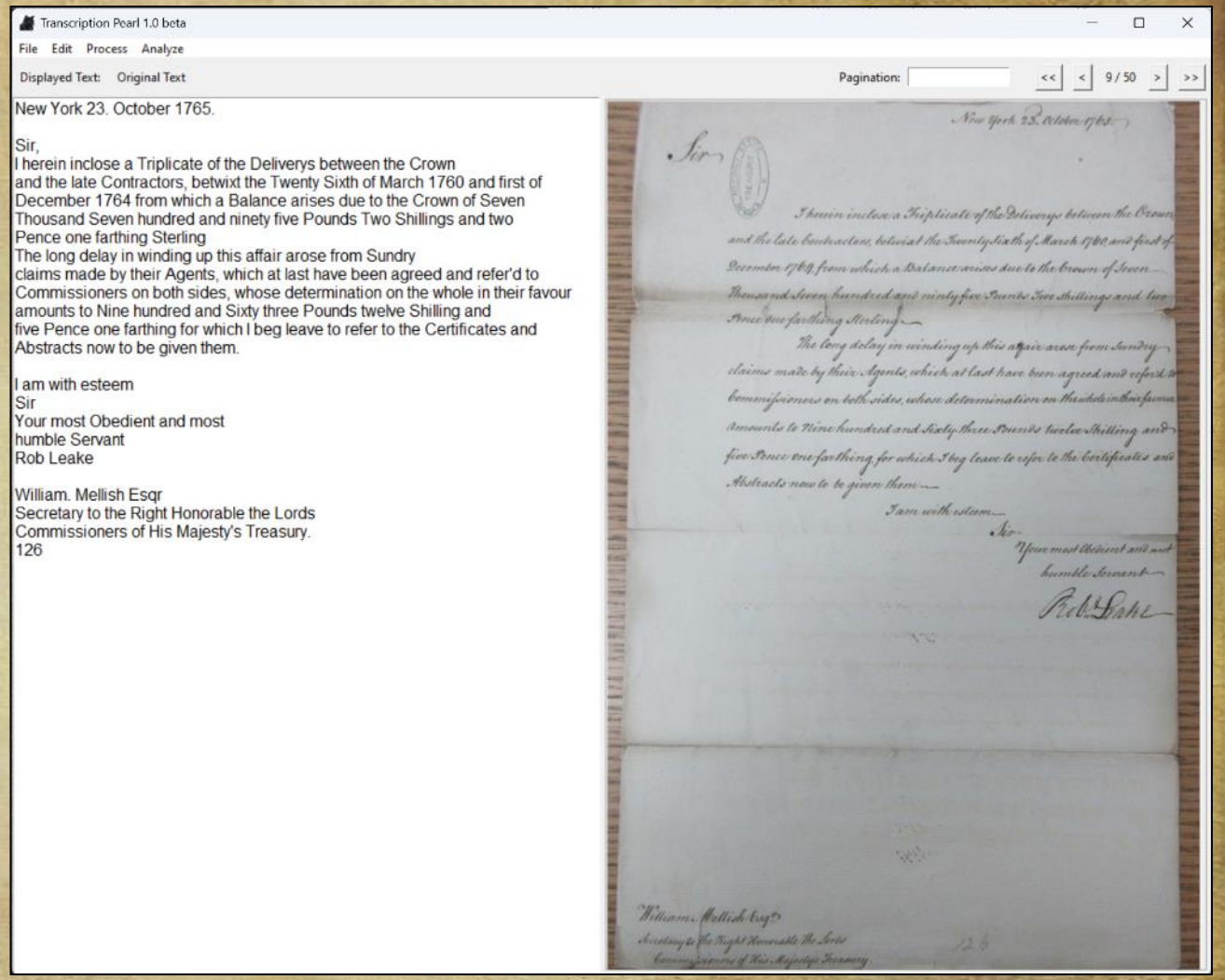
"Intelligent" Transcription and Correction of Handwritten and Typed Text

Automated Organization of Documents

Creation of Finding Aids

Translation

***Transcription Pearl** is available as open-source python code or a standalone executable file at:*
https://github.com/mhumphries2323/Transcription_Pearl



Transcription Pearl 1.0 Beta. You can read our paper on the accuracy of LLM based HTR here:
https://arxiv.org/abs/2411.03340v1

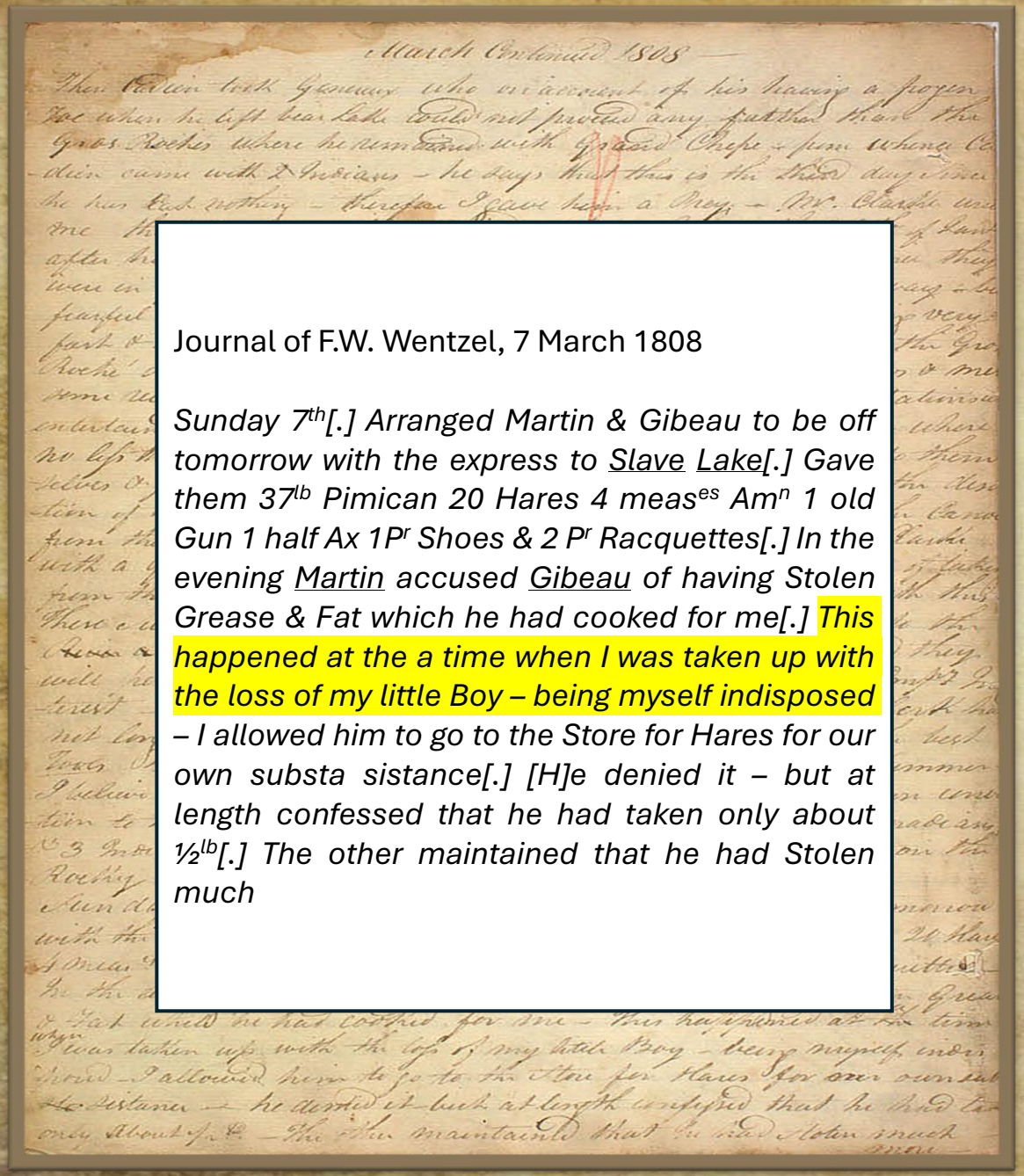
Example of a partial embedding

[...0.0655804, 0.0242895987, -0.0155617073, 0.0324265361, 0.0395482555, -0.0130539546, 0.0208651125, -0.0016336384, -0.000763785152, -0.00604588259, 0.0252290592, 0.00424272474, -0.00737552205, 0.0167890675, -0.00853090733, -0.00795510877, 0.00114212628, 0.00611785753, 0.00414802087, -0.0440031141, -0.0227591861, -0.00966735091, -0.0172436442, 0.0237289518, -0.0069739786, -0.0276989304, -0.0205014516, 0.0182437152, -0.0356085822, -0.0263655018, 0.0453365408, 0.0163193364, 0.0173951704, -0.0059701195, -0.0119932732, -0.0411847346, -0.0373662822, 0.0138191599, -0.0125160376, 0.00858394057, 0.0150540955, 0.00073726807, 0.0410938188, 0.00546250772, -0.000616047415, -0.0231834594, 0.0283959489, -0.00686412212, 0.0320325717, 0.0287596118, -0.0000392428337, 0.0470639393, -0.0277292356, -0.00562539836, -0.0264867228, 0.0248805489, 0.0202135518, 0.00697776675, 0.0156374704, 0.00467836158, 0.00922035, 0.0496701822, 0.0162284207, 0.0147510441, -0.031426467, -0.010281031, -0.0087809246, 0.0180770364, 0.0262291301, -0.00574661884, -0.0129933441, -0.00302483537, 0.0164708626, -0.0306991432, -0.00638681557, 0.0213499963, 0.0107962191, 0.0138873467, 0.0515491031, 0.00927338377, 0.0308506694, -0.0146222468, 0.00793238, -0.0336387455, -0.0242441408, 0.0386391, 0.0156677756, -0.00301725906, -0.00440182677, -0.0176376123, -0.027153438, 0.010621964, 0.0222894568, 0.0315779932, -0.00707625831, -0.0132660903, -0.014675281, 0.0158344544, -0.0128645469, -0.00311196269, 0.0116599165, -0.0203499254, -0.00315173832, 0.00681866426, -0.00369533733, 0.00595875503, 0.0300475806, 0.00127376441, 0.0147586204, -0.0177739859, 0.00329189957, -0.00124345918, -0.0242441408, -0.000620782608, 0.0130084967, 0.019486228, 0.0476094298, 0.0290626641, -0.00622013723, -0.016683, -0.0263655018, -0.0050912695, 0.00562539836, 0.0292747989, 0.016970899, 0.0218651835, -0.0287747644, -0.00204181112, -0.0260321461, 0.0236683413, 0.0219106413, -0.0238501728, -0.0150086386, 0.0134024639, 0.0237138, -0.0144176874, 0.0110538127, 0.0245471913, 0.00343395513, -0.00607997598, 0.031941656, -0.0162284207, 0.00952340104, 0.000752894208, -0.00546629587, -0.0219864044, 0.0239410885, 0.00655728253, -0.0189558864, -0.009303689, -0.00444349647, 0.020925723, -0.0151904691, -0.00244714296, 0.00670502, 0.000451499771, -0.0151601639, -0.0150313666, 0.00568600837, -0.000649193709, 0.0214560647, -0.000943722087, 0.00748537853, -0.0270170644, 0.0315173827, 0.0273655728, 0.0231076963, -0.00778085366, -0.00169803691, -0.00202665851, -0.0269413013, -0.0311840251, 0.00122925371, -0.0048298873, -0.0217288099, 0.0475488193, -0.0316083, -0.00897790864, 0.00135142147, -0.00945521519, -0.0133797349, 0.00862939842, 0.0226076618, 0.00270284293, -0.00815209188, -0.0166072361, 0.0020134002, -0.00203234074, 0.0283656437, 0.00736036943, -0.0302748699, 0.0243805144, -0.0308355168, -0.0110310838, 0.00306839892, 0.00858394057, 0.00100954121, -0.0176982228, -0.011258373, -0.0216227435, 0.0292596463, 0.00925065484, 0.0138646178, -0.024077462, -0.000162061668, -0.041851446, -0.00788692199, -0.0111371521, -0.0155314021, 0.018728599, -0.0176073071, 0.0626711, -0.00138835586, 0.00192532572, -0.0186679885, -0.00731491158, -0.0131297177, -0.00532234646, -0.00377299427, -0.000898737868, 0.00158723362, -0.0196680594, 0.0295323934, -0.0178345963, 0.0230167806, -0.0303809382, 0.0172587968, -0.0205166042, -0.0199711099, 0.00326159457, 0.0230622385, -0.0181679521, 0.0225773565, 0.0113417115, 0.0358813293, 0.00698534306, 0.0491246879, 0.0164405573, -0.0251229908, 0.0184558518, 0.00785661675, -0.00228425255, -0.00411013933, -0.0217439625, -0.0310021937, -0.0129630389, 0.00775812473, 0.0177588332, 0.0306688379, -0.0468518026, -0.0226076618, 0.018410394, -0.00178895239, -0.0197589751, 0.00760659901, -0.0063148411, 0.0117735611, -0.017925512, 0.00214409106, -0.0268049277, -0.00415938534, 0.014894994, 0.0417302251, 0.0181376468, -0.0110386601, 0.0412150398, -0.0146525521, 0.00358548108, 0.0177891385, 0.0206378251, -0.0146449758, 0.024638107, -0.0253351275, -0.000691336812, ...]

Databases

Conventional relational databases store the main body of information and are the backbone of the system.

Vector databases allow us to find documents that are thematically or semantically relevant to a given text.



Journal of F.W. Wentzel, 7 March 1808

Sunday 7th[.] Arranged Martin & Gibeau to be off tomorrow with the express to Slave Lake[.] Gave them 37lb Pimican 20 Hares 4 meases Amn 1 old Gun 1 half Ax 1Pr Shoes & 2 Pr Racquettes[.] In the evening Martin accused Gibeau of having Stolen Grease & Fat which he had cooked for me[.] This happened at the a time when I was taken up with the loss of my little Boy – being myself indisposed – I allowed him to go to the Store for Hares for our own substa sistance[.] [H]e denied it – but at length confessed that he had taken only about ½lb[.] The other maintained that he had Stolen much

Fine-Tuning Models

LLMs do not work all that well with historical documents "out of the box" because of differences in language and the style/format of primary sources.

Fine-tuning an LLM involves teaching it to complete specific types of tasks with historical records, like assigning keywords or determining whether a document is relevant to a query.

Validation

If LLMs are going to be useful, we need to know how well they actually perform on a given task…but how?

Manual validation (e.g. check the sources)

Automated validation

LLMs seem to perform at a similar level to trained humans on many historical tasks

MidJourney's image for the prompt: "a historical photograph of fur traders portaging a canoe"

What AI Research Assistants Can Do Now

Speed up the research process (but only for certain types of history)

Answer questions on your data

Reduce time on side tasks

Information triage system

Find obscured meanings and relationships

Help trace kinship networks

What AI Research Assistants Cannot Do (Yet…)

They cannot not write whole journal articles and books for historians…

They still make mistakes so treat their outputs as you would those of a human RA…and use common sense.

They are not (autonomous) agents capable of undertaking complex research tasks on their own

Final Thoughts

If we use it responsibly, historians can harness AI to broaden the scope of their inquiries to tackle "big projects" that would have been impractical a few years ago

The technical learning curve is steep right now, but will become much more gradual in the coming months and years

New Ways of Understanding the Past with Generative AI

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Using AI in Historical Fur Trade Research

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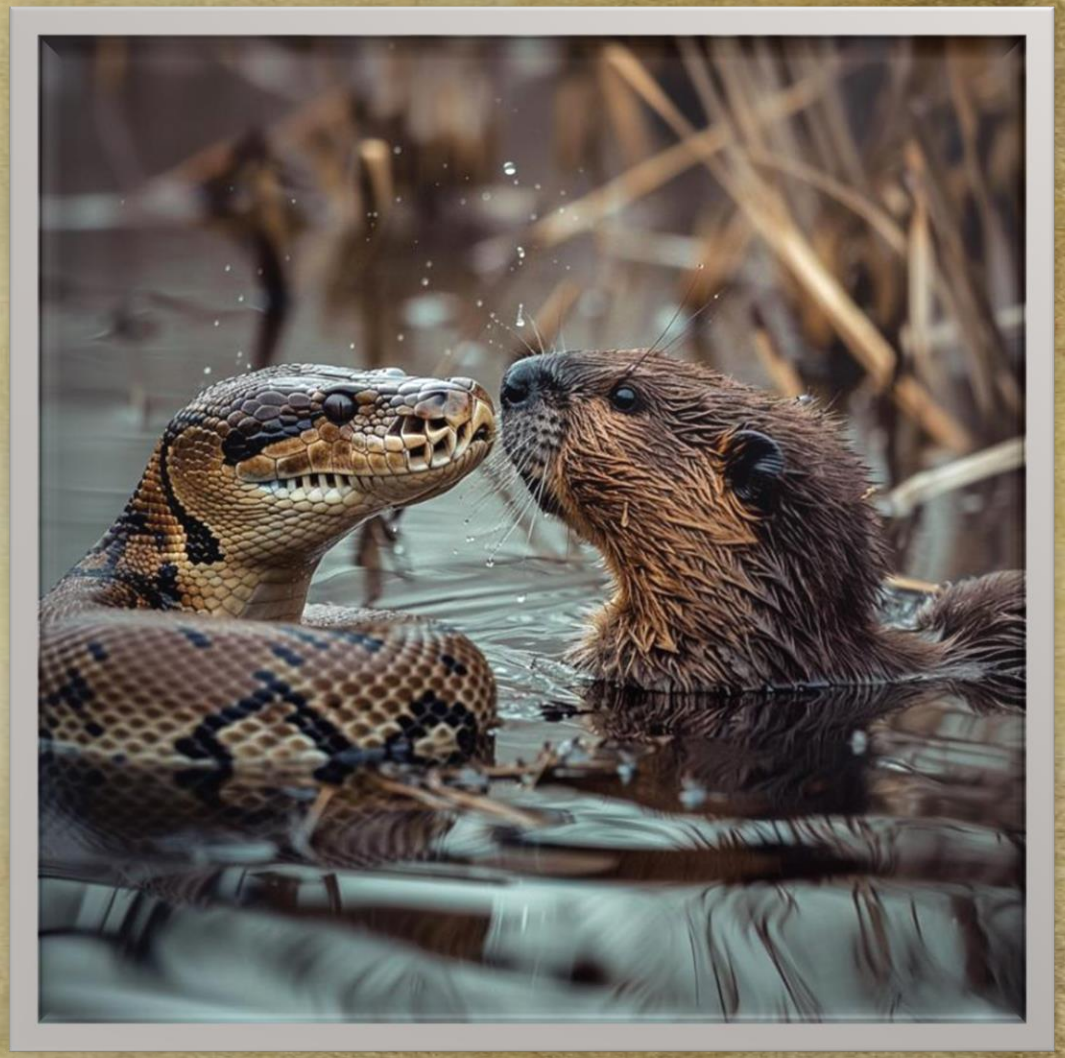

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