University at Buffalo The State University of New York

THE EVOLUTION OF ARTIFICIAL INTELLIGENCE

A perspective on human language communication

December 4, 2024

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LANGUAGE COMMUNICATION

SPEECH

WRITING

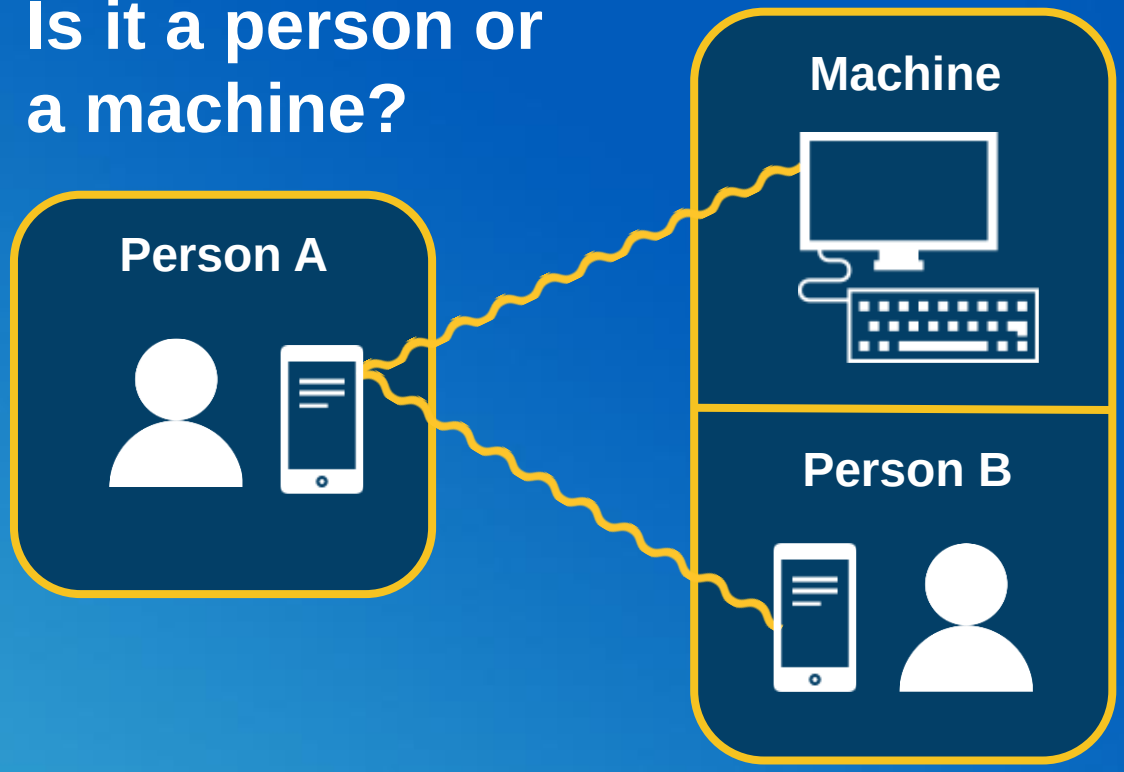
NON-VERBAL

10 emotional states related to learning

- Concentration
- Confusion
- Contemplation
- Disappointment
- Distress
- Doubt
- Interest
- Realization
- Confidence
- Boredom

How do you know a MACHINE is intelligent?

Is it a person or a machine?



Turing Test *['tur-iŋ 'test]*

A method to determine whether a machine can demonstrate human intelligence.

Source: Investopedia

Beyond Turing Test

- Emotions
- Nuance
- Context
- Humor
- Sarcasm
- Perception
- Common Sense

What magical trick makes us intelligent? The trick is that there is no trick. The power of intelligence stems from our vast diversity, not from any single, perfect principle.

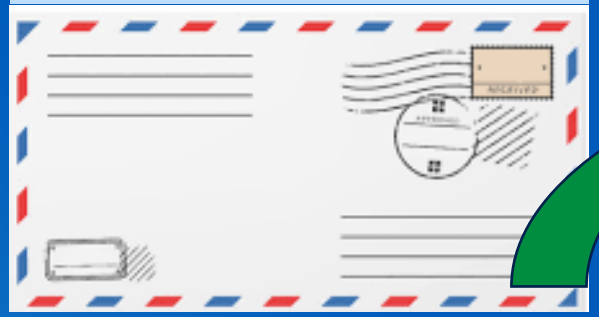
~ *Marvin Minsky, The Society of Mind*

What is intelligence?

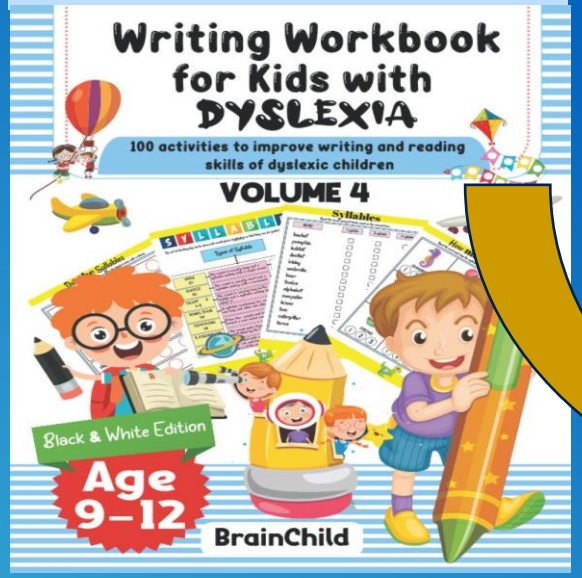
- **Challenges reductionist views**, showing intelligence as emergent from interactions among multiple components.
- **Intelligence is a fluid, adaptable process**, not static or monolithic.
- Encourages **diverse and cooperative interactions among varied agents** for complex goals.
- Emphasizes intelligence as **social and interdependent**, not isolated or predetermined.

Applications Landscape

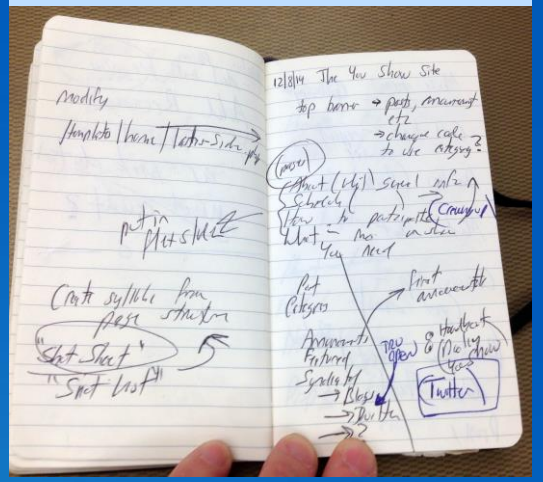
POSTAL APPLICATION



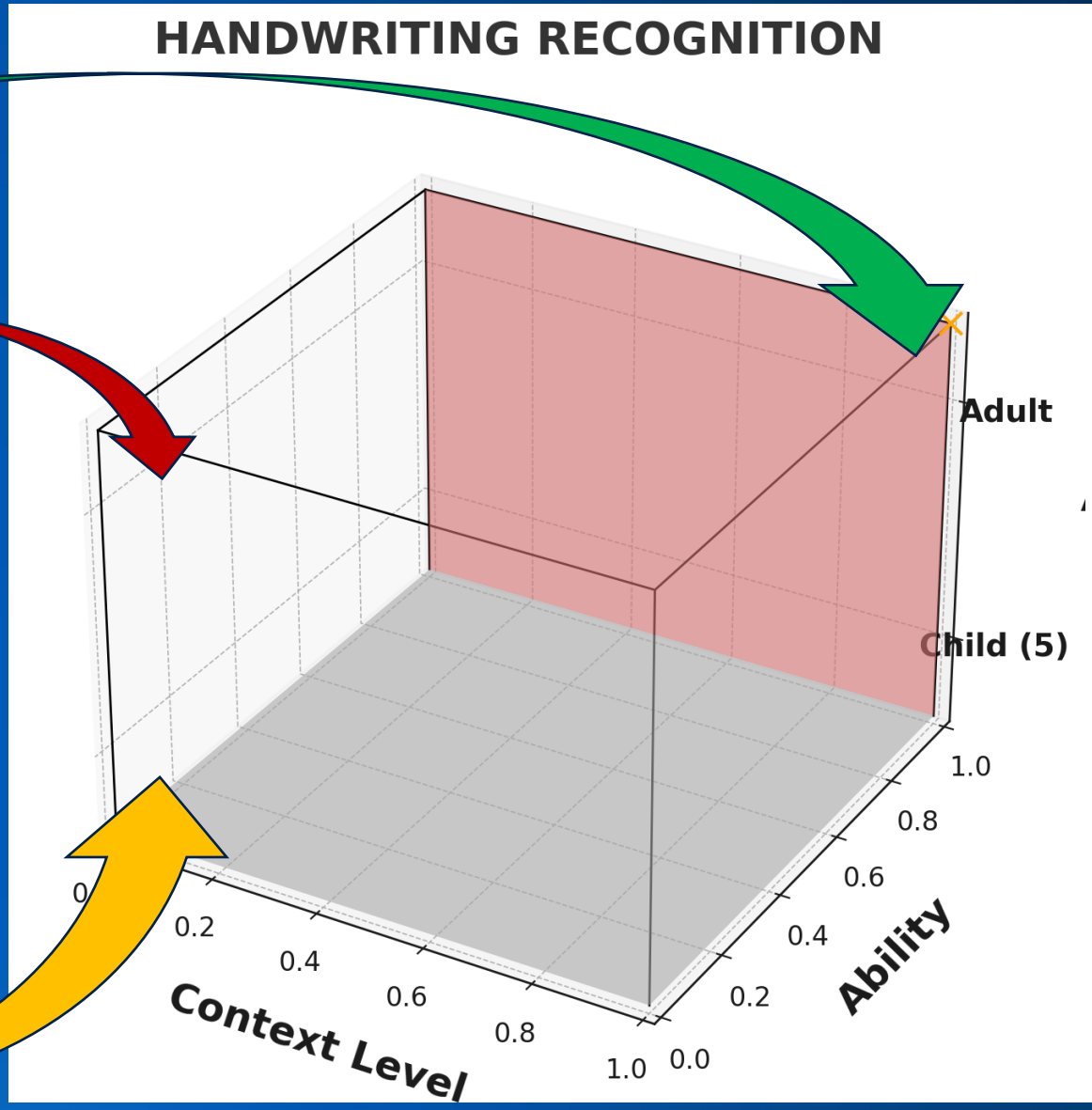
DYSLEXIC KIDS ESSAYS



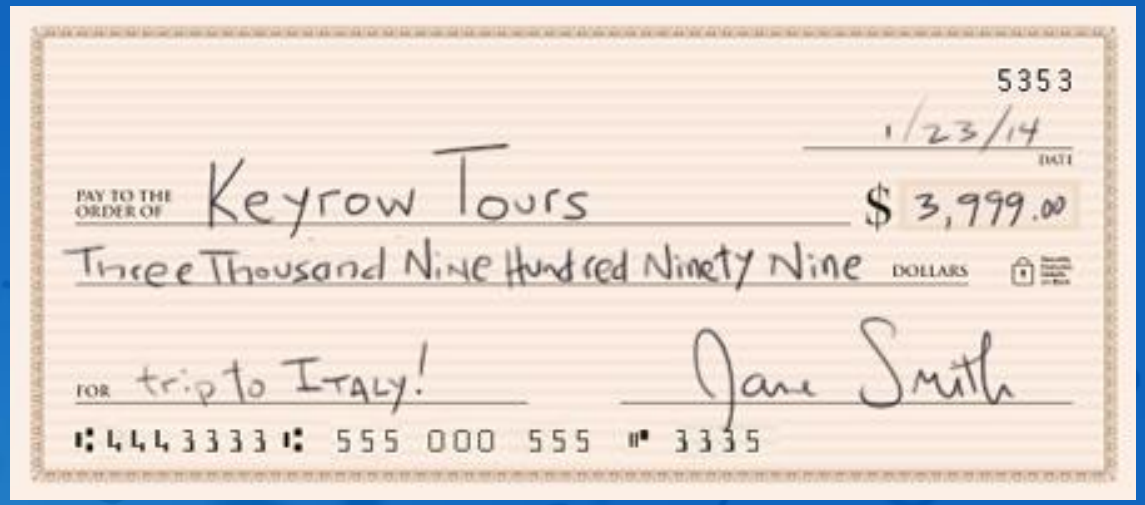
UNCONSTRAINED



HANDWRITING RECOGNITION



Static Lexicons



ONE	TWO	THREE
FOUR	FIVE	SIX
SEVEN	EIGHT	NINE
TEN	ELEVEN	TWELVE
THIRTEEN	FOURTEEN	FIFTEEN
SIXTEEN	SEVENTEEN	EIGHTEEN
NINETEEN	TWENTY	THIRTY
FORTY	FIFTY	SIXTY
SEVENTY	EIGHTY	NINETY
HUNDRED	THOUSAND	LAKH
LAC	LACS	AND
ONLY	CRORE	LAKHS

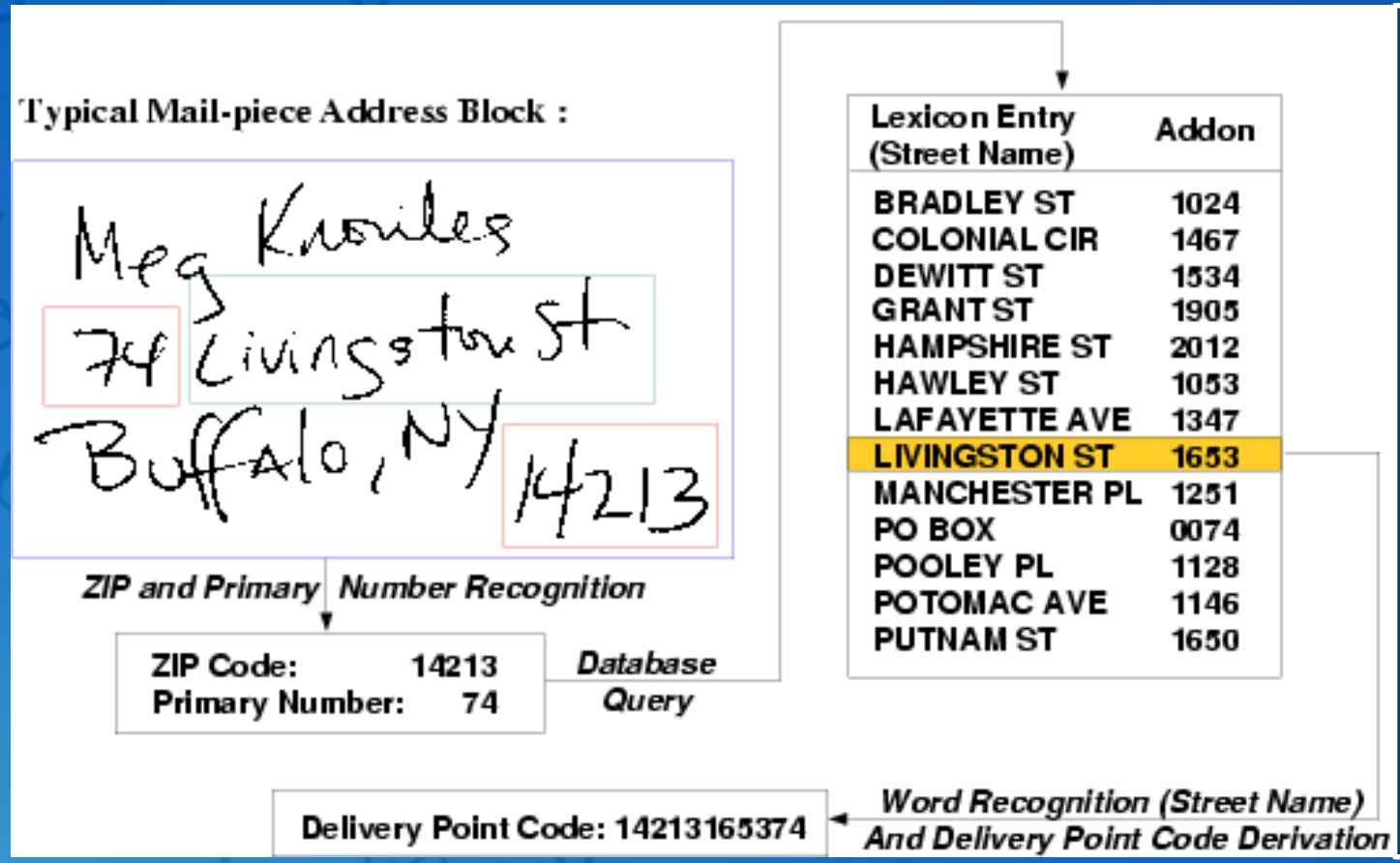
CLASSIFICATION TASK

Classify legal amount words as

one of 36

R. Jayadevan, U. Pal, and F. Kimura: Recognition of Words from Legal Amounts of Indian Bank Cheques. ICFHR 2010

Classification Task



Classify address image as one of

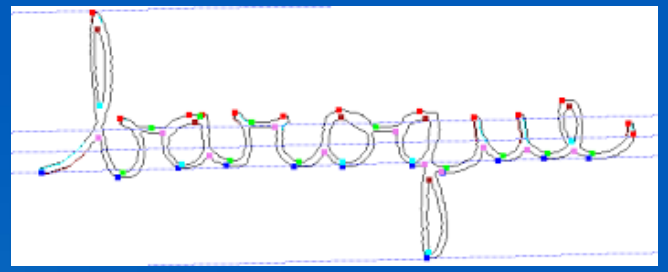
250M classes

potential destinations

30% of ZIPs contain less than 100 street names; max streets returned is 3,071.

H. Xue, V. Govindaraju, "On the dependence of handwritten word recognizers on lexicons", *IEEE Transactions Pattern Analysis and Machine Intelligence*, IEEE Computer Society Press, 24(12): 1553-1564 (2002)

Interactive Features



Hyderabad

A - - - D - -

A D A - - - A - A

A - A A - A A-

a. Delhi b. Kolkatta c. Patna d. Dehradun

Top-down Segmentation

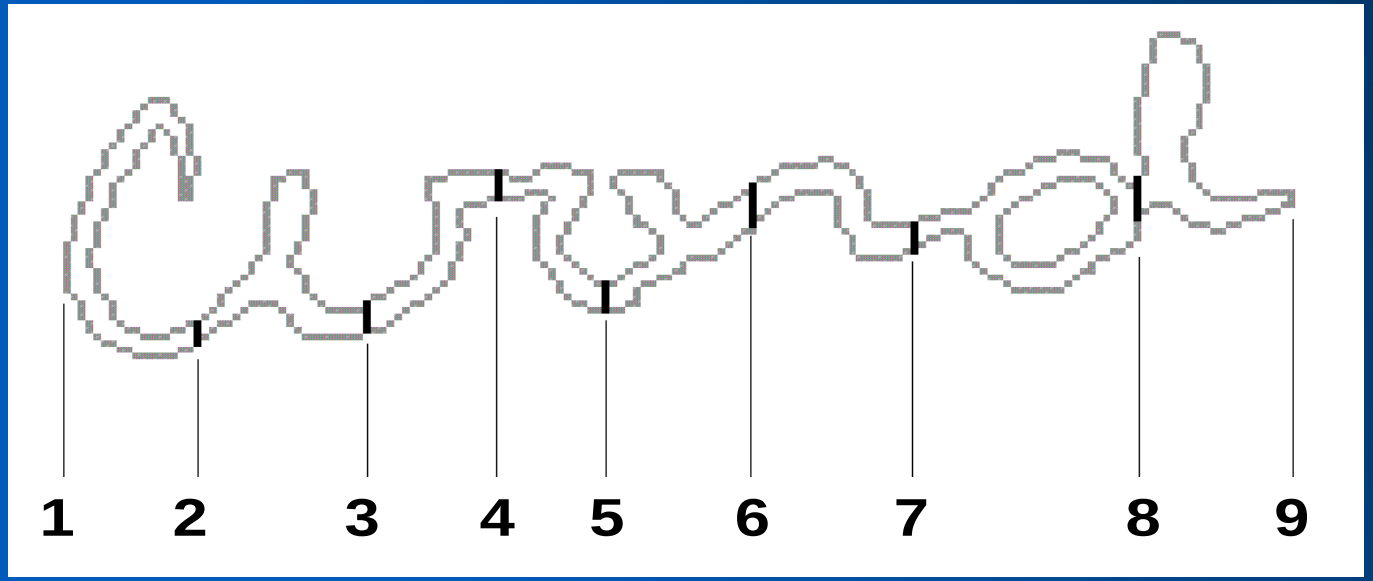
WORD

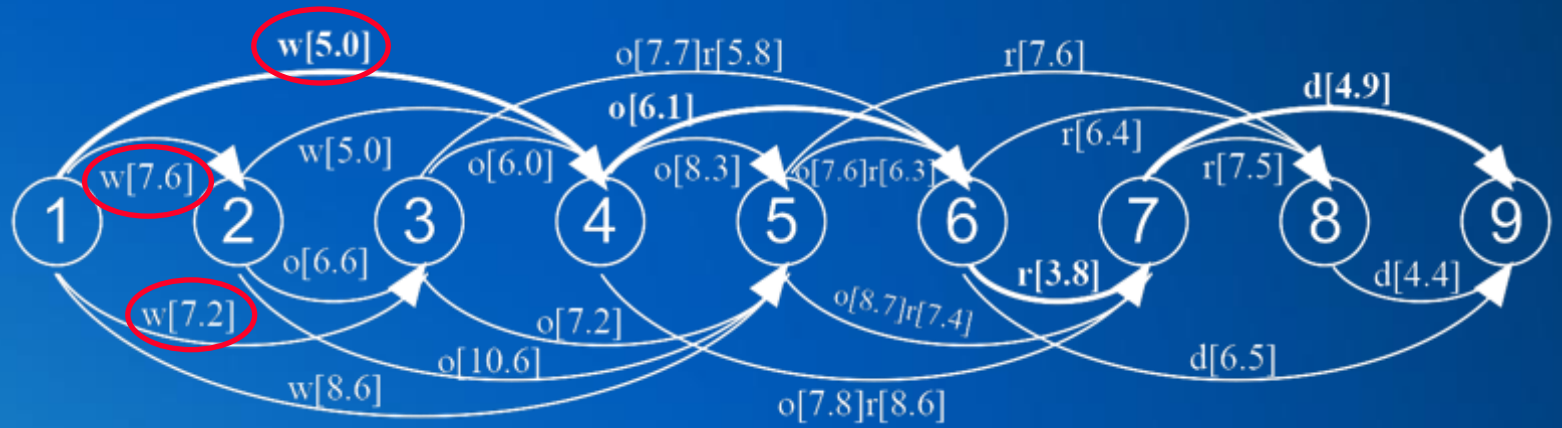
WELL

WORLD

HOUSE

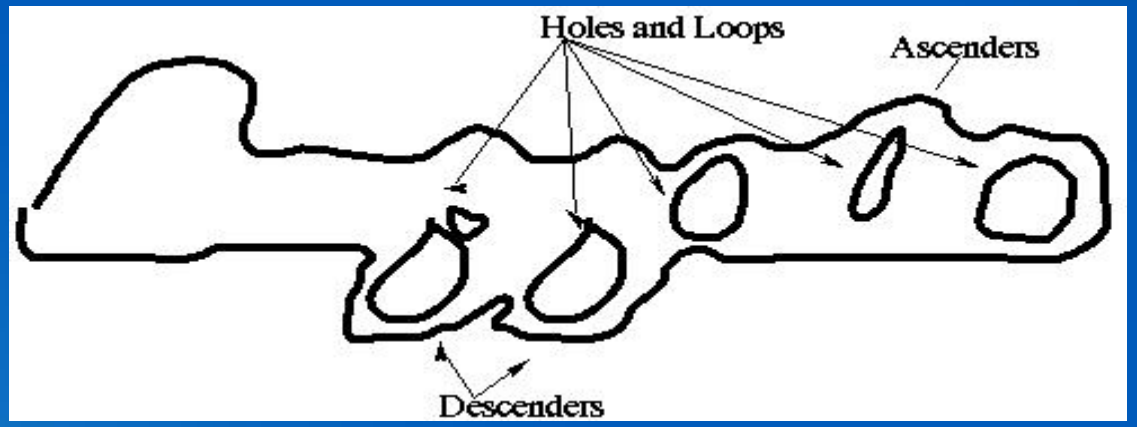
SCHOOL





G. Kim, Venu Govindaraju: A Lexicon Driven Approach to Handwritten Word Recognition for Real-Time Applications. IEEE Trans. Pattern Anal. Mach. Intell. 19(4): 366-379 (1997)

Interactive Features



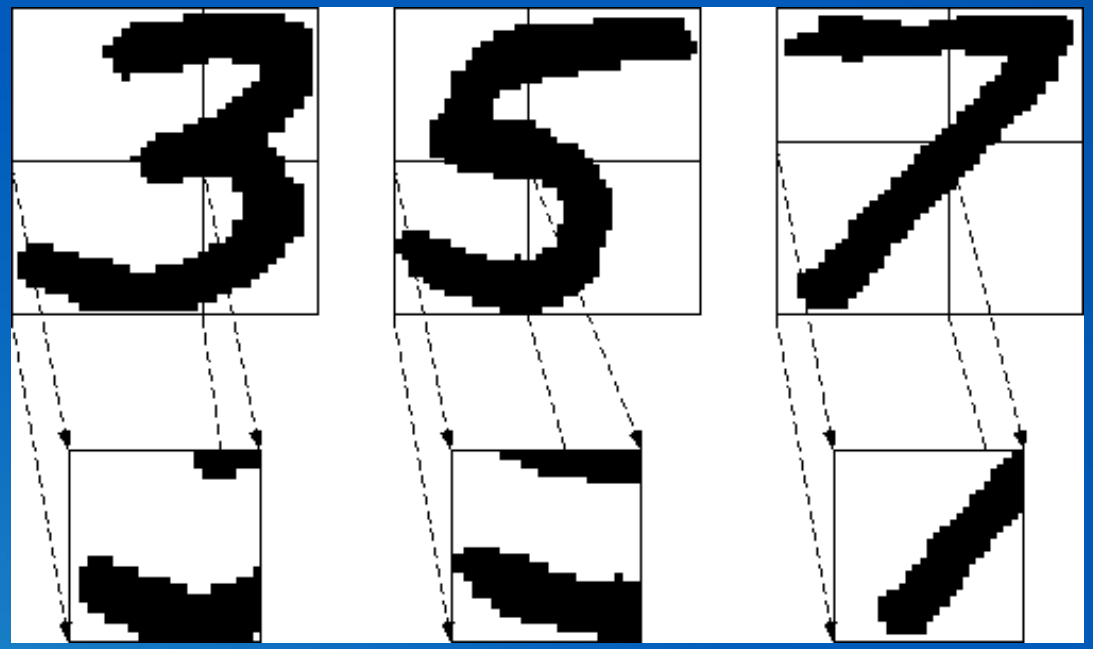
MULTIPLE CHOICE QUESTION

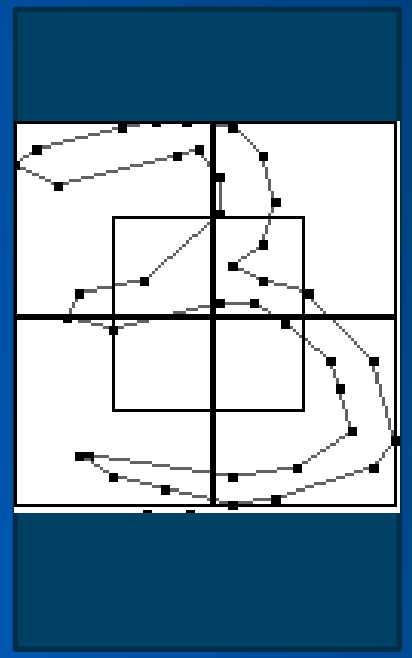
a) Amherst
b) Buffalo
c) Boston
d) None of the above

Length	Ascenders / Descenders	Parts	Holes / Loops	i-dots / t-crossings
Short (<5 chars)	Beginning (< 3 chars)	1	0	
Long (>8 chars)	End (> 6 chars)	>1	>0	

S. Madhvanath, V. Govindaraju, “The role of holistic paradigms in handwritten word recognition”, *IEEE Transactions Pattern Analysis and Machine Intelligence,* IEEE Computer Society Press, 23(2): 149-164 (2001)

Multisolution Features



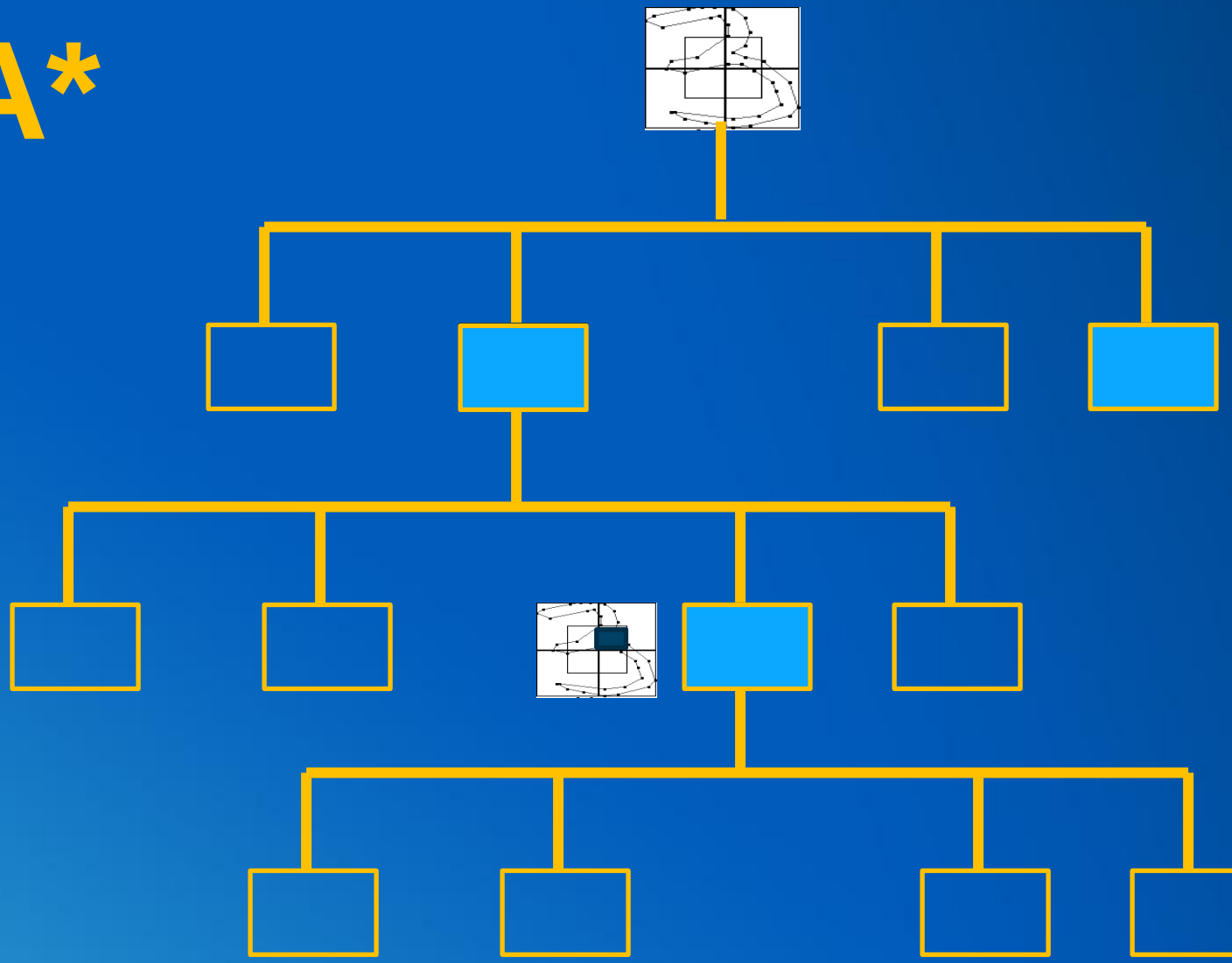


N-S	E-W	NE-SW	NW-SE	NE	SE	SW	NW	C
1	0	0	1	1	1	1	0	1

2^9 binary

PJ. Park, V. Govindaraju, and S. Srihari,: OCR in a Hierarchical Feature Space. IEEE Trans. Pattern Anal. Mach. Intell. 22(4): 400-407 (2000)

A*



4^0 nodes

4^1

4^2

4^3

Lookup table: 2^9 x 10 x 85 (quad tree, 4 levels)

Impact

1995-2000

Lex size	%
10	96
100	91
1000 (Top 50)	80 (98)
20000 (Top 100)	62 (94)
Postal Encoding	40

Today

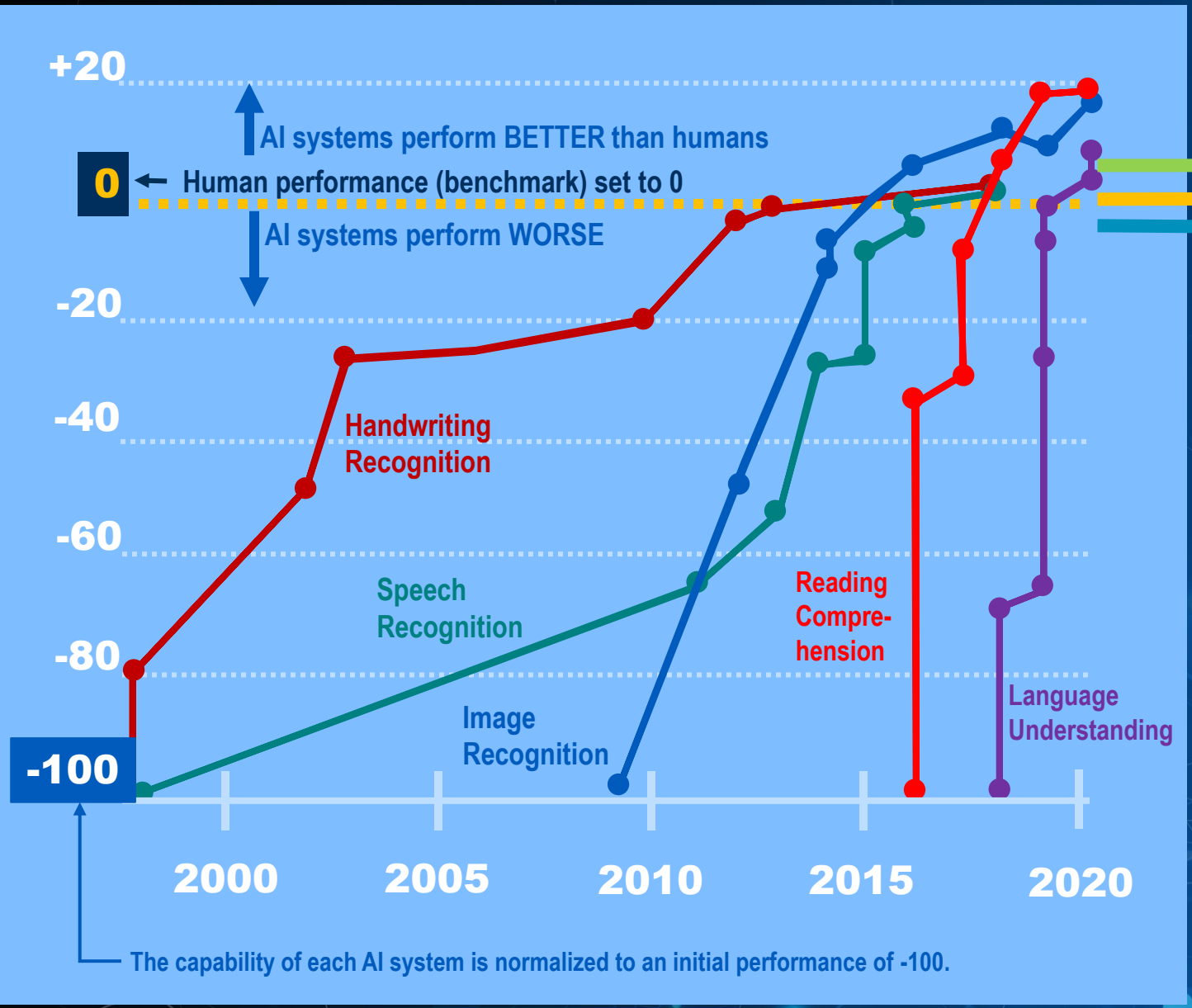
Lex size	%
10	~99
100	~99
1000	~99
Postal Encoding	98

Nearest Neighbor Classifier

Threshold possible

Cost of making an error considered

https://cubs.buffalo.edu/media/Horvitz-USPS.mp4



NARROW AI
Specialized in One Task

GENERAL AI
Operating at a Human level

SUPER AI
Smarter than Humans

AI vs Human PERFORMANCE

SOURCE: Kiela et al. (2021) Dynabench: Rethinking Benchmarking in NLP OurWorldData.org/artificial-intelligence

Narrow Applications

con·text /ˈkäntekst/

the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood and assessed.

Handwriting Recognition	Speech Recognition
Postal	Voice Assist
Cheque	SIRI, ALEXA
Forms	Dictation
Transcription	DRAGON

Image Recognition: OCR, Face Recognition, Radiology, Retail Fashion

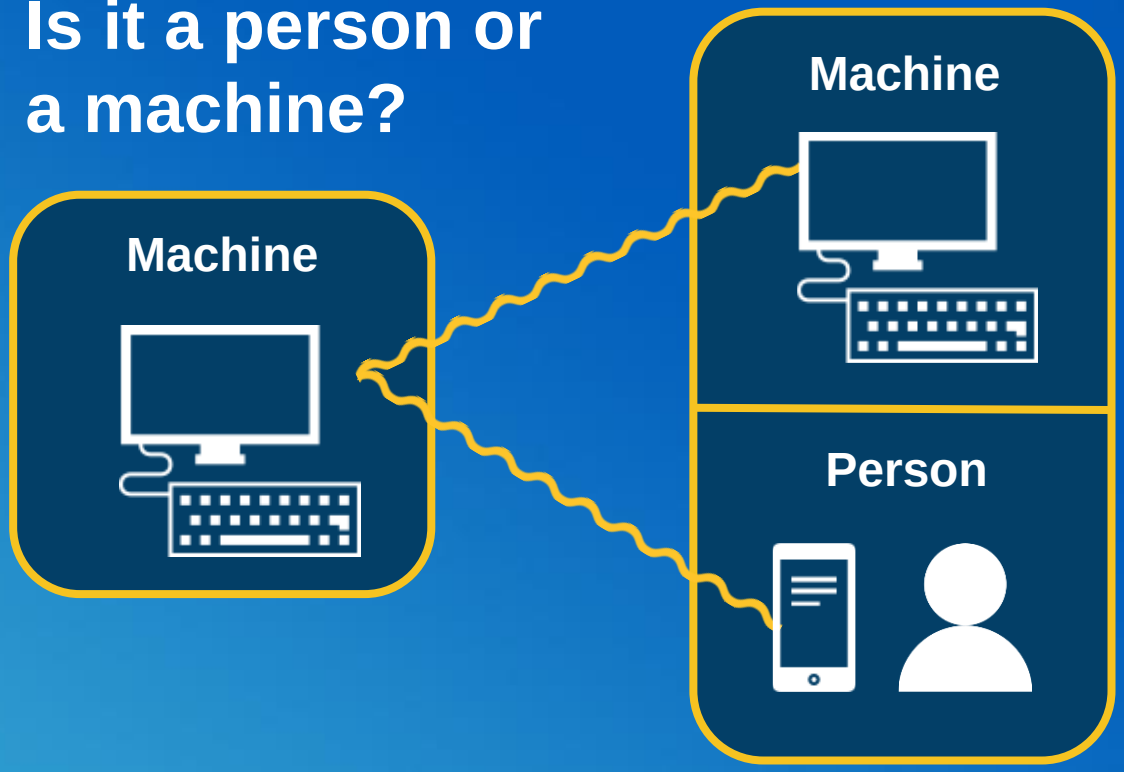
Video Understanding: Sports Analytics, Surveillance, Gesture Recognition

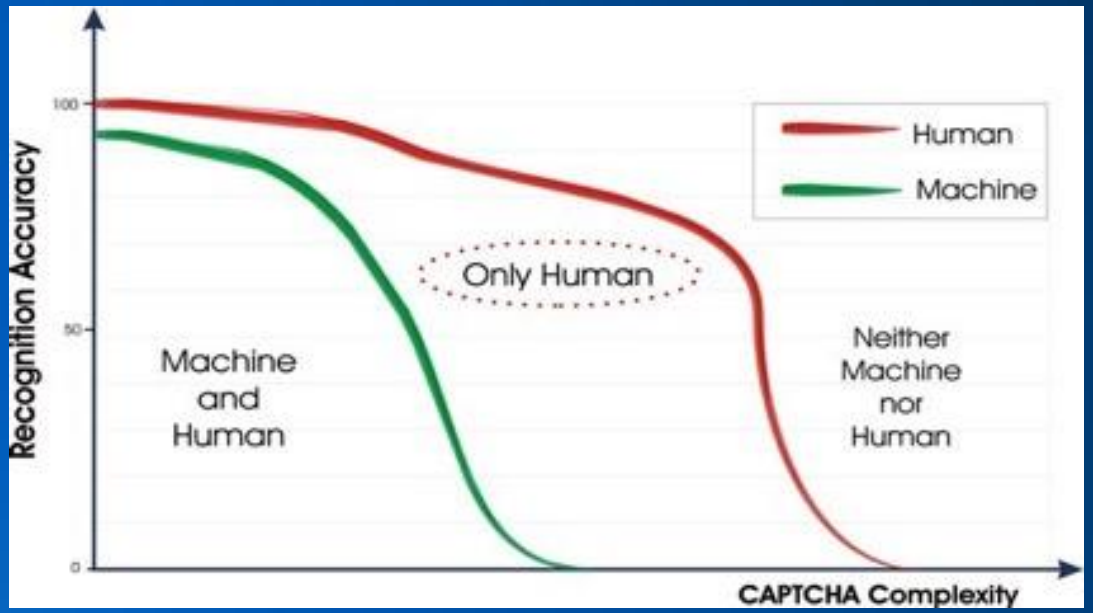
Language Understanding: Q&A, Form filling, Summarization

CAPTCHA

Completely Automated Public Test to tell Computers and Humans Apart

Is it a person or a machine?





OCRs

ChatGPT-4:

Best for reasoning and language tasks but not a standalone OCR tool for handwriting.

Microsoft Azure OCR:

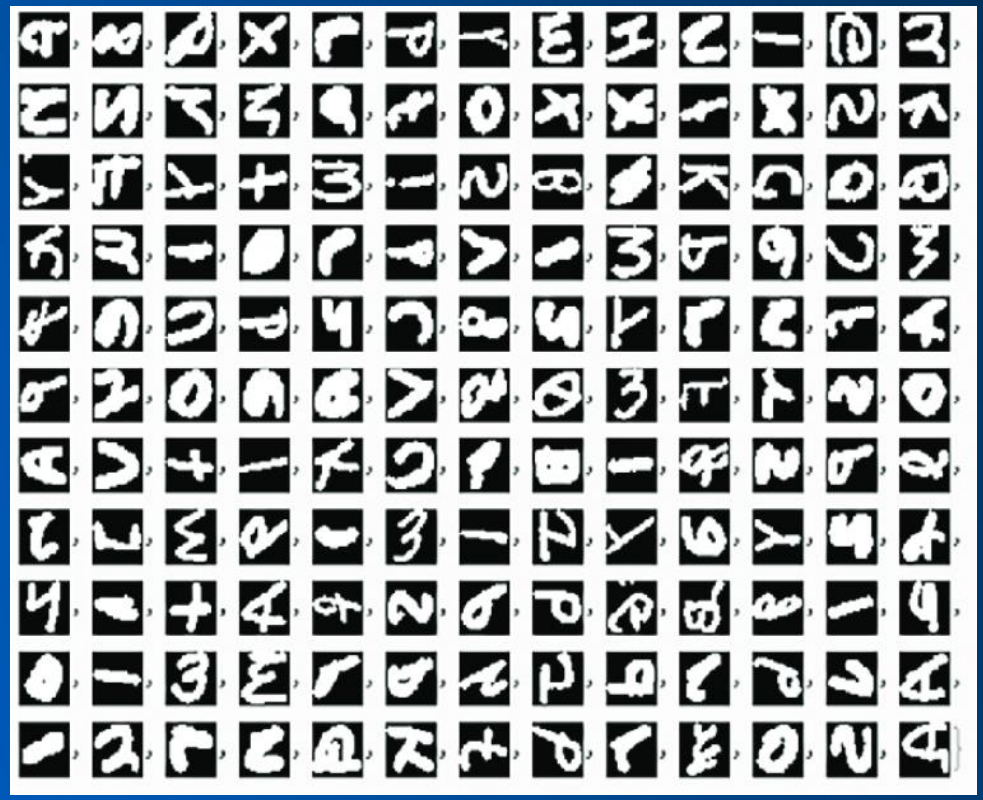
Excellent for real-world handwritten and printed text recognition, with robust APIs for structured and unstructured data.

Amazon Textract:

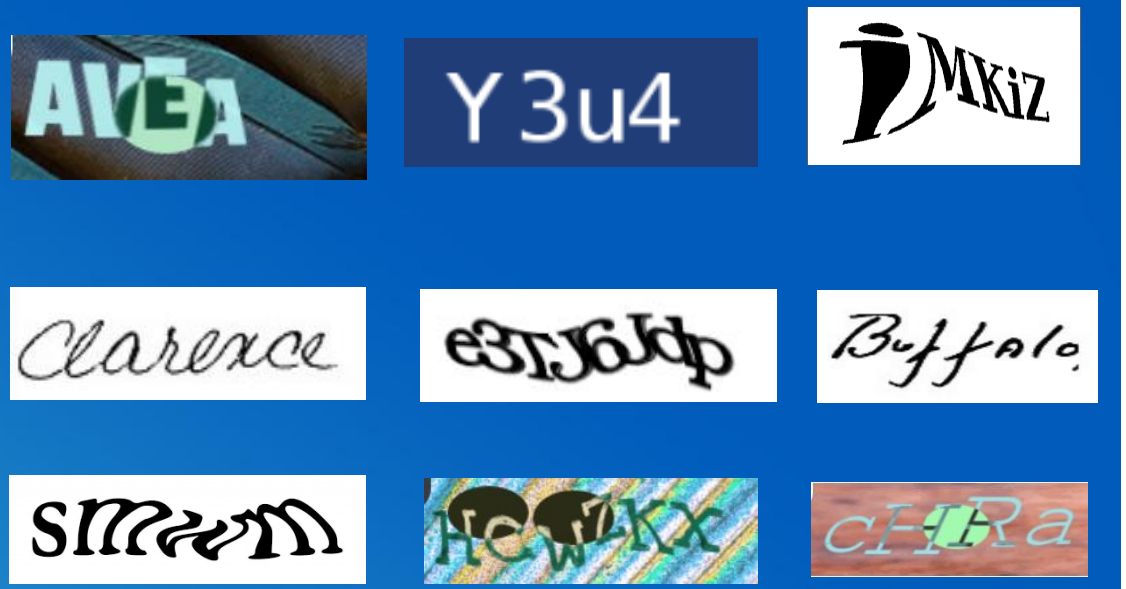
Well-suited for document analysis with a focus on extracting text; Handwriting recognition is secondary.

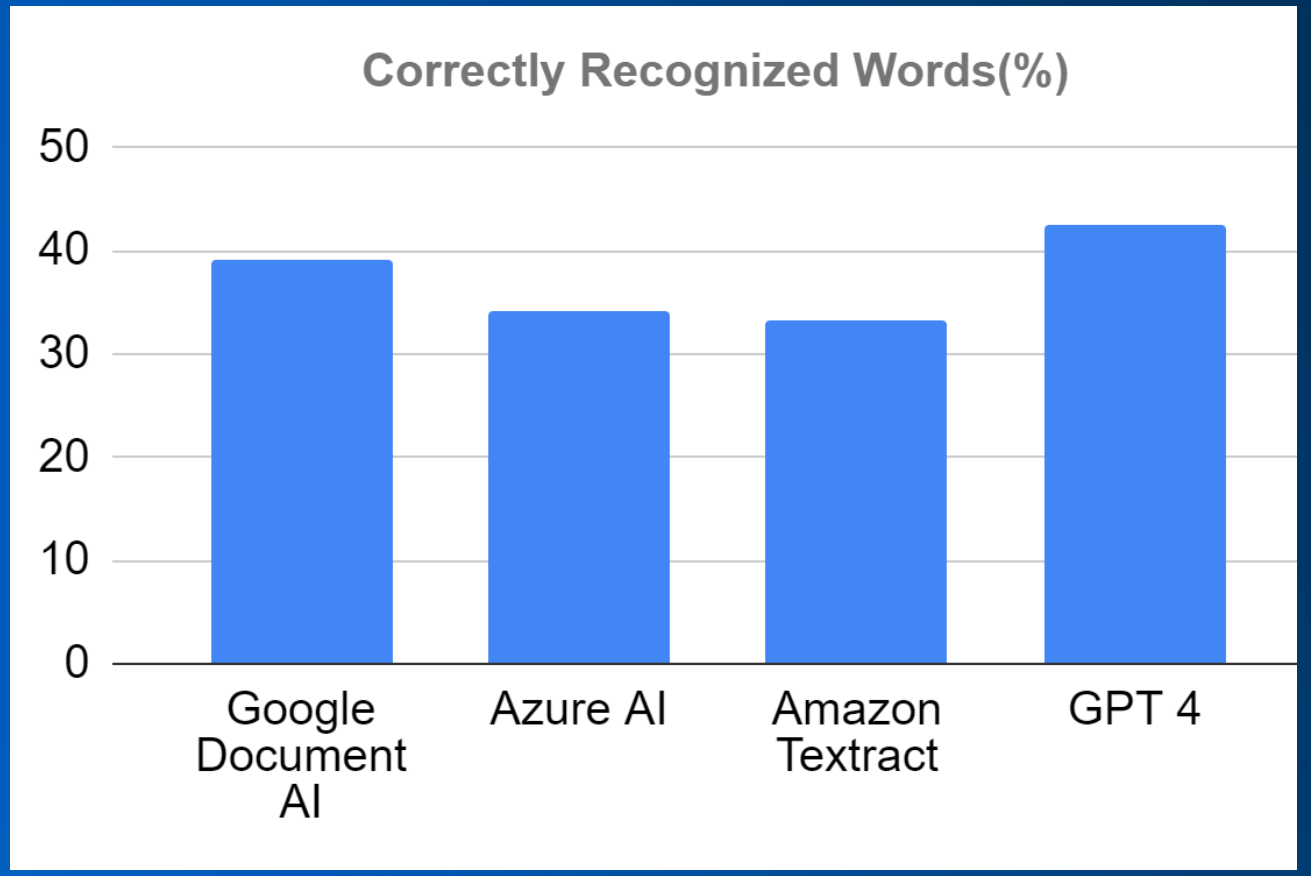
TrOCR:

Designed specifically for OCR tasks but requires setup and training for specific use cases.



CAPTCHAS Broken





1) irctc.co.in (Indian Railway Booking Platform)
2) https://www.mtcaptcha.com (Text CAPTCHA Service Provider)

Handwriting hardwired?

- **Humans utilize motor knowledge**, in recognizing handwritten letters.
- Left primary cortex and supplementary motor area, **show increased activation** when viewing handwritten letters compared to printed.
- This **embodied cognition aspect is unique to human processing** and not present in current LLM architectures.

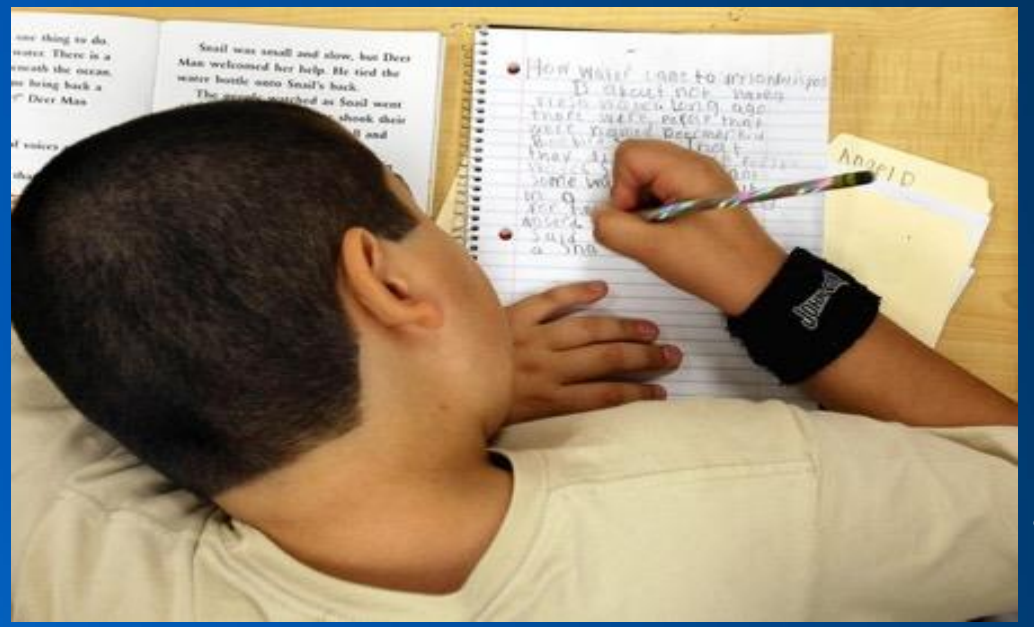

THE WALL STREET JOURNAL.

TUESDAY, OCTOBER 5, 2010 ~ VOL. CCLVI NO. 81

How Handwriting Trains the Brain

Forming Letters Is Key to Learning, Memory, Ideas

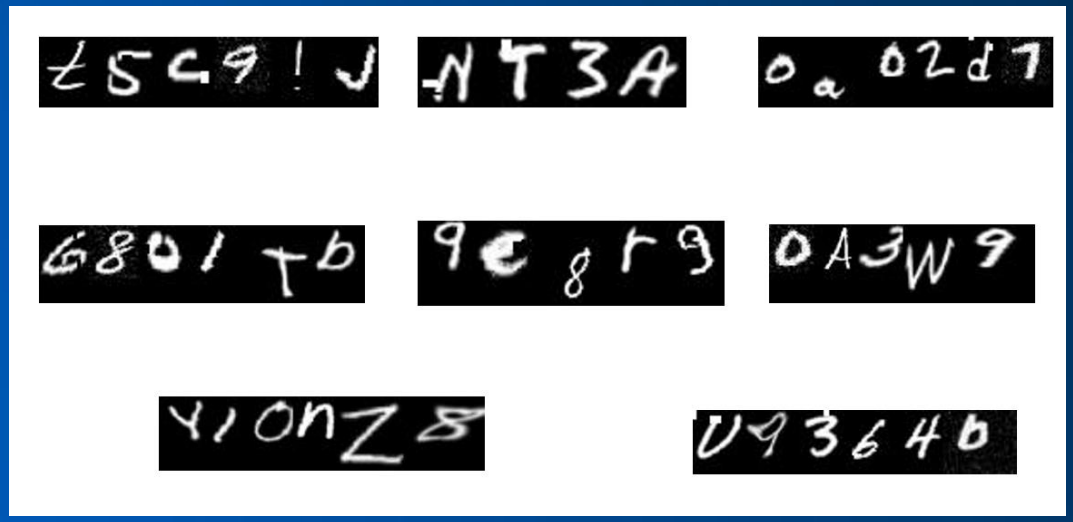
A Dialysis Treatment For The Busy Patient



HW – CAPTCHAS

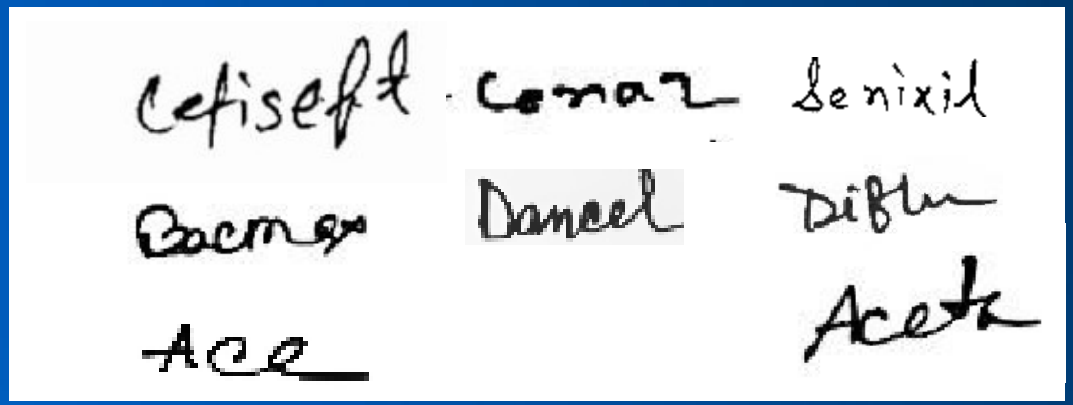
Use EMNIST (28x28) dataset (a-z, A-Z, 1-9)
GENERATE 200K training and 30K test samples

Model	Accuracy
TrOCR (Fine-Tuned)	38.39%
ChatGPT 4o	15.0%*



Doctor's Handwritten Prescription BD dataset (Kaggle)
Training Data: 3120, Test: 780

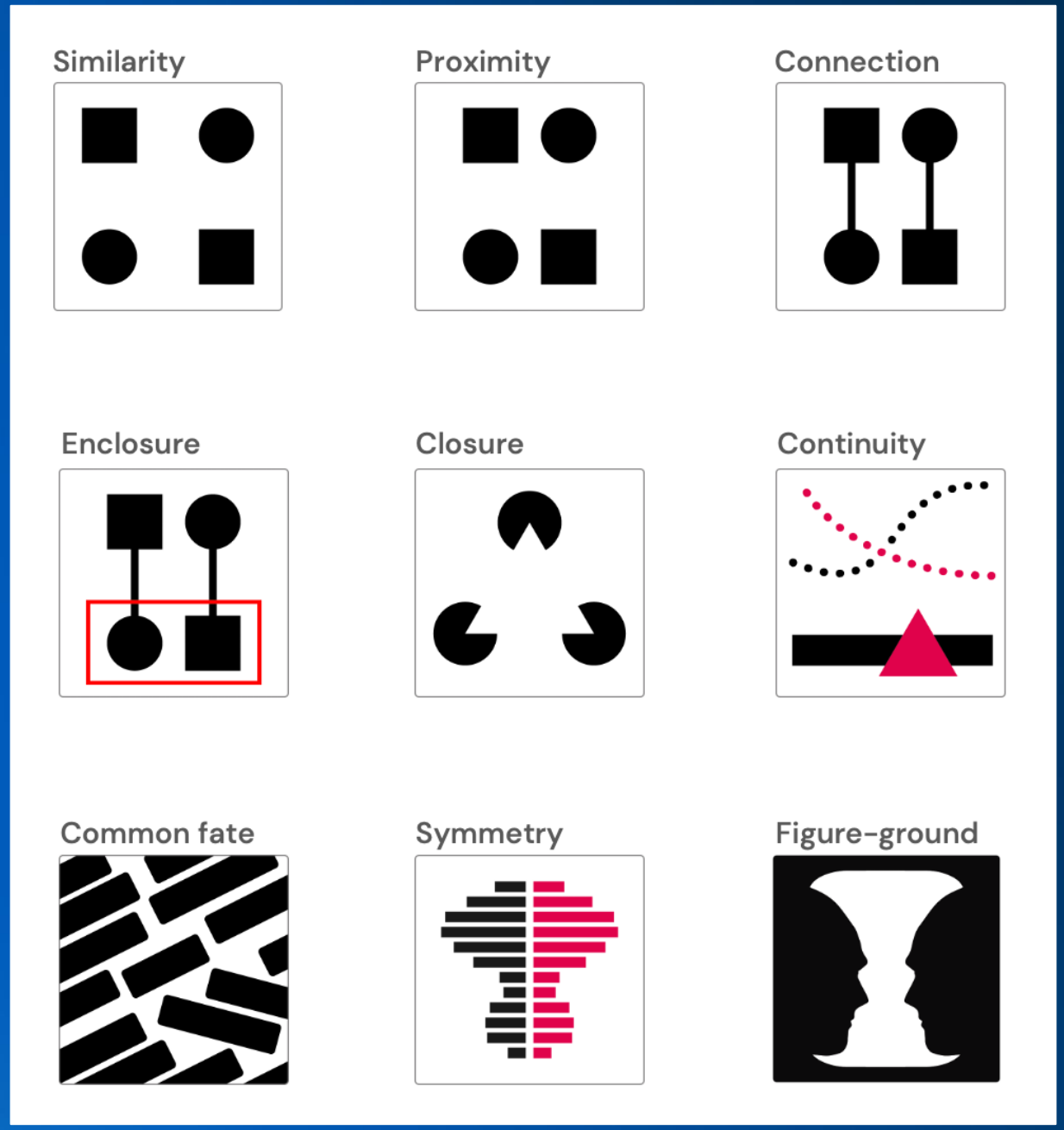
Model	Accuracy
TrOCR (Fine-Tuned)	86.79%
ChatGPT 4o	57%



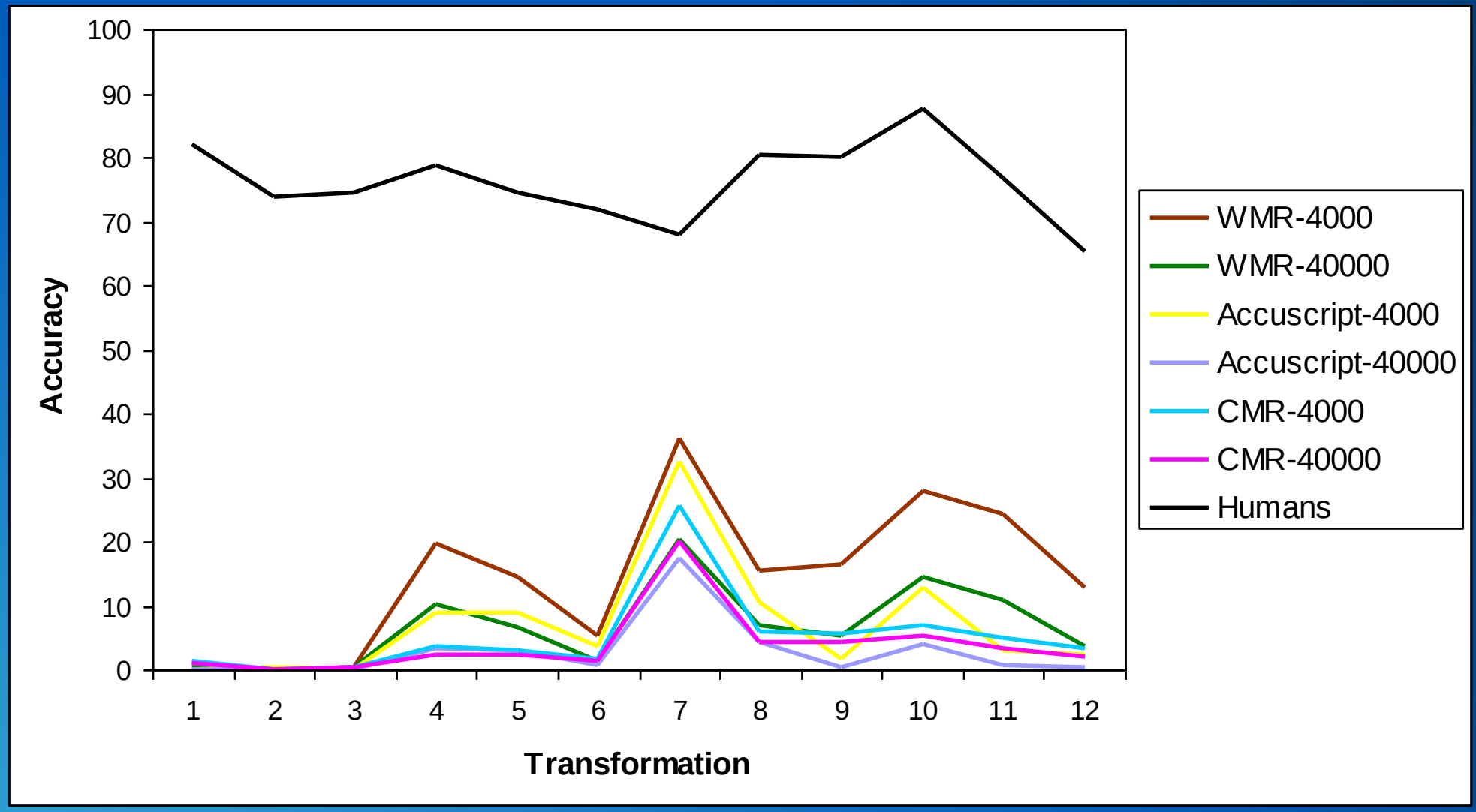
[1]Li, M et. al. (2023). TrOCR: Transformer-Based Optical Character Recognition with Pre-trained Models. *Proceedings of the AAAI Conference on Artificial Intelligence*, *37*(11), 13094-13102. https://doi.org/10.1609/aaai.v37i11.26538

Human Edge

- **Humans developed Gestalt processing** by evolution.
- Humans **rely on mental models** to represent and reason spatial information.
- **Machines cannot attain** this by training only at the surface level.
- **Each principle can be expressed in many forms** making learning from examples challenging.

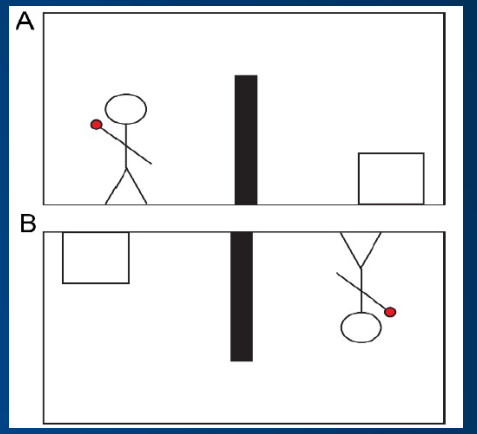


Postal Gestalt



Spatial Ability

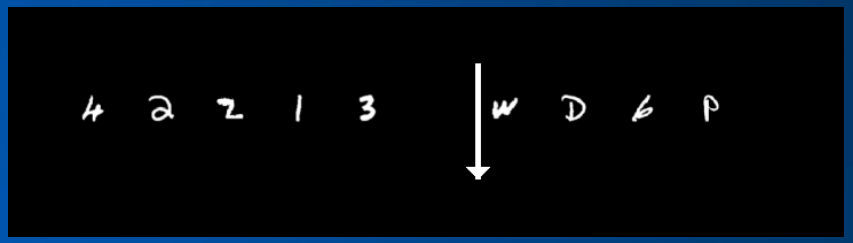
Humans possess rich spatial intelligence with the ability to understand and manipulate spatial information.

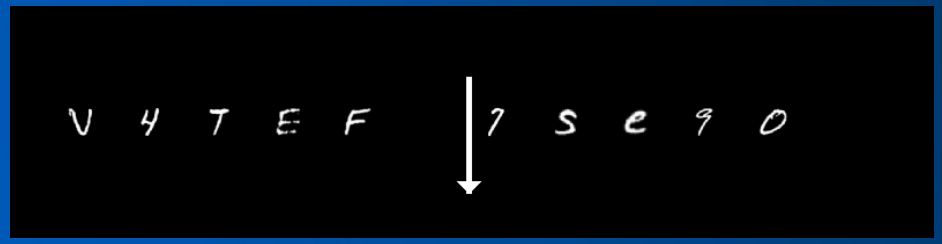


Prompt for GPT4o:

Act like an OCR model.
Recognize the handwritten CAPTCHA images;.
Read letters to the right of the arrow direction.
The characters are A-Z, a-z, 0-9.

Accuracy: 0/100





Murray, Scott O., and Bridget Leonard. "Spatial Representations in Multimodal AI Systems." *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2024.

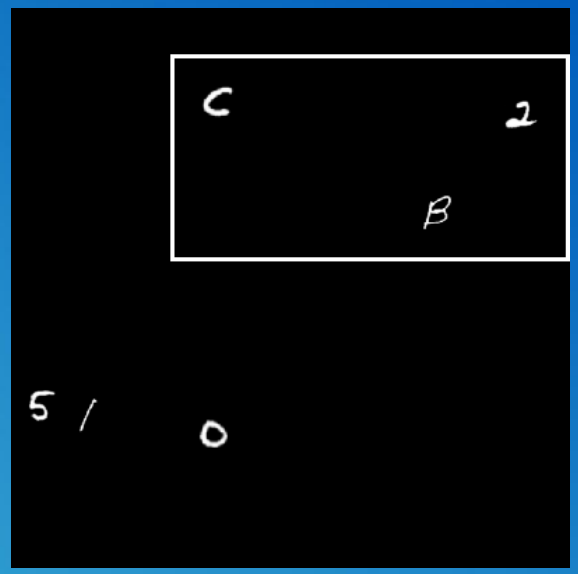
Spatial Ability

Prompt for GPT4o:
Act like an OCR model; read all the letters completely inside the box; order does not matter.

←7/100

0/100→

Prompt for GPT4o:
Act like an OCR model; read the letters which are to the right of the letter in the box.



Geometry Gestalt

Prompt for GPT4o:

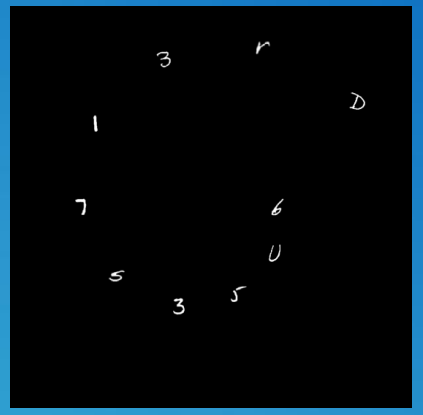
Act like an OCR model. Characters are A-Z, a-z, 0-9.

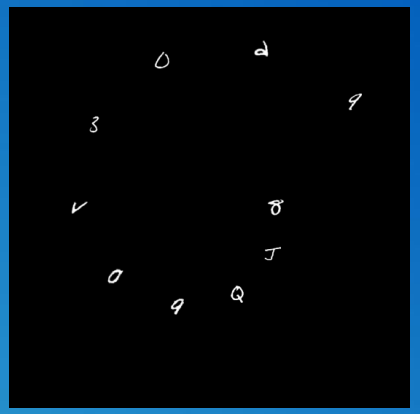
Read letters in **circular pattern** with any starting point.

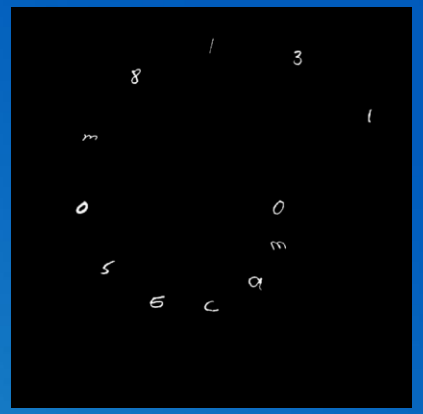
Accuracy: 3/100

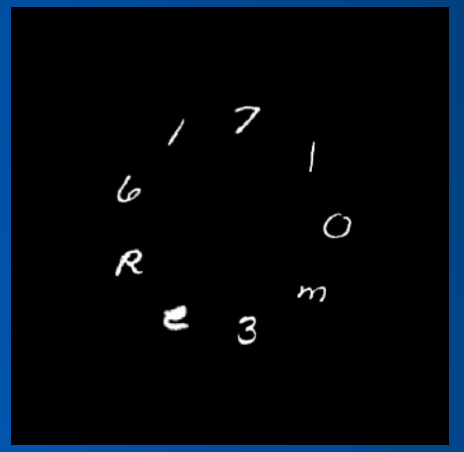
Read letters in spiral inside out

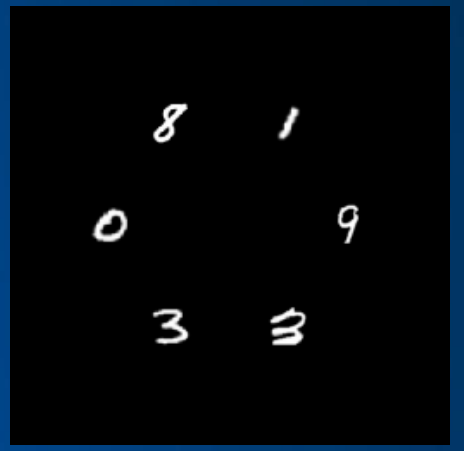
Accuracy: 0/100

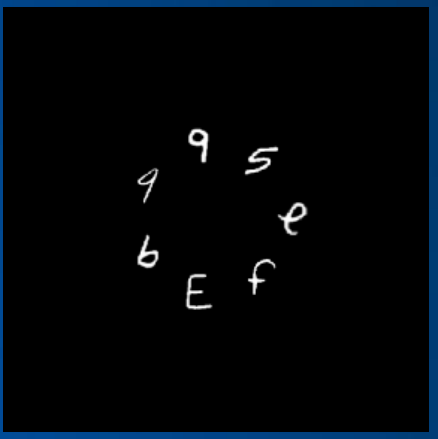












Geometry Gestalt

Prompt for GPT4o:

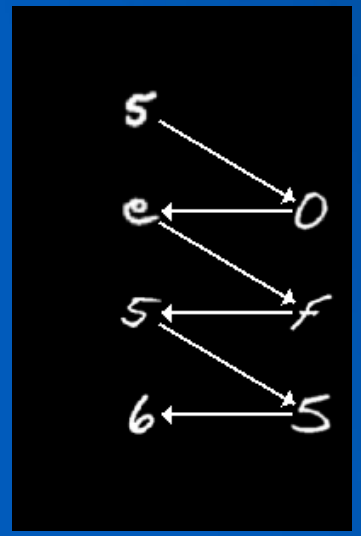
Act like an OCR model.
Characters are A-Z, a-z, 0-9.

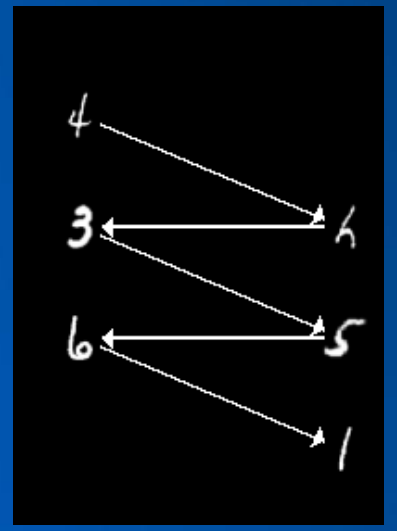
Read letters **in order**

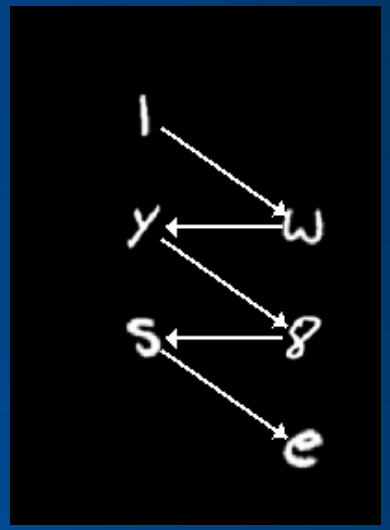
Accuracy: 2/100

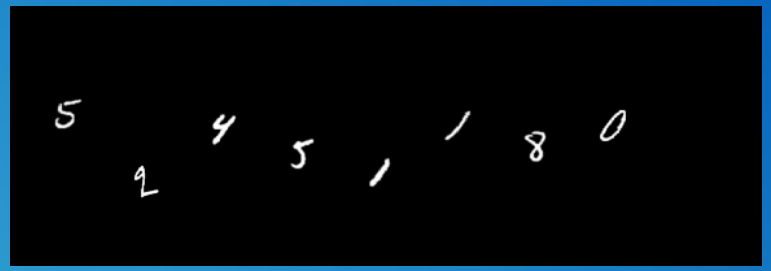
Read letters **left to right**

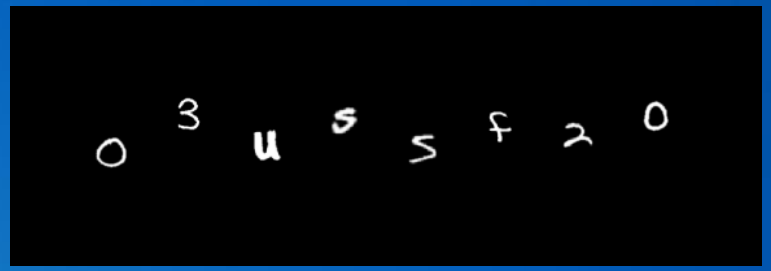
Accuracy: 2/100

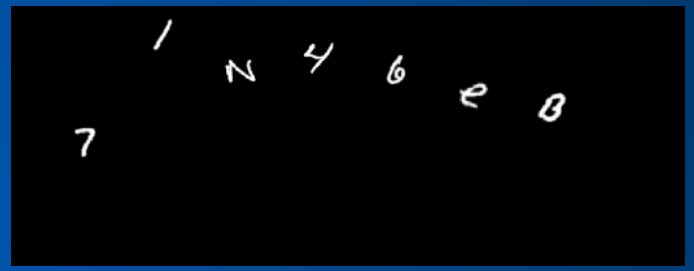












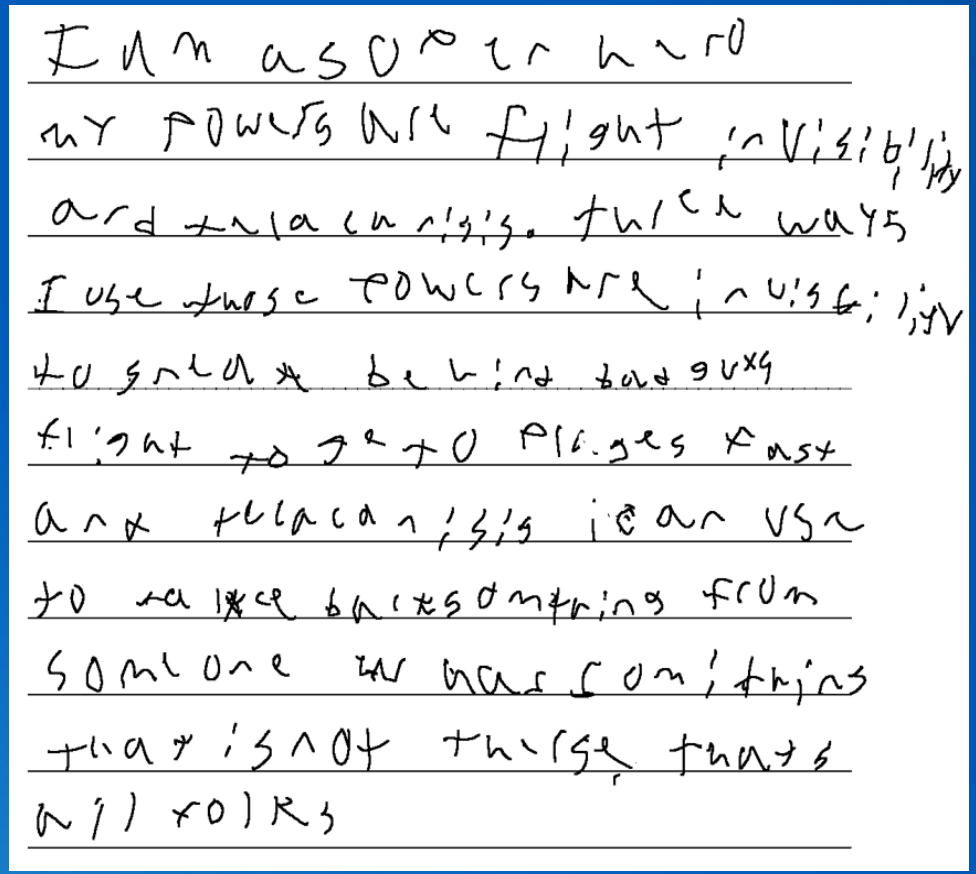
TASK:

Handwriting Recognition OCR

DIMENSIONS	HUMAN EDGE	MACHINE EDGE
CONTEXT	★	★
NO CONTEXT		★
GESTALT	★	

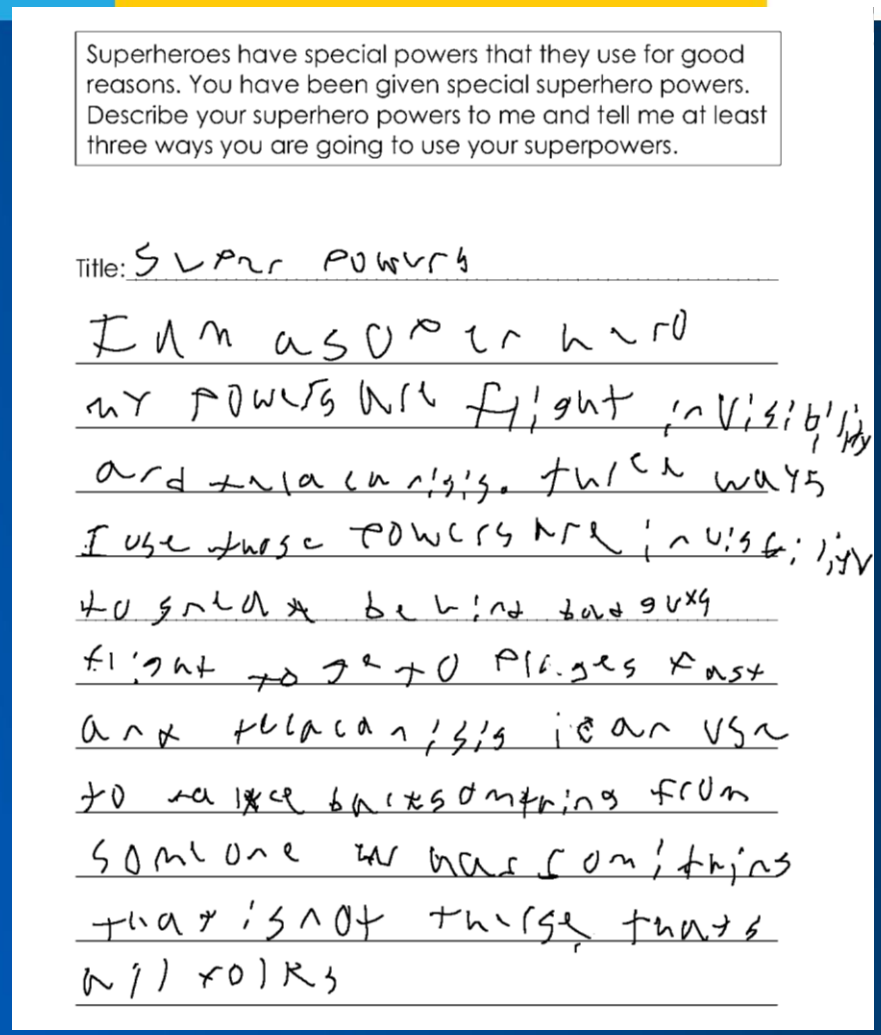
Machine Edge

Context or No-context



ChatGPT 4

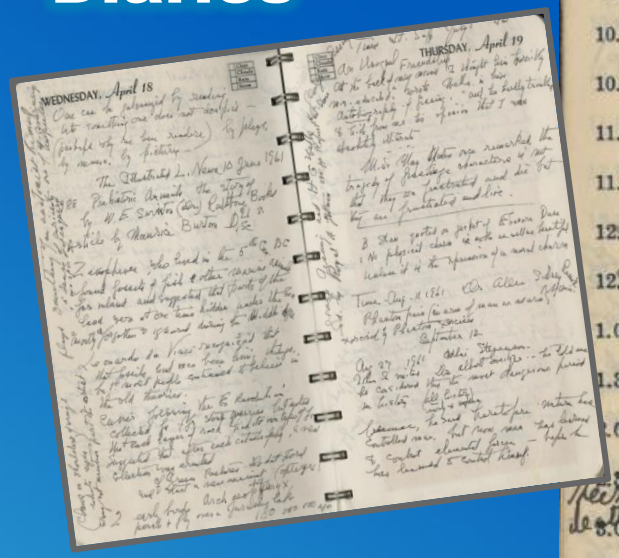
It looks like there was an error with the image processing. Please try re-uploading the image, or if you can describe the content, I can assist you further based on that description.

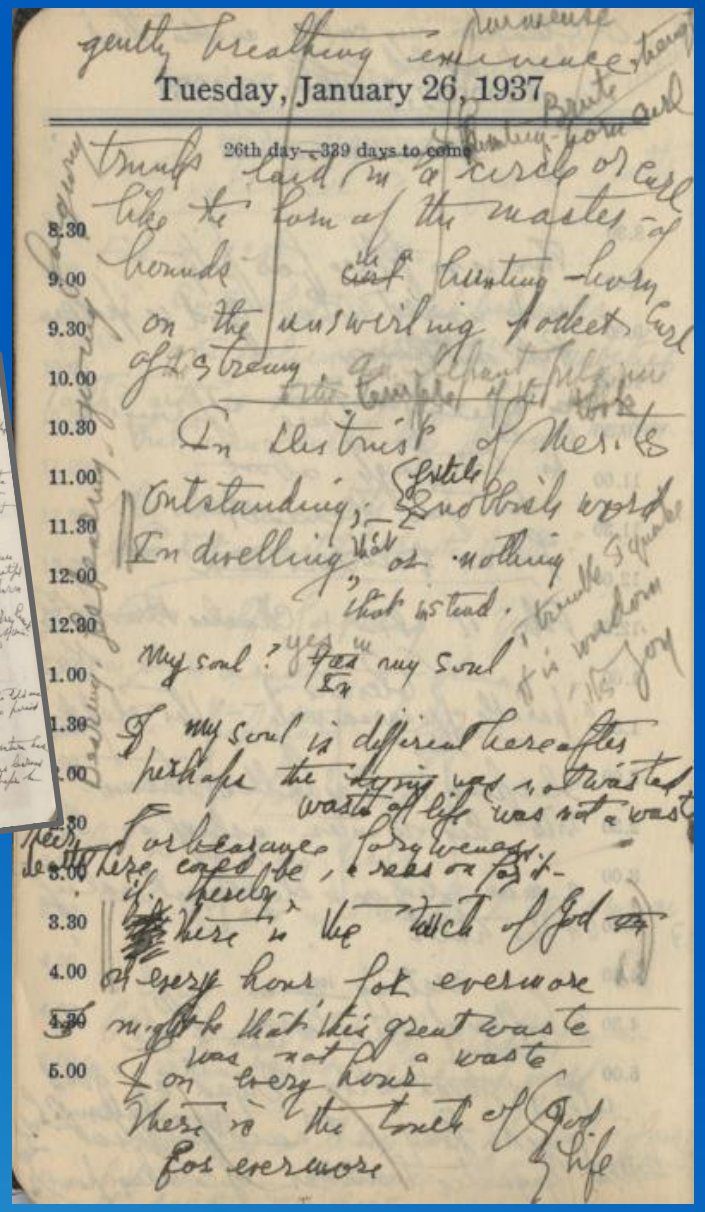


Title: Super Powers I am a super hero my powers are flight, invisibility,and telekinesis. Three waysI use these powers are: invisibility, to sneak behind bad guys, flight to get to places fast, and telekinesis I can use to take back something from someone who had something that is not theirs. That's my powers.

Machine Edge

Marriane Moore Diaries





Tuesday, January 26, 1937

26th day – 339 days to go

8.30 – Thoughts far in the recesses of old life, to find the realities of the moments.

9.00 – Threads that glitteringly burst on the unknowing wakes & ends of life's being.

9.30 – (more musings and crossings out)

10.30 – In electricities of the write outstanding – both! [rest unclear]

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9.30 – (more musings and crossings out)
10.30 – In electricities of the write outstanding – both! [rest unclear]
11.00 – I'm dwelling on nothing,
12.00 – void instead!

12.30 – "My soul," I say my soul
1.00 – If my soul is different there's perhaps always this sense of waiting. Life wastes its [part crossed out] or leaves. Yet always, this sense I need a fix.
2.30 – [unclear] in the truths of God and
3.00 – A deep hour for everyone.
3.30 – My note: this year wastes. I was not to waste
4.00 – my very heart.
There is the truth of God
5.00 – For everyone's life.

ChatGPT4o

Nurweuse
gentlybreathingexperience
Tuesday,January26,1937
26thday-
39daystocomunteryhoraeur
laidinacircleofcare
meg
liketheformofthemasterof
8.30
wathunting-leary
9.00
Meurt
on
theunswirlingpockets
9.30
ofthistrewyq
10.00
10.80
InDistrictofthesites
11.00
Outstanding;Suolbalword
11.30
Indwellinghat
ornothingSquall
12.00
thatinstead.
12.30
Mysoul?"Da"
-tomulle
1.00
150Joy
tiswadom
1.30
ofmysoulisdiferentthereafter
2.00
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d
Forbearanceforaweng,

MS Azure

gently breathing excensuse
Tuesday, January 26. 1937
trunks 26th laid day -339 in days to a come circle or born
8.30 like the form of the master Cell of
9.00
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9.30
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10.00
10.80
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11.00
11.30
Ontstanding, word
12.00
In direlling , that of nothing that is tead.
12.30
my soul It w my soul
jay state,
1.00
1.30
of my Soul is different heeroftes
2.00
their Forbiarance was sota wast perhape the wasting notwasted ill
corpo abe / reas on pit
3.30
here in the totte lfded &
$3.00 many might that this great waste
4.00 Herry hour for everwore

TexTract

Semantic Similarity

Transformer Models	1	2	3
ChatGPT4o x MS Azure	0.61	0.70	0.62
ChatGPT4o x Textract	0.71	0.79	0.76
MS Azure x Textract	0.72	0.79	0.78

Cosine similarity

between embeddings produced by different pre-trained SentenceTransformer models

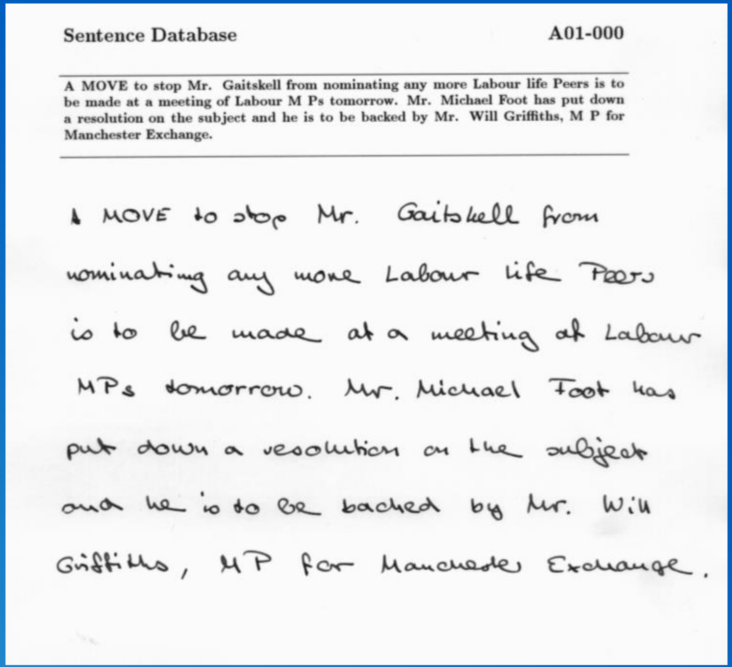
TASK:

Handwriting Recognition
OCR

DIMENSIONS	HUMAN EDGE	MACHINE EDGE
CONTEXT	★	★
NO CONTEXT		★
GESTALT	★	
CHILD	?	?

Adult vs Child HWR

ChatGPT4


Sentence Database A01-000

A MOVE to stop Mr. Gaitskell from nominating any more Labour life Peers is to be made at a meeting of Labour M Ps tomorrow. Mr. Michael Foot has put down a resolution on the subject and he is to be backed by Mr. Will Griffiths, M P for Manchester Exchange.

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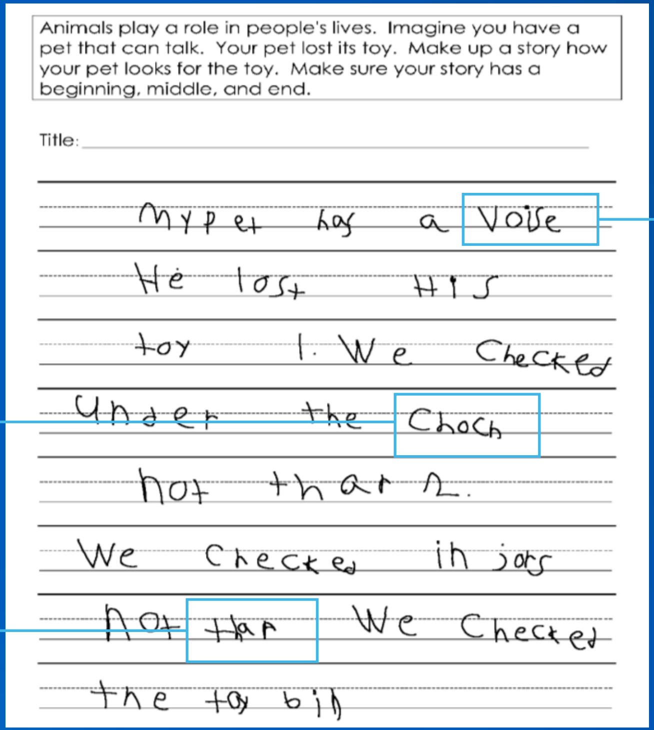
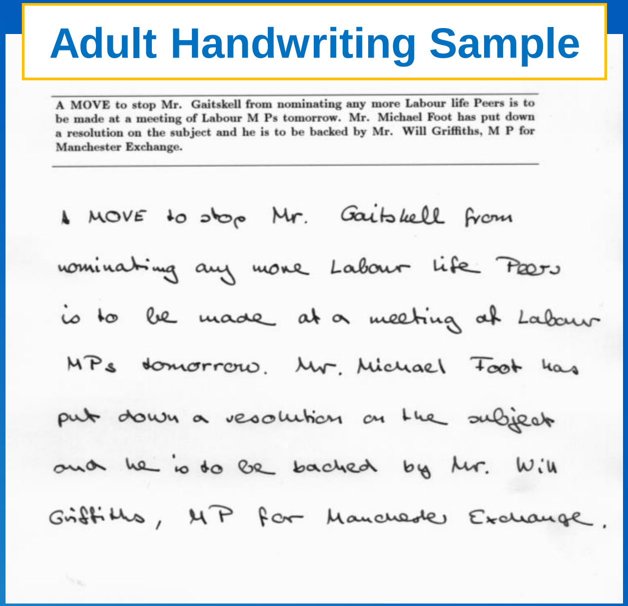


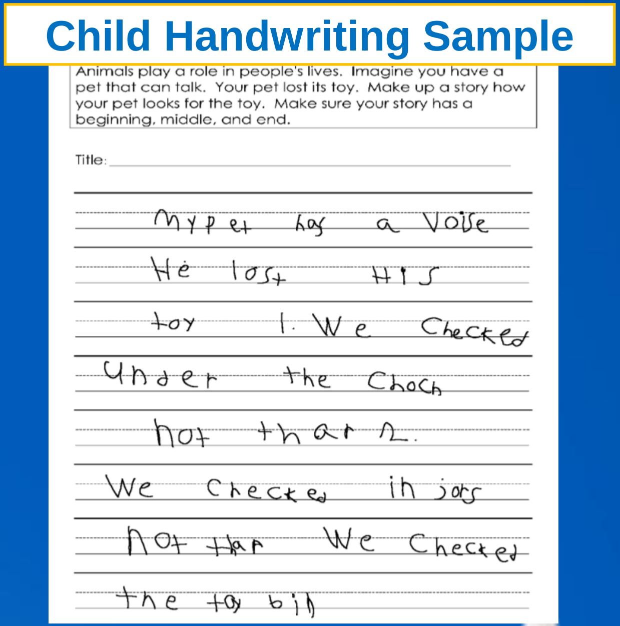
My pet has a voice. He lost his toy! We checked under the couch, not there. We checked in jars, not there. We checked the toy bin.

Error Metric	Adult Sample	Child Sample
CER	0.78	18.89
WER	7.8	44.83
ED	2	24
CRW	92.86	54.54

Error Metric	Adult Sample	Child Sample
Precision	100	44.32
Recall	100	44.32
F1_Score	100	44.32
Accuracy	100	44.2

Data





Absence of

the **distinctive**

characteristics

found in children's

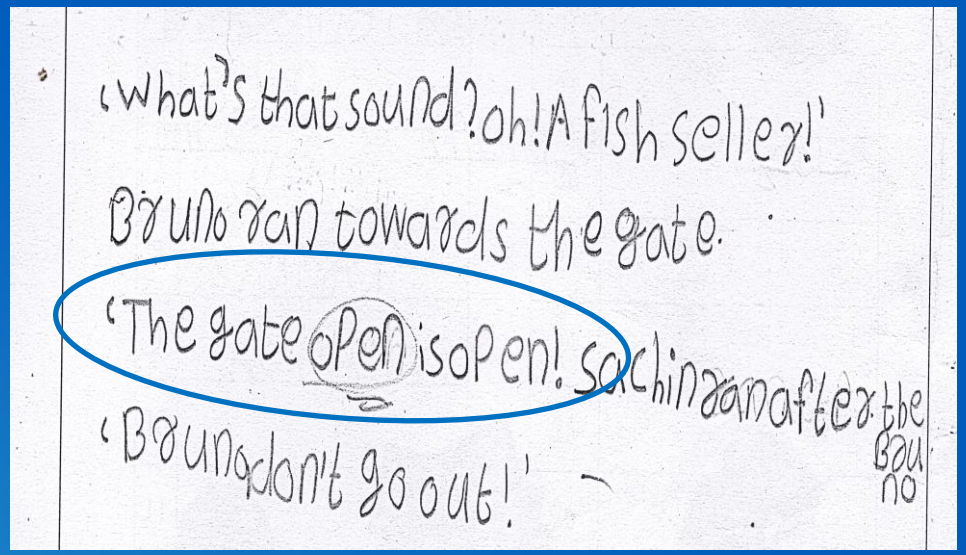
handwriting

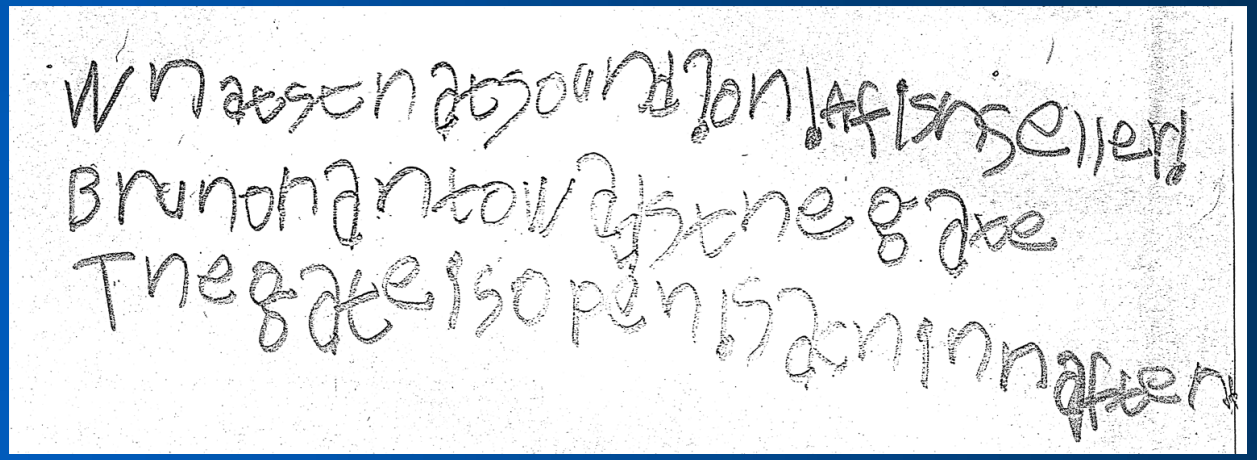
- Letter crowding & poor legibility
- Inconsistent sizing of letters & atypical use of margins
- Atypical writing in relation to the vertical axis
- Letter reversals, inversions & transpositions
- Spelling errors & abandoned words

Machine Edge

Interpretation (not exact transcription)

ChatGPT 4





"What's that sound? Oh! A fish seller?"

"Bruno ran towards the gate."

"The gate is open!"

"The gate is open!"

"Sachin ran after the Bruno."

"Bruno, don't go out!"

What's that sound?
Oh! A fish seller!

Bruno ran towards the gate.

The gate is open!
Sachin ran after Bruno.

Predicted the missing word

Children handwriting sample obtained from "Amrita Vishwa Vidyapeetham, Amritapuri Campus

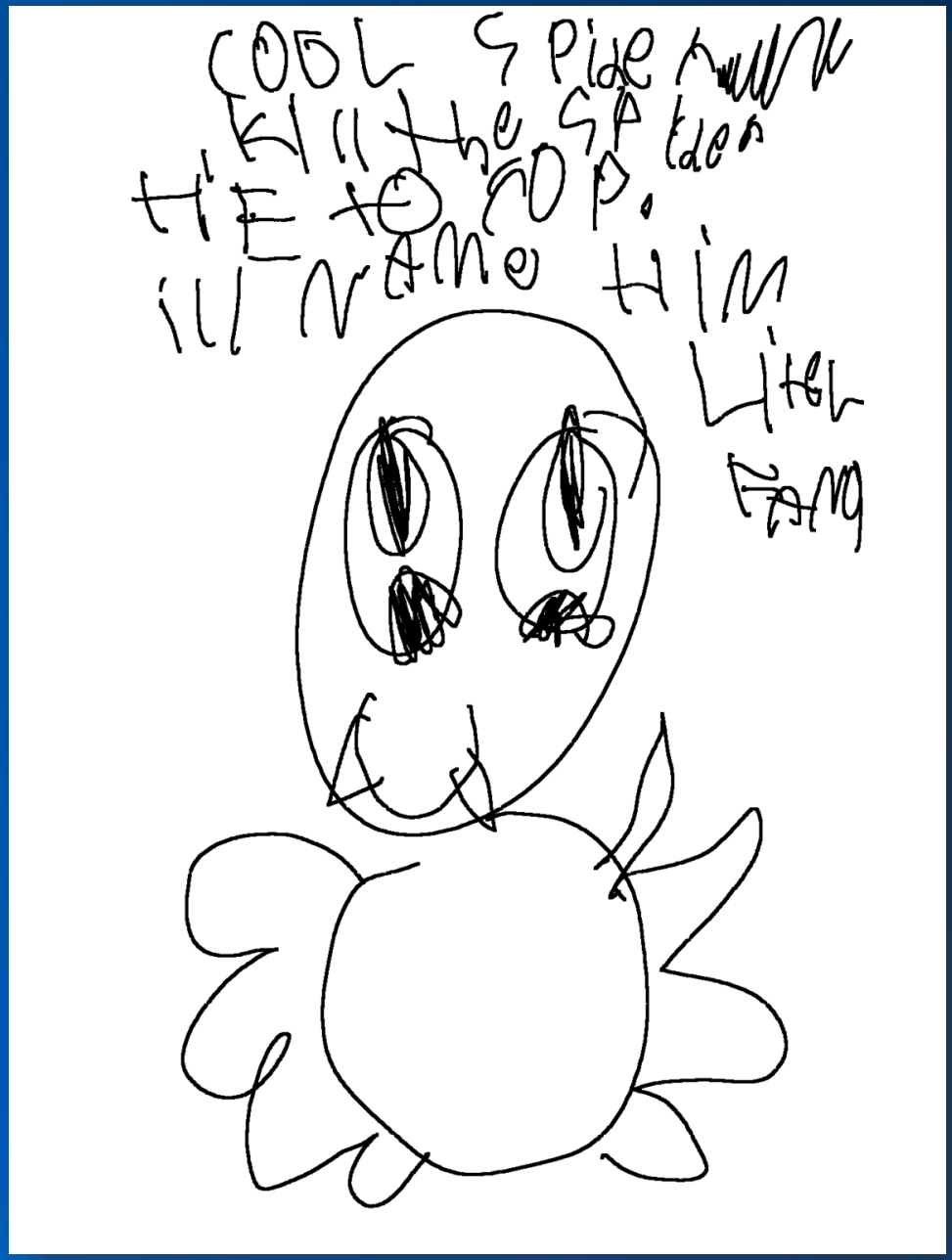
Machine Edge

Interpretation

ChatGPT4o

The image contains a drawing of a figure with large eyes, a round body and multiple limbs that resemble a spider. Above the drawing, there is text written in a childlike style that says:

"COOL SPIDE KILL THE SPIDER TO TOP. I'LL NAME HIM LITTLE FANG."

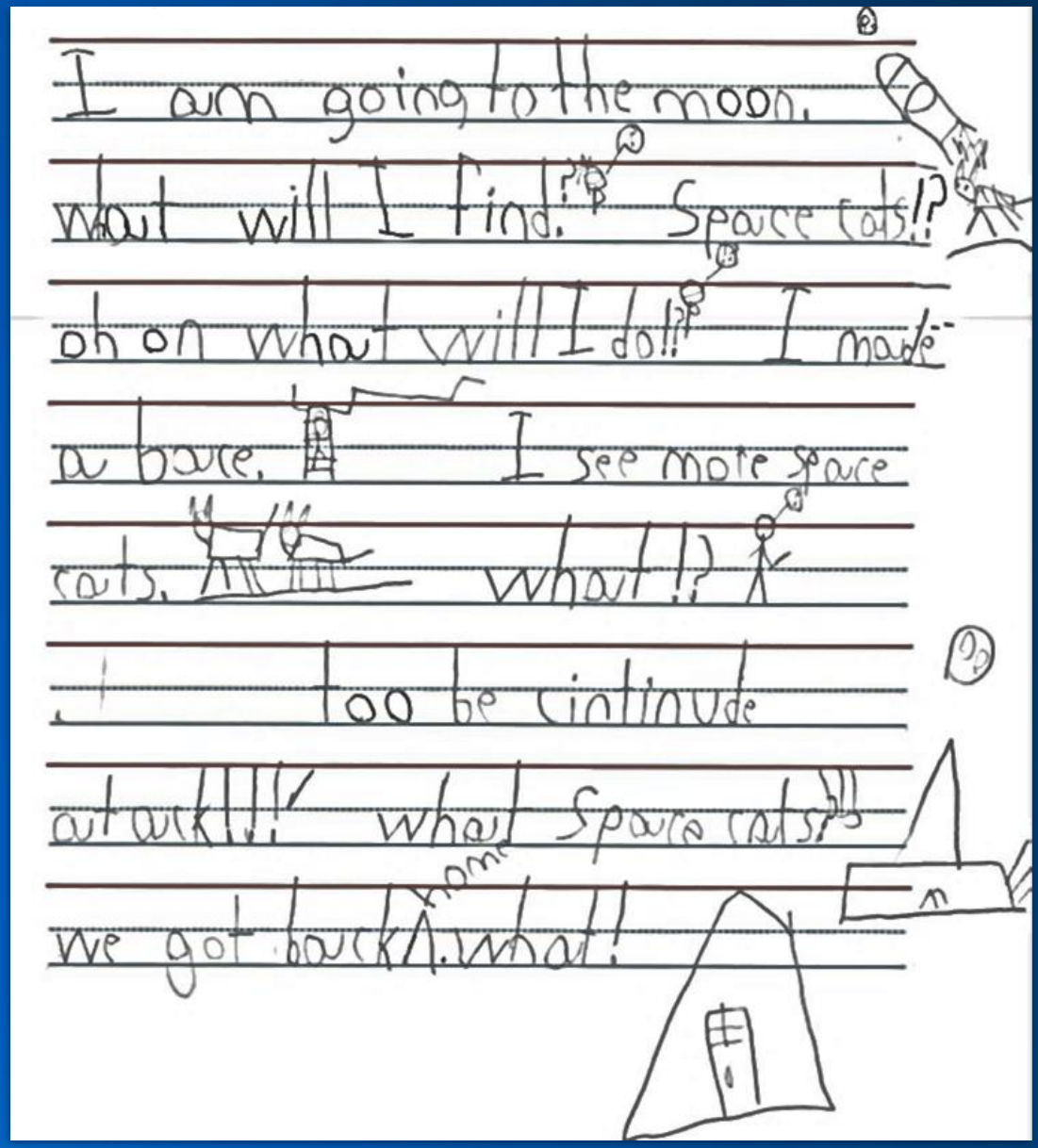


Machine Edge

Interpretation

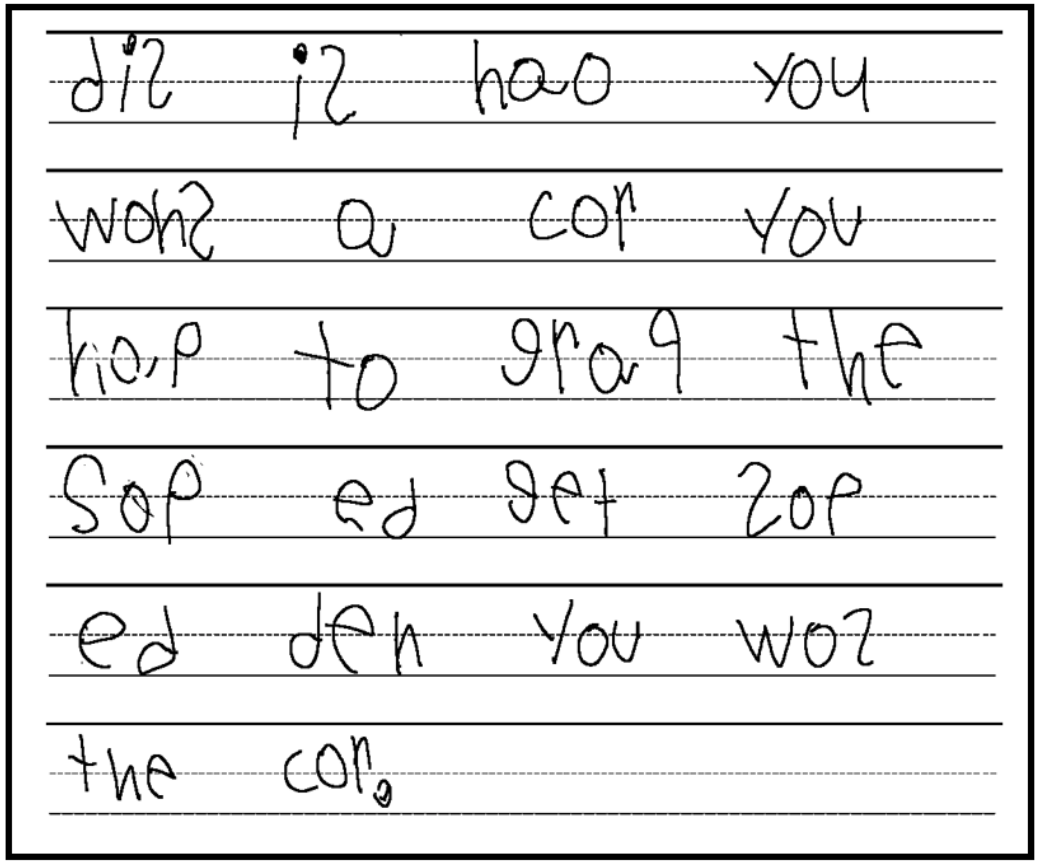
ChatGPT4o

“I am going to the moon. What will I find.
Space cats!?
Oh no what will I do!! I made a base.
I see more space cats. What?
I too be continued attack!! What space cats!?
We got back home! What!



Dyslexia

ACTUAL vs INTENDED



Child Handwriting Sample

MS AZURE

dil iz hoo you wohl a con you hop to frag the Sop ed get Zop ed den you woz the col.

ACTUAL TEXT

diS iS hao you wohS a cor you haP to grab the SoP ed get SoP ed den You wos the cor.

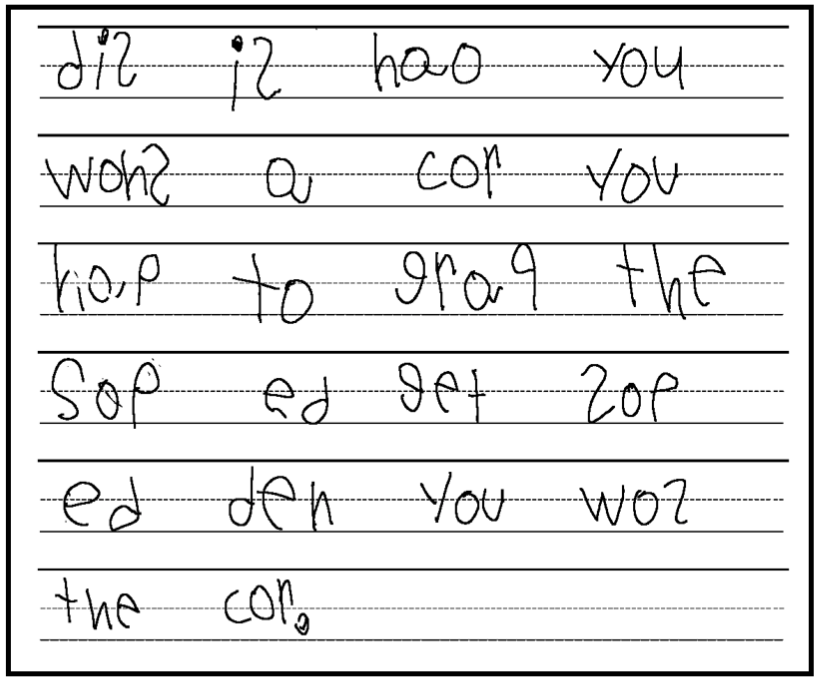
INTENDED TEXT

This is how you wash a car. You have to grab the soap and get soap and then you wash the car.

Handwriting sample collected from an elementary school in Reno, Nevada, USA

Dyslexia

ChatGPT4o



Child Handwriting Sample

Prompt: Transcribe

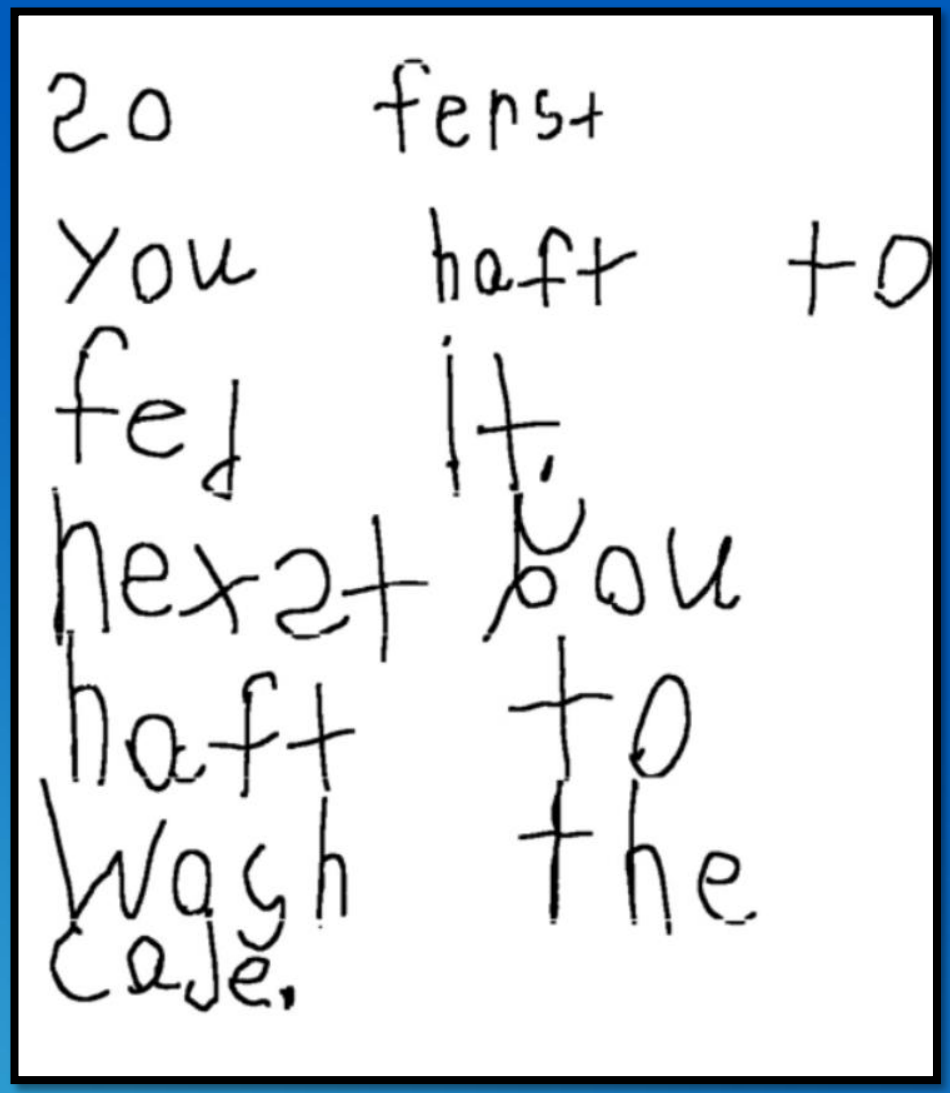
This is how you wash a car. You have to grab the soap and get some, and then you wash the car.

Prompt: Transcribe without corrections

diz iz hoo you winz a cor you hop to gra9 the sop ed get zop ed den you woz the cor,

ChatGPT Prompt

Transcribe without corrections. Detect mirrored letters.

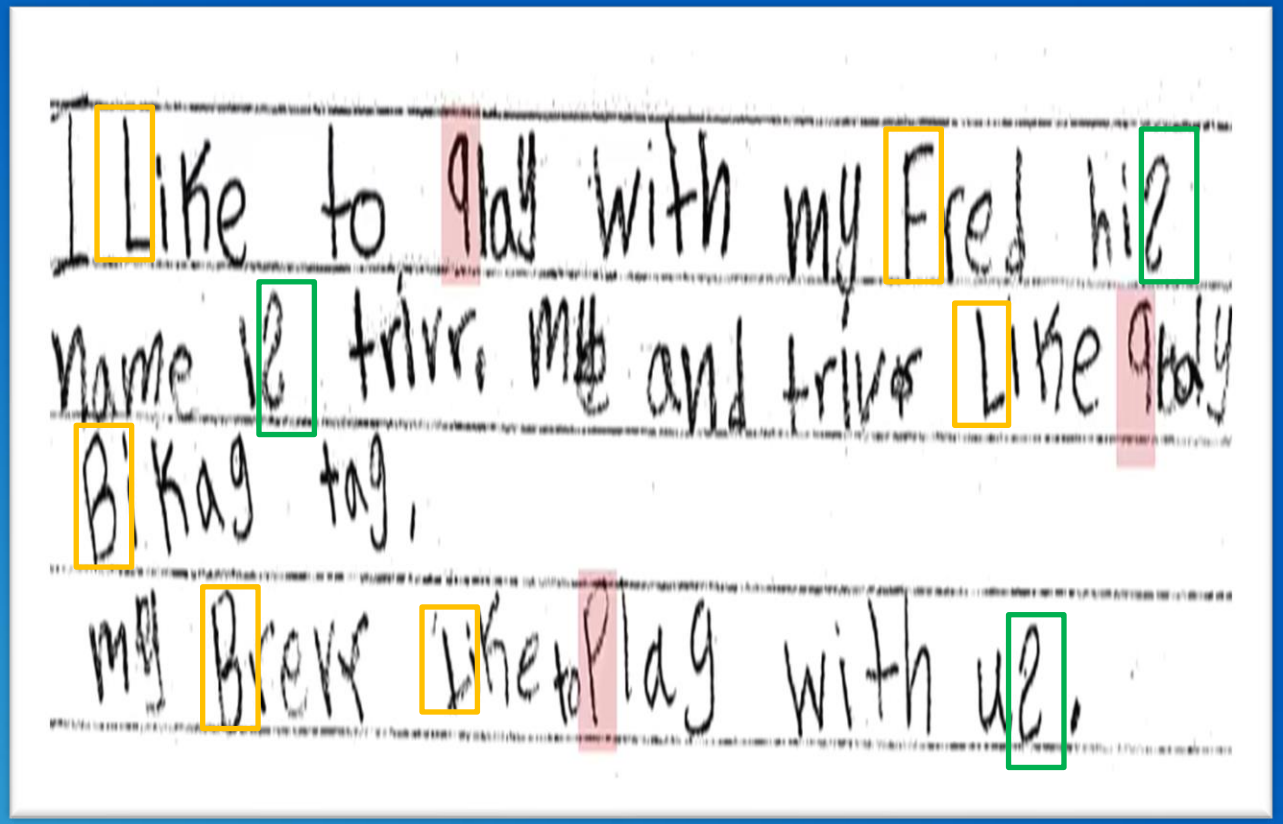


2o ferst
you haft to
fed it
nex2t you
haft to
wach the
caje.

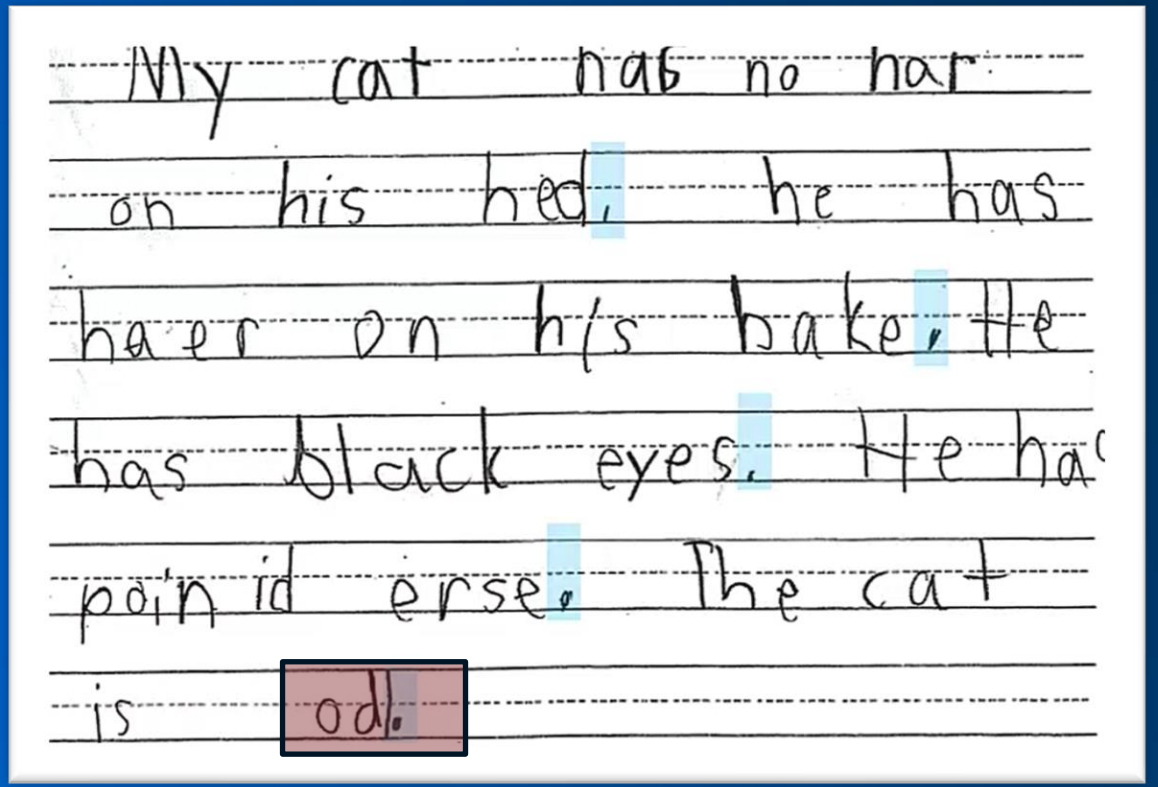
so first
you have to
feed it
next you
have to
wash the
cage.

Handwriting sample collected from an elementary school in Reno, Nevada, USA

Case Insensitive



Dyslexia Insensitive



Can LLMs Tune Context Dynamically?

Architecture Limitations:

Autoregressive transformer design intertwines features and context, making it hard to isolate or disable specific contexts.

Superficial Understanding:

Current models rely on superficial patterns, not true comprehension and lack deeper cognitive flexibility.

Training Constraints:

Requires supervision with fine-grained labels which are impractical at scale.

Contextual Tuning

Learning from End Results Only:

- Training on vast datasets of input-output pairs
- Not trained on the *process* of how the context develops
- Not exposed to incremental learning
- No continuous feedback loops in real-time environments

Superficial Adaptation:

- Lacks mechanisms to "choose" the appropriate level of context
- Blind to intermediate steps, meta-reasoning, or alternative paths
- Lack of prioritization, curiosity, or deeper comprehension

Absence of Evolutionary Drivers:

- Contextual awareness comes from interplay of survival, emotions, and social necessity,

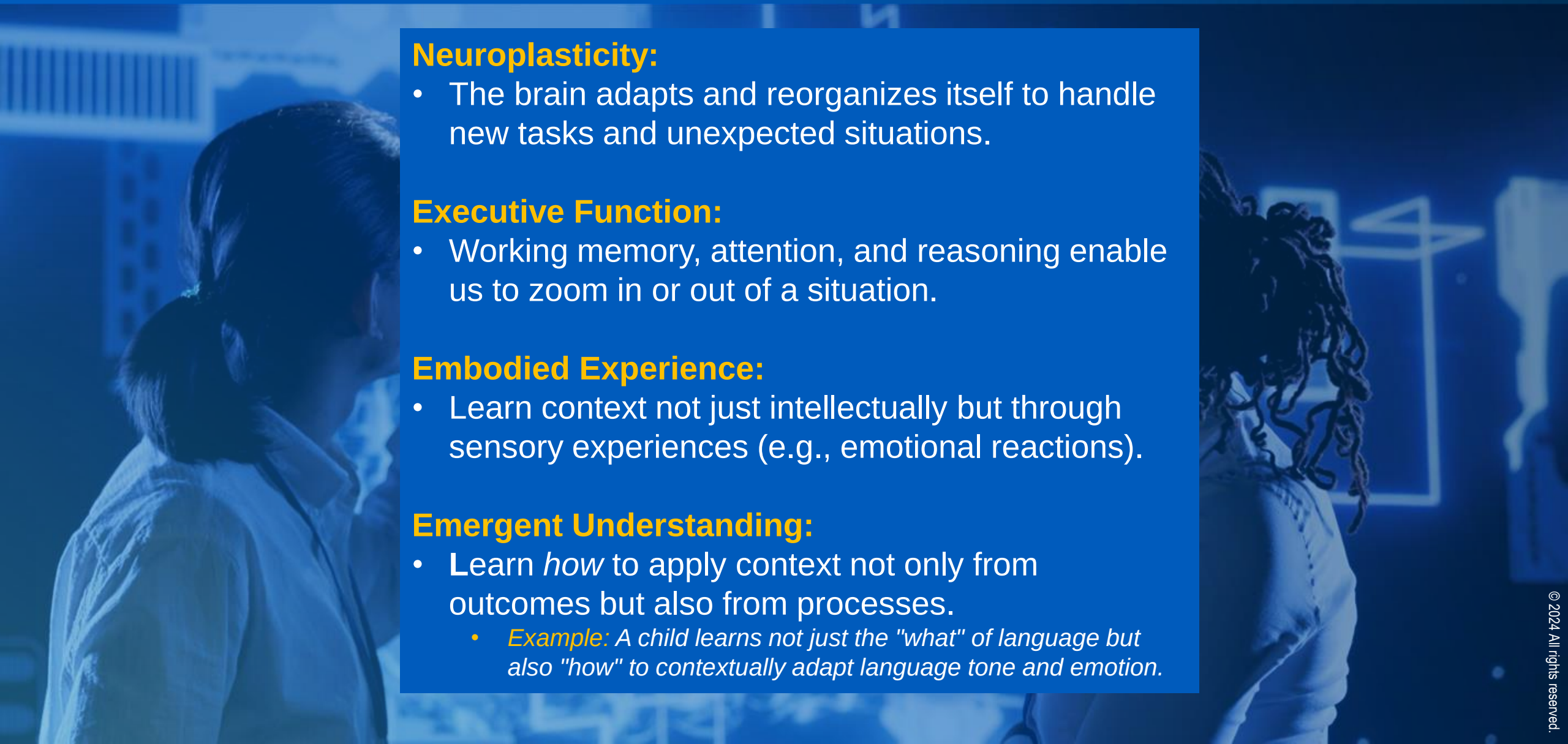
TASK:

Handwriting Recognition OCR

DIMENSIONS	HUMAN EDGE	MACHINE EDGE
CONTEXT	★	★
NO CONTEXT		★
GESTALT	★	
CHILD	?	?
DYSLEXIA	★	

Human Edge

Apply context dynamically through evolutionary pressures
adapting to new environments, understanding social cues, and solving problems.



Neuroplasticity:
- The brain adapts and reorganizes itself to handle new tasks and unexpected situations.

Executive Function:
- Working memory, attention, and reasoning enable us to zoom in or out of a situation.

Embodied Experience:
- Learn context not just intellectually but through sensory experiences (e.g., emotional reactions).

Emergent Understanding:
- **L**earn *how* to apply context not only from outcomes but also from processes.
  - *Example: A child learns not just the "what" of language but also "how" to contextually adapt language tone and emotion.*

1 Specific learning disability (SLD)

Approximately 15% of people in the US have dyslexia; This equates to over 30 million adults
(source: IDA, 2023).

AI Solutions

How can AI help?

Checklists, Tests Observations → **Disability Identification** → **AI Interventions** → **Generative AI Tools Storytelling Avatars Robots**

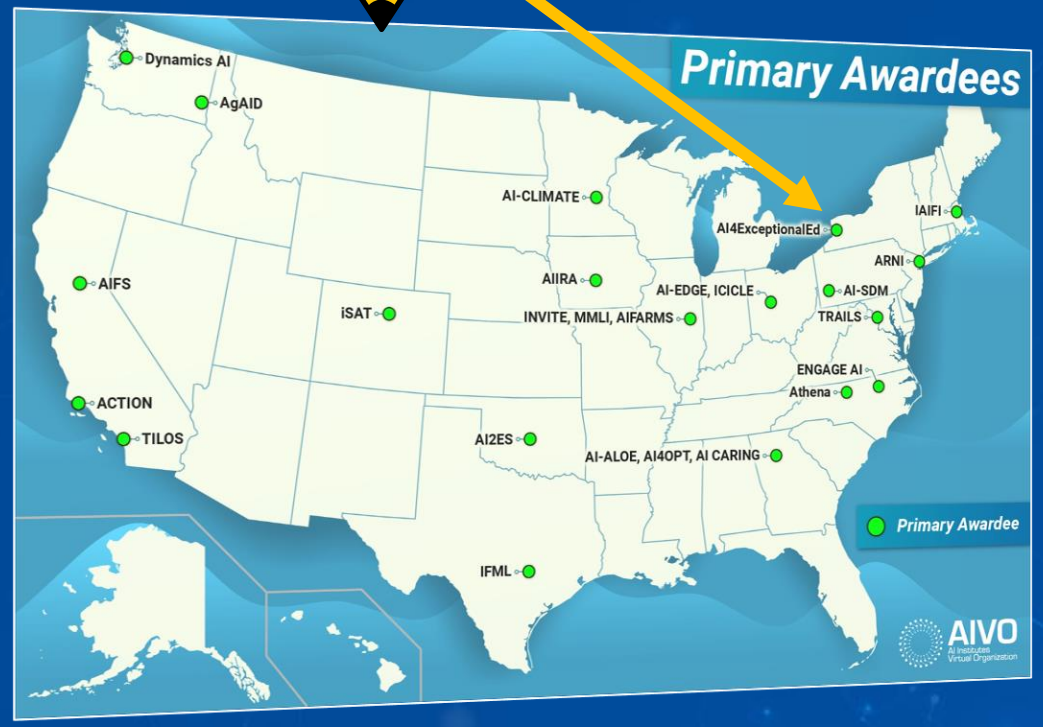
S&L METRICS

Writing	Speech	Non-verbal
Tidiness, legibility	Vocabulary	Micro exp
Spellings	FSV, PGU	Action units
Punctuation	Automaticity	Symmetry
Grammar	Construction	Duration

University at Buffalo The State University of New York

AI INSTITUTES

NATIONAL AI INSTITUTE for Exceptional Education



ACTION
AI Institute for Agent-based Cyber Threat Intelligence and Operation
Funded by NSF

AgAID
Institute for Agricultural AI for Transforming Workforce and Decision Support
Funded by USDA-NIFA

AI2ES
AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography
Funded by NSF

AI4ExceptionalEd
National AI Institute for Exceptional Education
Funded by NSF

AI4OPT
AI Institute for Advances in Optimization
Funded by NSF

AI-ALOE
AI Institute for Adult Learning and Online Education
Funded by NSF

AI CARING
AI Institute for Collaborative Assistance and Responsive Interaction for Networked Groups
Funded by NSF

AI-CLIMATE
AI Institute for Climate-Land Interactions, Mitigation, Adaptation, Tradeoffs and Economy
Funded by USDA-NIFA

AI-EDGE
AI Institute for Future Edge Networks and Distributed Intelligence
Funded by NSF

AIFARMS
Artificial Intelligence for Future Agricultural Resilience, Management, and Sustainability
Funded by USDA-NIFA

AIFS
AI Institute for Next Generation Food Systems
Funded by USDA-NIFA

AIIRA
The AI Institute for Resilient Agriculture
Funded by USDA-NIFA

AI-SDM
AI Institute for Societal Decision Making
Funded by NSF

ARNI
AI Institute for ARtificial and Natural Intelligence
Funded by NSF

Athena
AI Institute for Edge Computing Leveraging Next-generation Networks
Funded by NSF

Dynamics AI
AI Institute for Dynamic Systems
Funded by NSF

Engage AI
AI Institute for Engaged Learning
Funded by NSF

IAIFI
AI Institute for Artificial Intelligence and Fundamental Interactions
Funded by NSF

ICICLE
AI Institute for Intelligent Cyberinfrastructure with Computational Learning in the Environment
Funded by NSF

IFML
AI Institute for Foundations of Machine Learning
Funded by NSF

INVITE
AI Institute for Inclusive and Intelligent Technologies for Education
Funded by NSF

iSAT
AI Institute for Student-AI Teaming
Funded by NSF

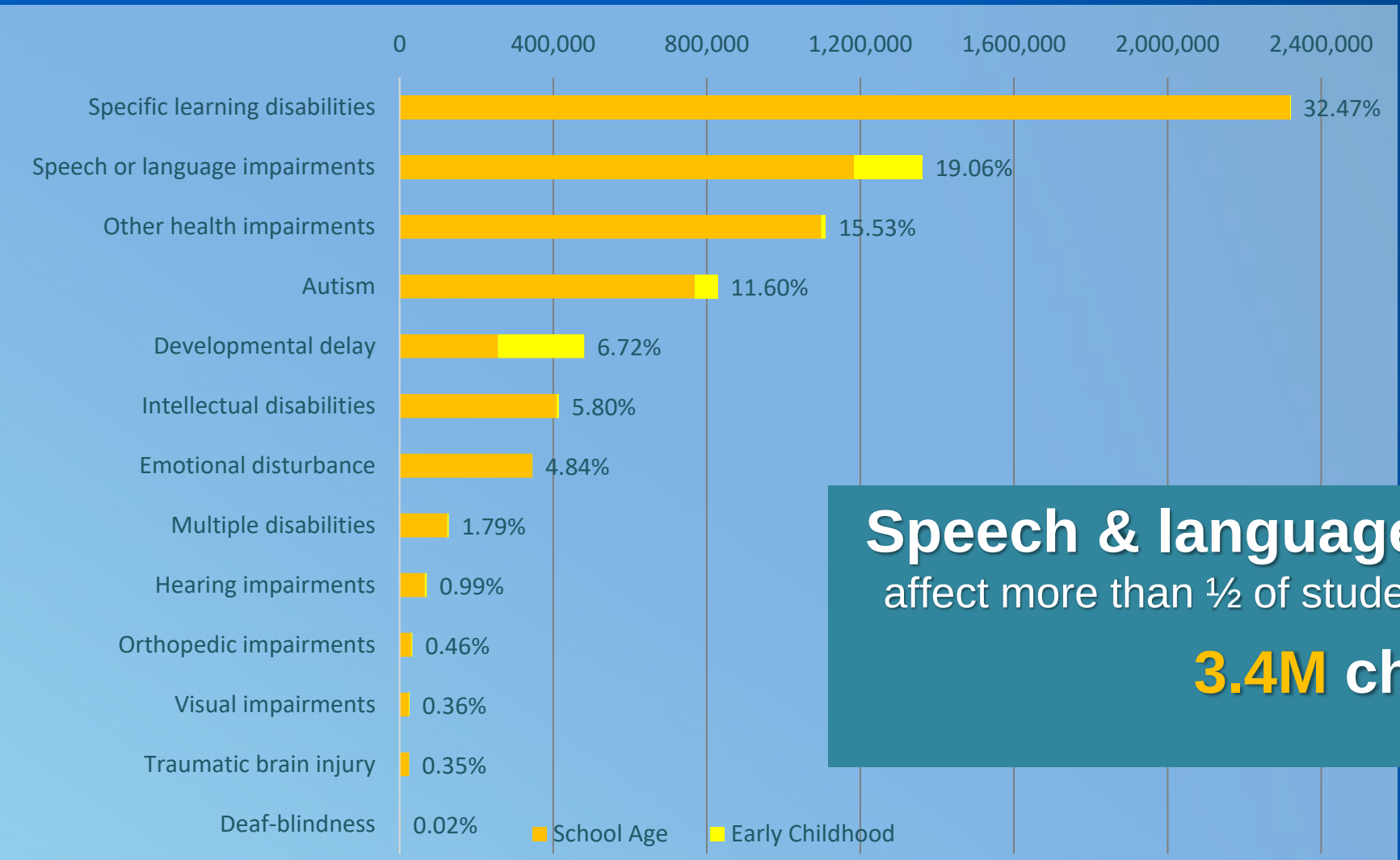
MMLI
AI Institute for Molecular Discovery, Synthetic Strategy, and Manufacturing
Funded by NSF

TILOS
AI Institute for Learning-Enabled Optimization at Scale
Funded by NSF

TRAILS
Institute for Trustworthy AI in Law & Society
Funded by NSF

EDUCATION AGRICULTURE (USDA)

NEEDS | Treating S&L Related Disorders



1. About **80%** of children with **specific learning disability** struggle with literacy and language (American Psychiatry Association, 2021) **(~1.86M)**
2. **Speech or language impairment**: all **(~1.36M)**
3. About **half** of the children under **other health impairments** have DLD (Mueller & Tomblin, 2012) **(~0.55M)**

Speech & language related disorders
affect more than ½ of students under IDEA, i.e., about
3.4M children.

Number of children in early childhood programs and of school age served under IDEA, Part B, by disability (Nov 2021)
https://www2.ed.gov/programs/osepidea/618-data/static-tables/index.html

CHALLENGE | Providing Quality Services

Children with **speech** and **language disorders** represent the **largest intervention caseload**[1].

3.4M*

Need S&L services

*Department of Education, 2021

60,900*

SLPs at US Schools

*Bureau of Labor Statistics, 2021

CHALLENGE

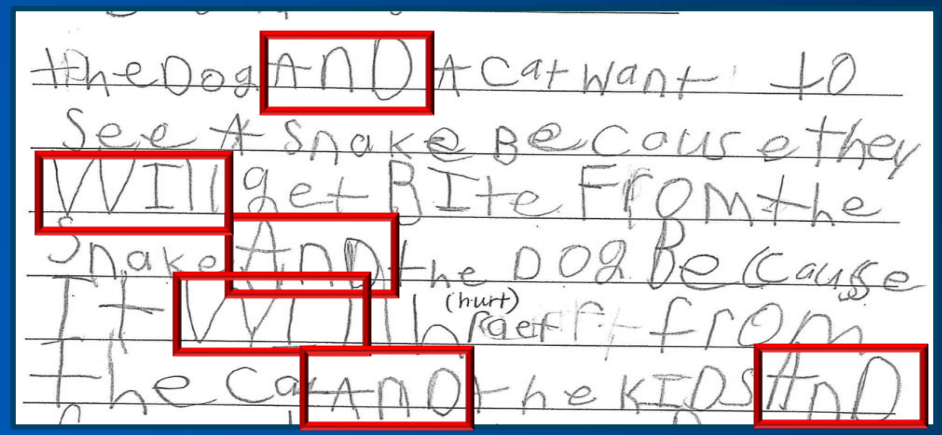
Which "evidence-based practice" should be used; and with what timing, intensity, duration?

[1] ASHA Schools Survey, 2020

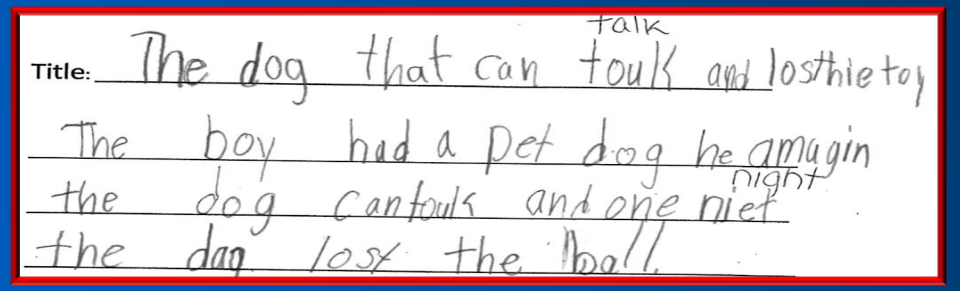
Step 4: Analyzing Writing Sample				Steps 5: Determining Plan and Collaborating Provider	
#	Behavioral Indicator		Presence of Behavioral Indicator	0 = Consultation with Collaborating Provider 1 = Instruction (Tier 1) 2 = Instructional Intervention (Tier 2) 3 = Intervention (Tier 3)	
1	W1	Atypical writing in relation to the vertical axis	[Y] N	0 [1] 2 3	OT
2	W2	Atypical use of margins/ space planning	[Y] N	[0] [1] 2 3	[OT]
3	W3	Inversions	Y [N]	0 1 2 3	OT
4	W4	Transpositions	Y [N]	0 1 2 3	OT
5	W5	Inconsistent sizing of letters	[Y] N	[0] [1] 2 3	[OT]
6	B1	Reversals	[Y] N	[0] 1 [2] 3	[OT & SLP]
7	B2	Spelling errors	[Y] N	[0] 1 [2] 3	[OT & SLP]
8	B3	Letter crowding/ atypical spacing	[Y] N	0 1 [2] 3	OT & SLP
9	B4	Poor legibility	[Y] N	0 1 [2] 3	OT & SLP
10	B5	Inconsistent/lack of grammatical conventions	[Y] N	0 1 [2] 3	OT & SLP
11	B6	Abandoned words	Y [N]	0 1 2 3	OT & SLP
12	R1	Lack of diverse vocabulary	[Y] N	[0] [1] 2 3	[SLP]
13	R2	Poor idea development/ organizations of ideas	[Y] N	[0] [1] 2 3	[SLP]

Figure 2. Antonio's completed Dysgraphia and Dyslexia Behavioral Indicator Checklist after writing sample, Steps 4 and 5.
Note. # = number of 13 indicators; W = dysgraphia; B = dysgraphia and dyslexia; R = dyslexia; Y = yes; N = no; OT = occupational therapist; SLP = speech-language pathologist.

DYSLEXIA
Indicators Checklist



1

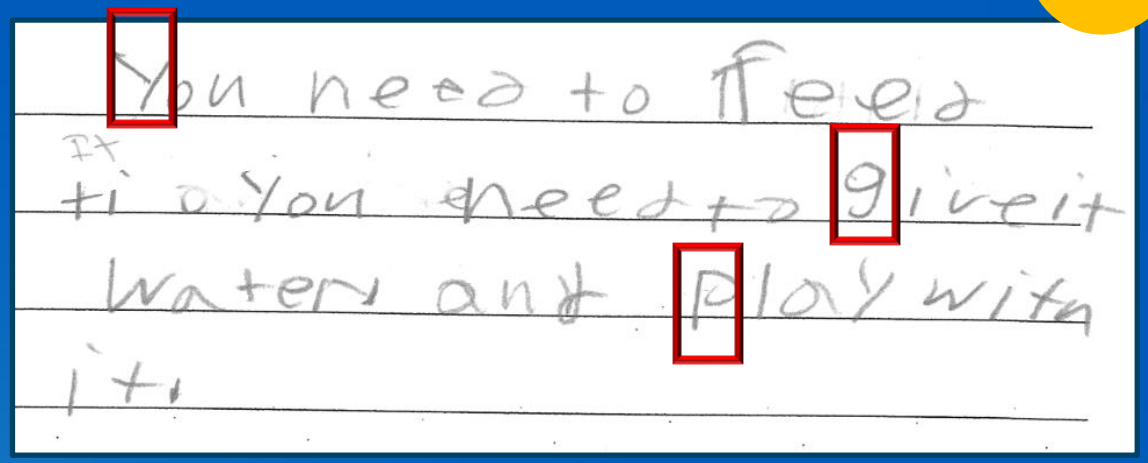


2

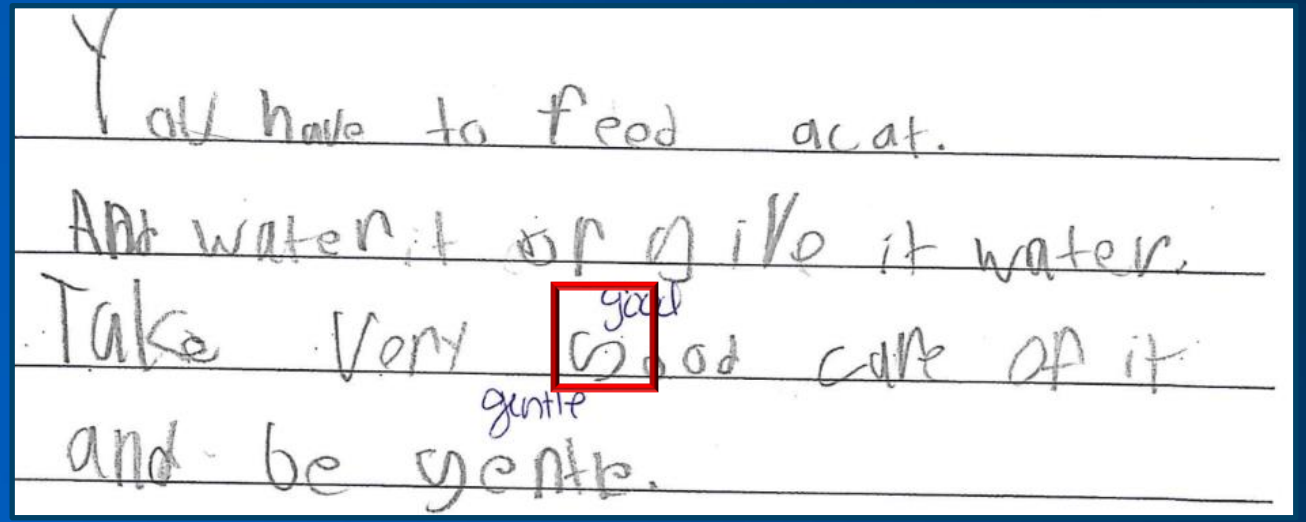
R1: vocabulary
R2: idea development and organization

DYSGRAPHIA

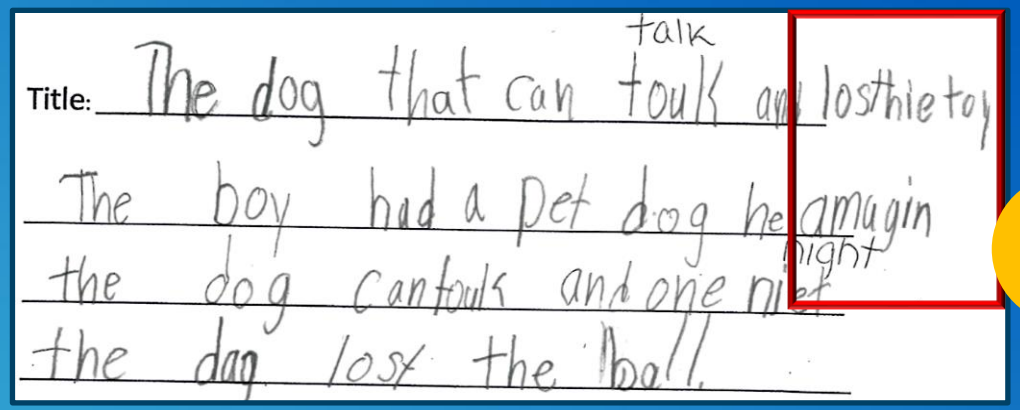
1



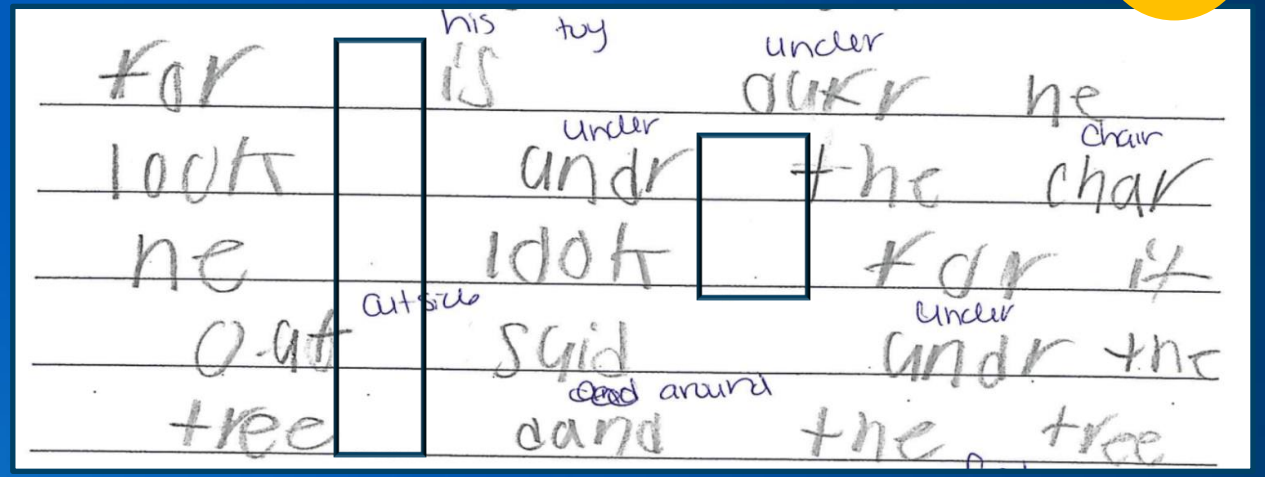
3



W1: y-axis relative alignment
W2: space planning and margins
W3: inversions

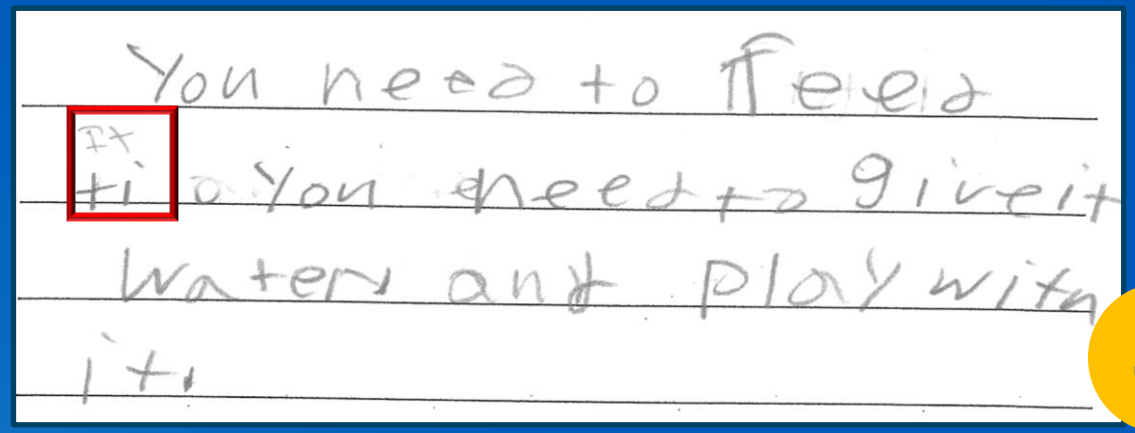


2

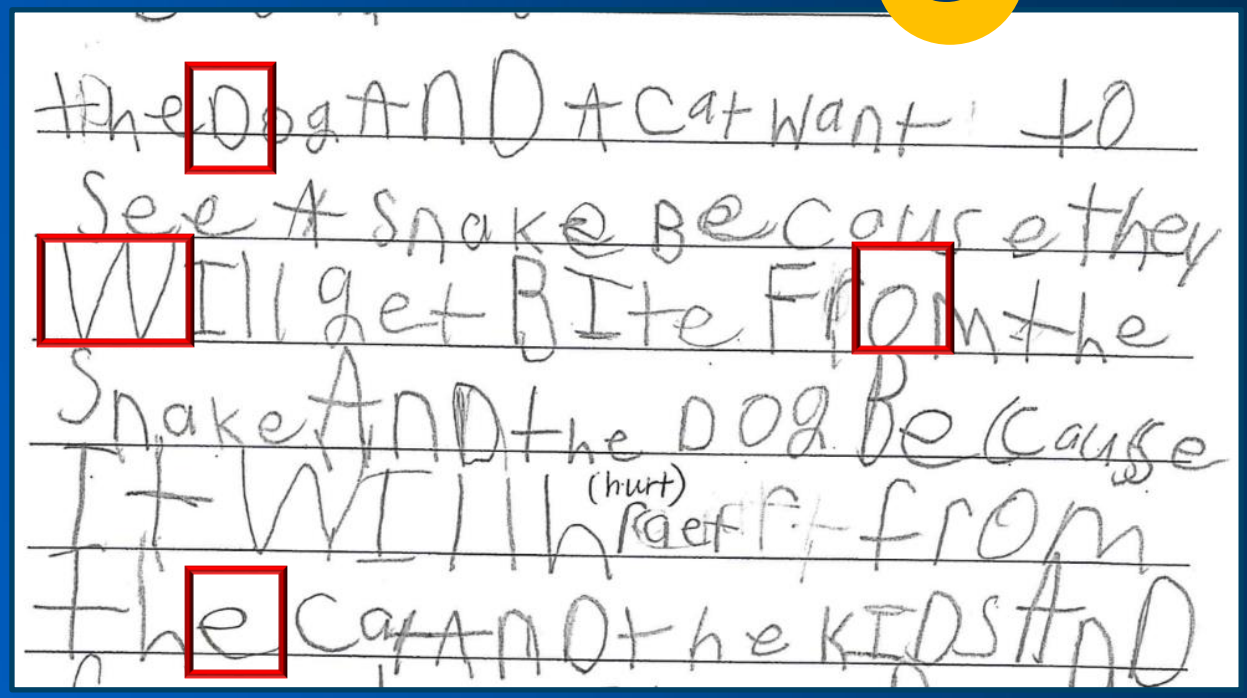


2

DYSGRAPHIA

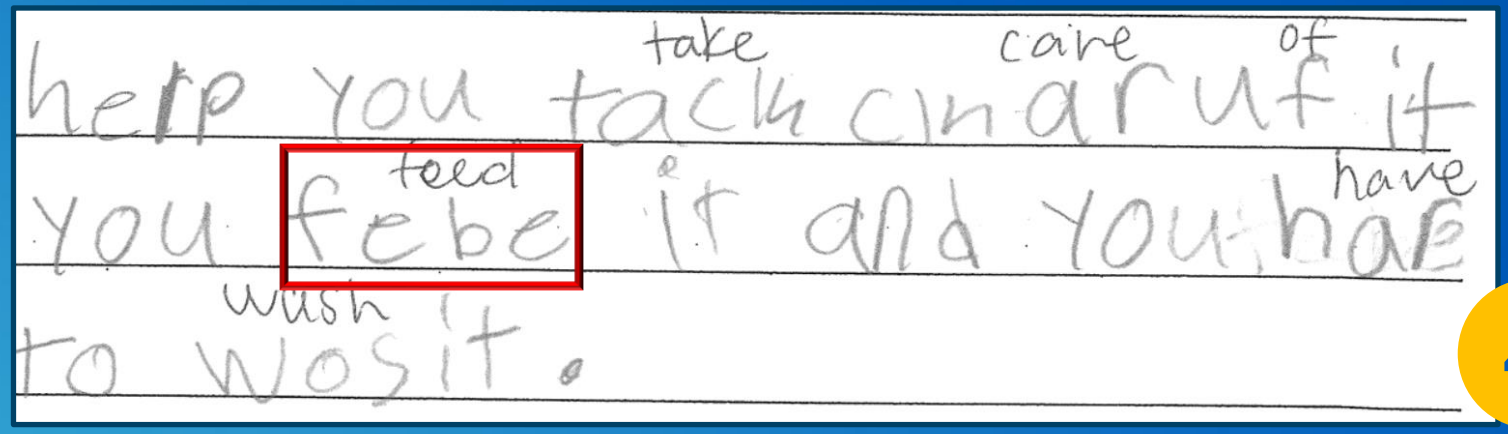


4



5

W4: transpositions
W5: inconsistent sizes

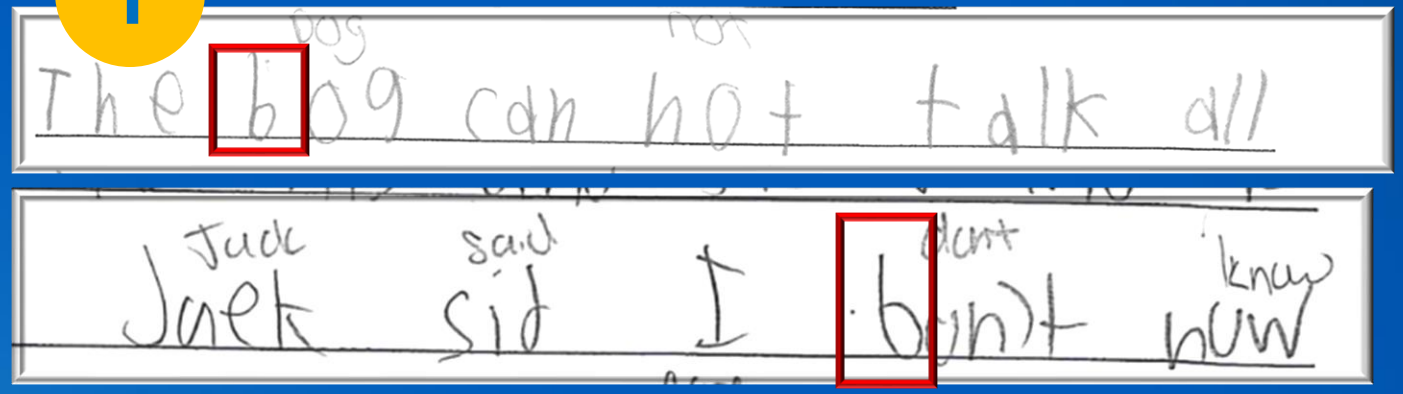


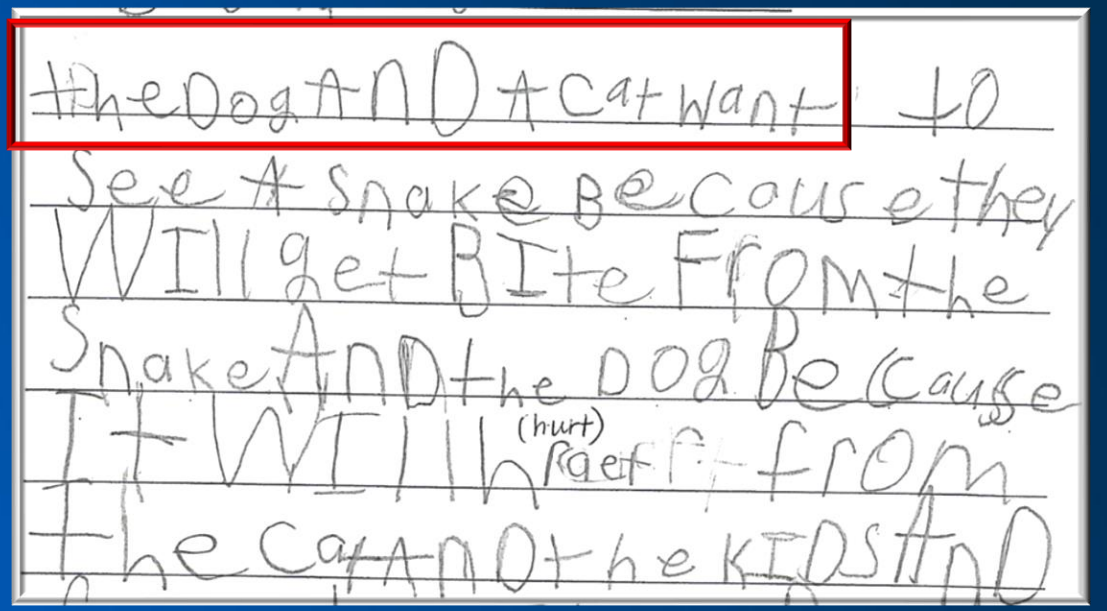
4

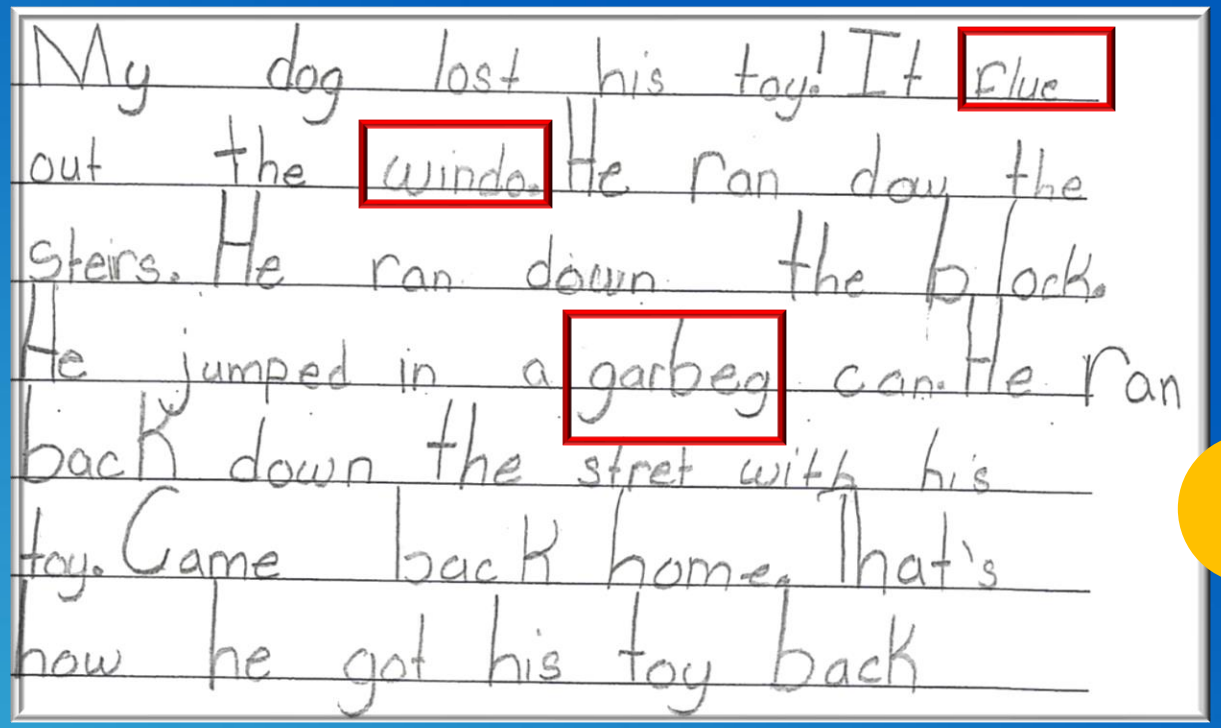
T3: Abbie et al @UNR

DYSLEXIA & DYSGRAPHIA

1

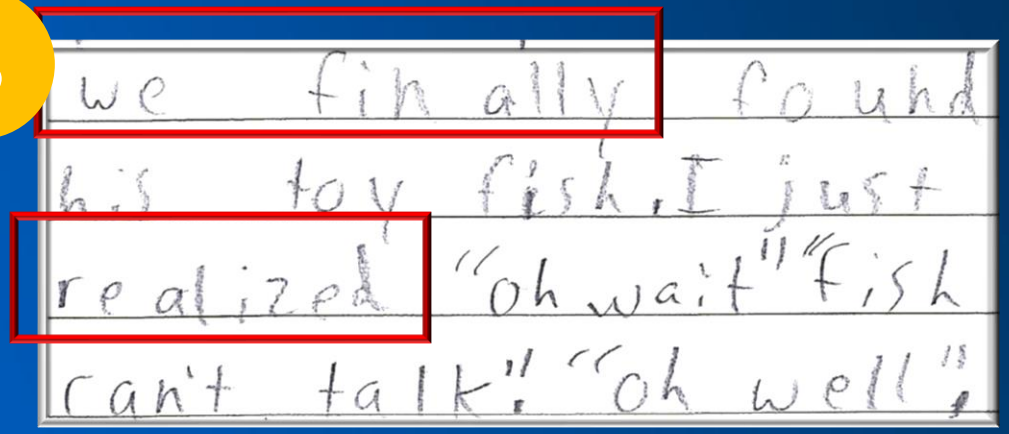






2

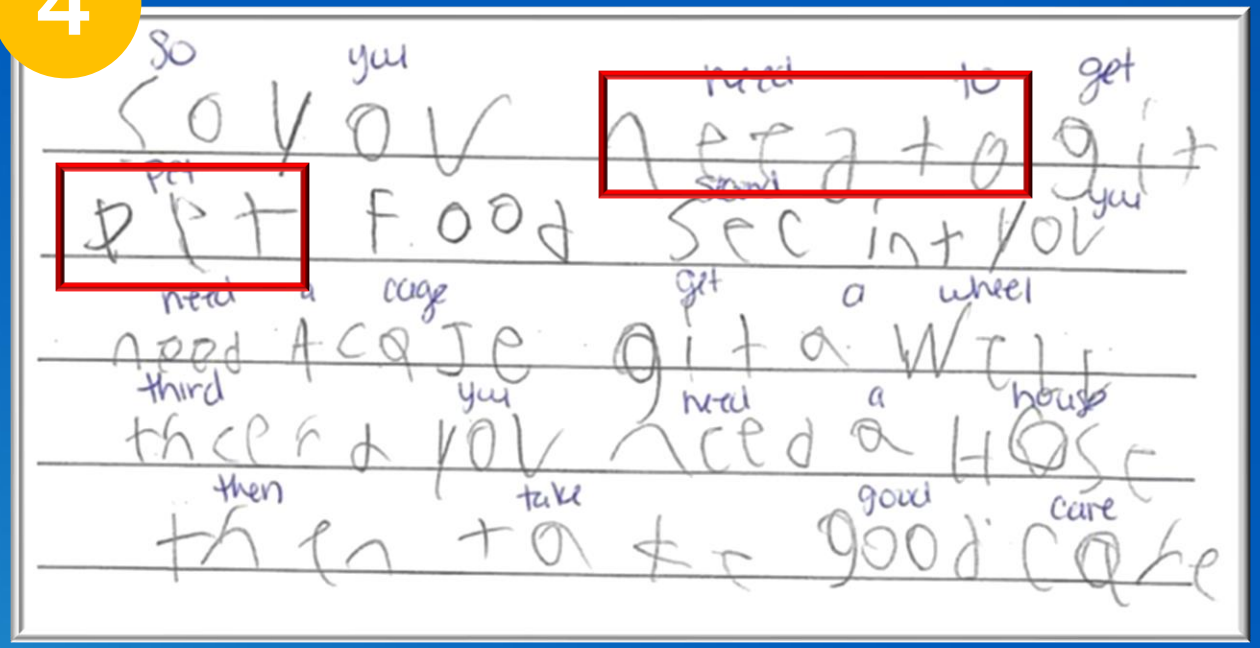
3



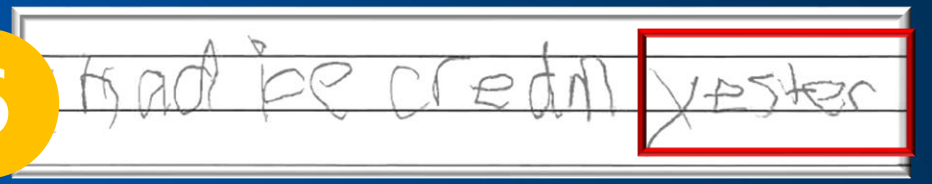
B1: reversal
B2: spelling errors
B3: crowding/ atypical spacing

DYSLEXIA & DYSGRAPHIA

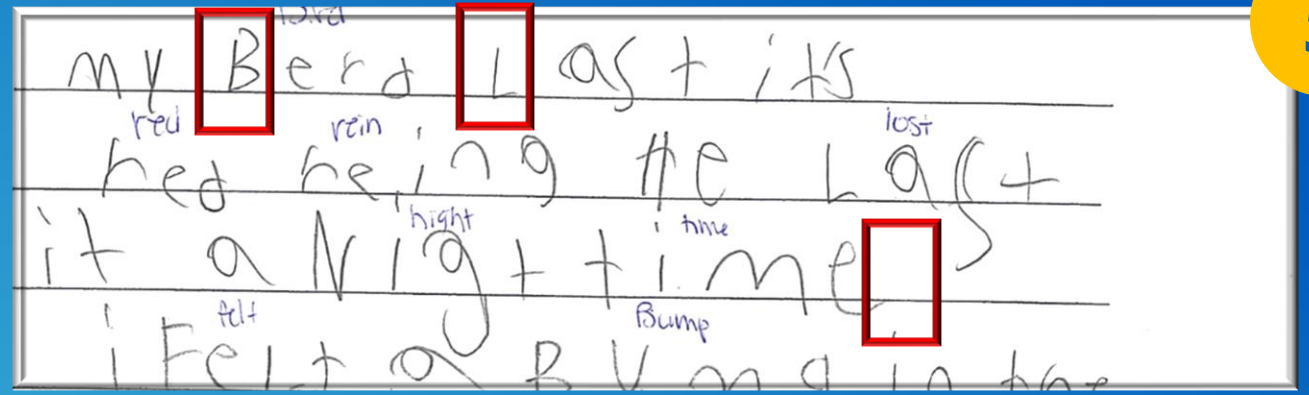
4



6



B4: legibility
B5: grammar/ punctuation
B6: abandon



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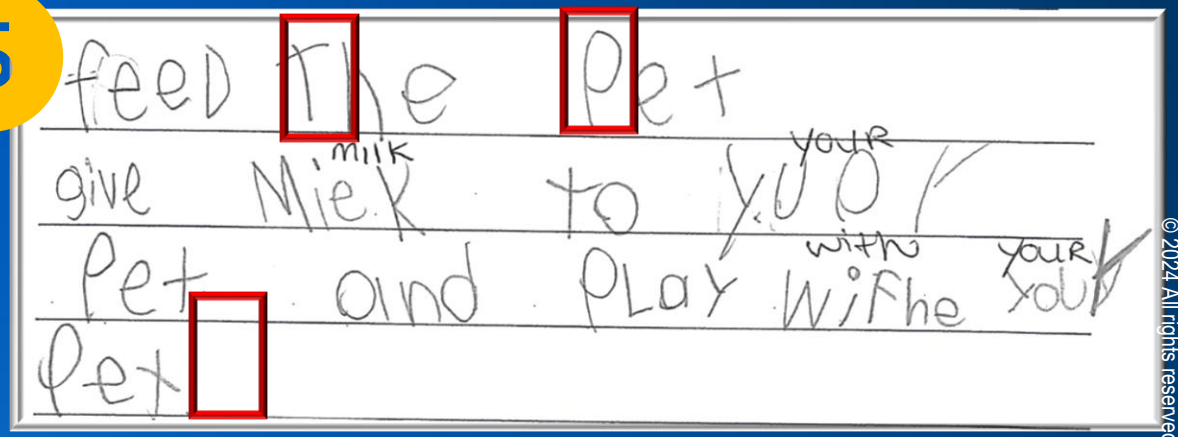
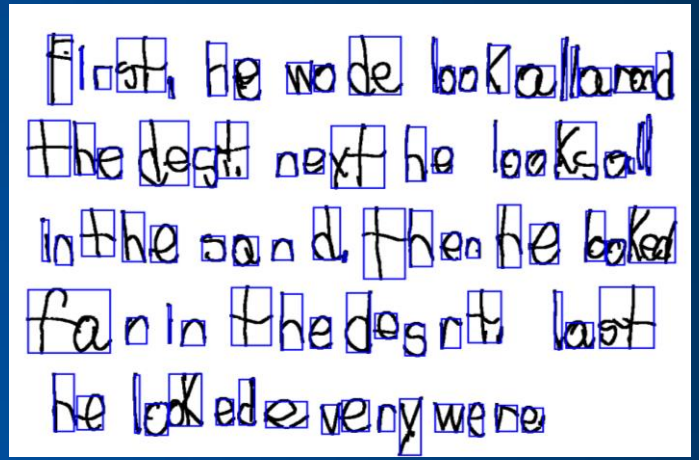
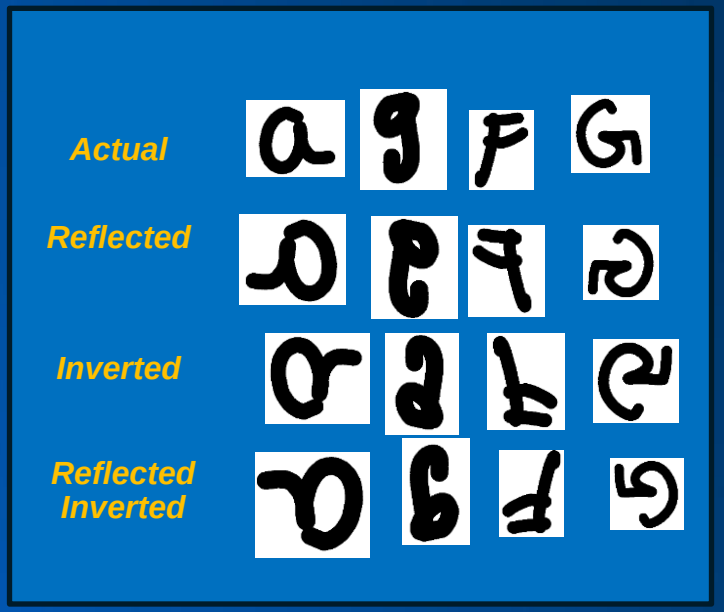


E-TrOCR

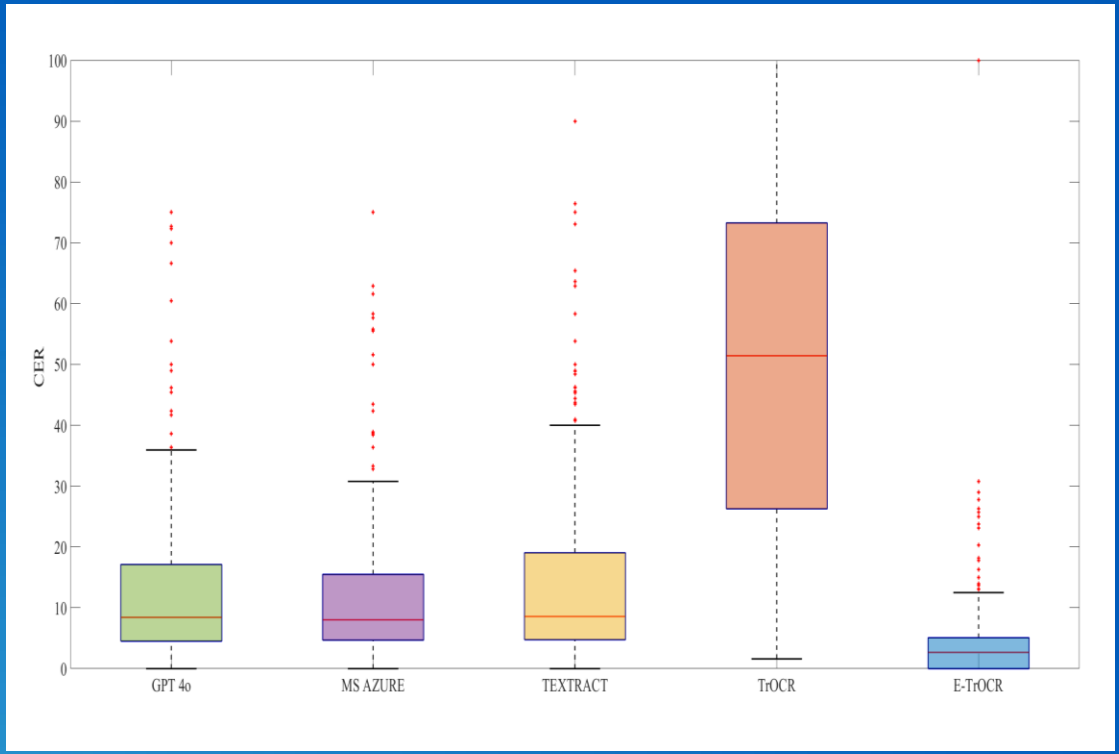
- Extension of TrOCR, an open-source encoder-decoder OCR model by Microsoft
- New characters added into training dataset
  - Added mirrored letters (reversals, inversions)
  - Fine-tuned on the Reno dataset (child writing)
- Tokenization at the character level to force E-TrOCR to predict text character by character
  - Instead of subword by subword as in TrOCR which tokenizes using the BPE algorithm)



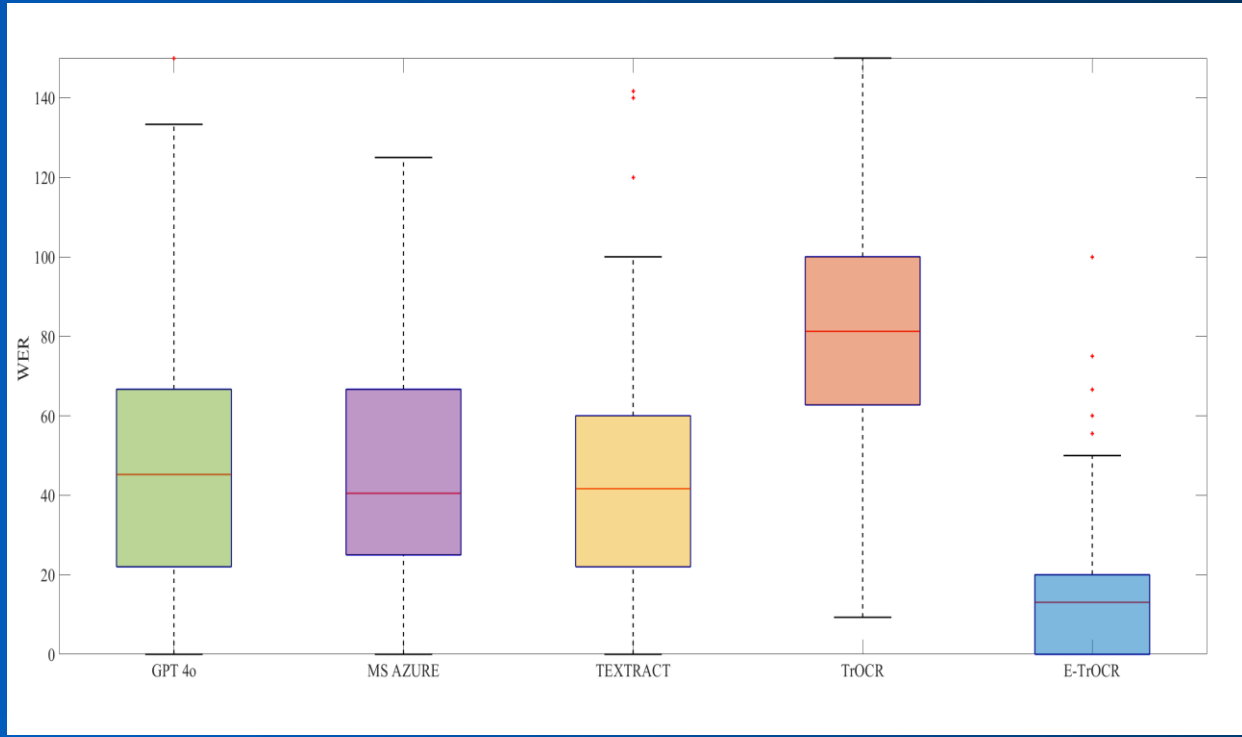


Error Analysis

GPT4o Azure Textract TrOCR E-TrOCR



GPT4o Azure Textract TrOCR E-TrOCR

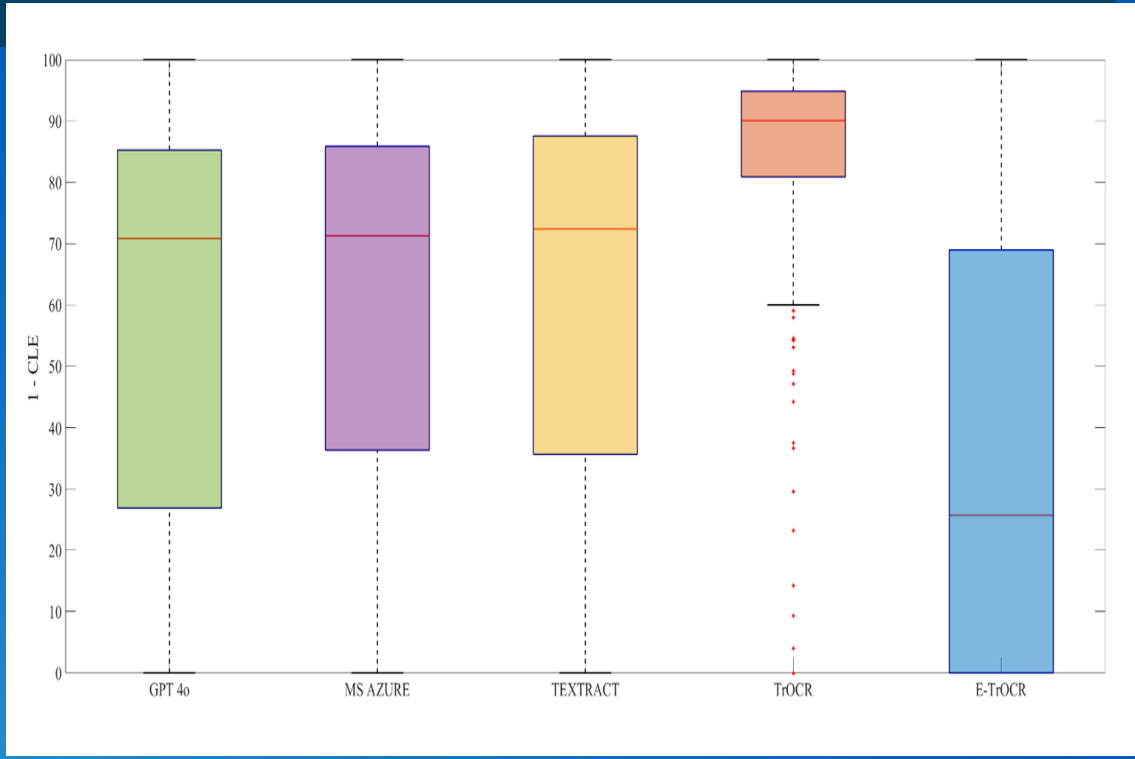


CER (Character Error Rate) **WER (Word Error Rate)**

400 Children handwriting sample collected from an elementary school in Reno, Nevada, USA

Error Analysis

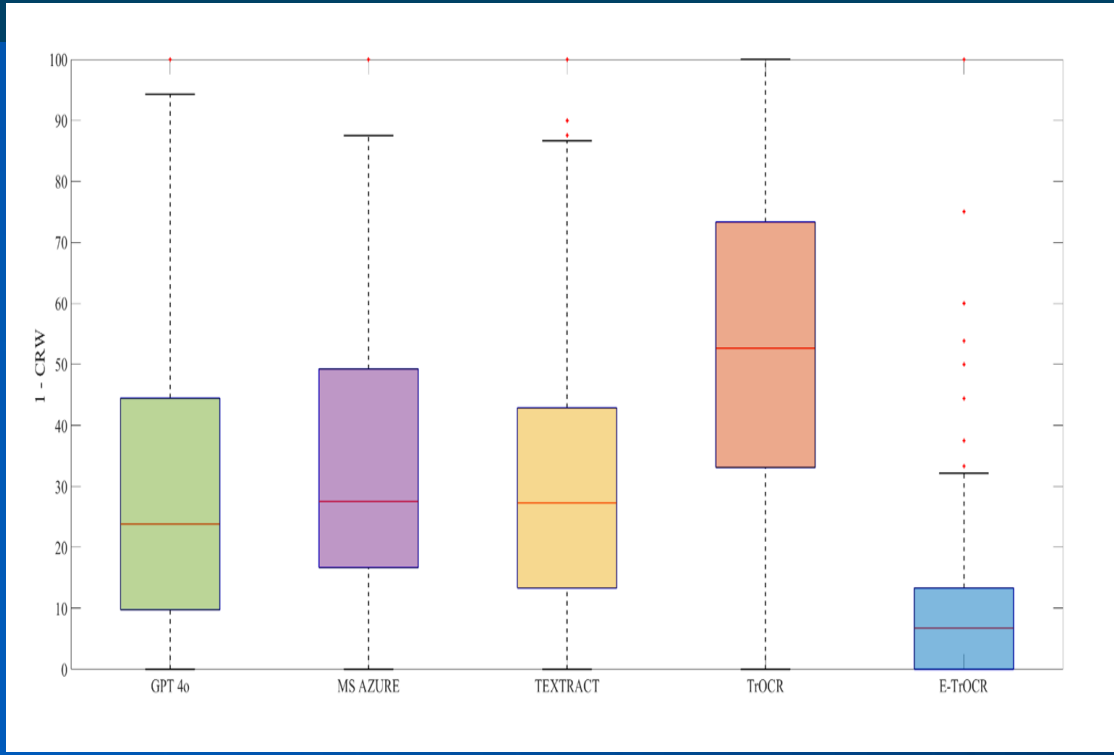
GPT4o Azure Textract TrOCR E-TrOCR



1-CLE

CLE (Character-Level Evaluation): Measures the correctness of individual characters between the recognized text and the ground truth.

GPT4o Azure Textract TrOCR E-TrOCR



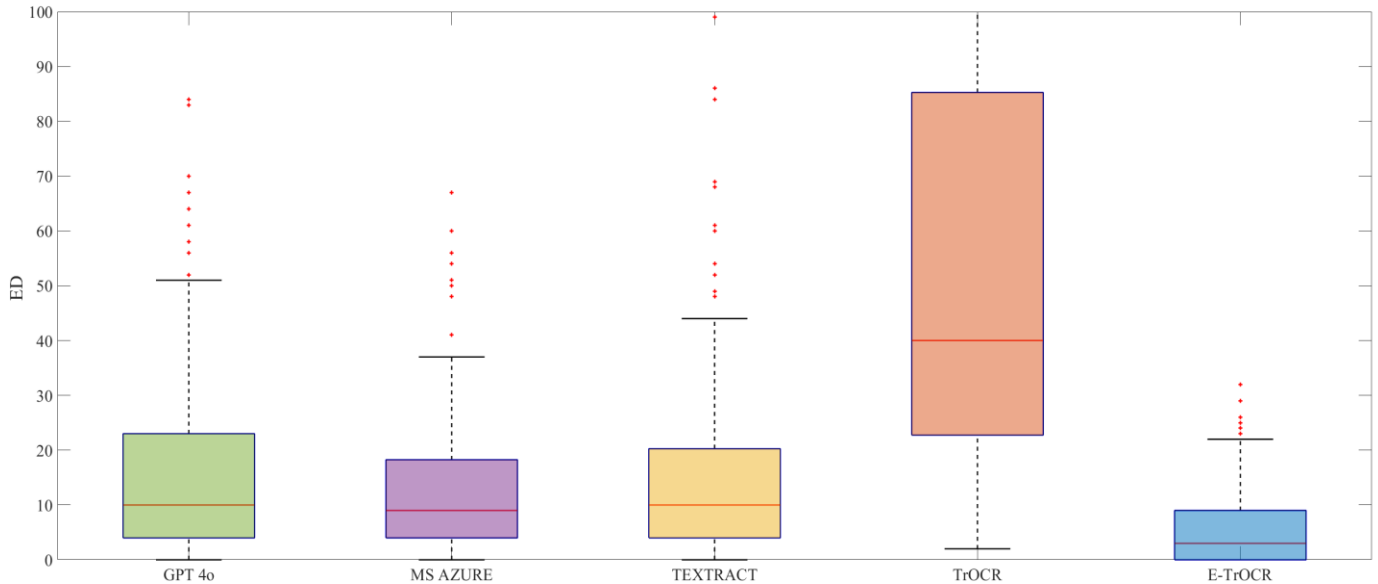
1-CRW

CRW (Correct Recognition Word): Measures the percentage of words that were correctly recognized without any error.

400 Children handwriting sample collected from an elementary school in Reno, Nevada, USA

Error Analysis

GPT 4o Azure Textract TrOCR E-TrOCR



ED (Edit Distance)

Minimum number of operations (insertions, deletions, substitutions) required to change the predicted string into the actual string.

400 Children handwriting sample collected from an elementary school in Reno, Nevada, USA

INTERVENTION

SLDs with Structured Word Inquiry

Interrelationship of English spelling, pronunciation, and meaning

Four questions to guide inquiry:

- » What is the meaning of a word?
- » How is the word built?
- » What are the relatives of the word?
- » How are the graphemes functioning in the word?

TOOL USED | Word Matrix

ad pre	**dict** *say, declare*	ate	or
		ion	ary

TOOL USED | Word Sum

ad + dict → addict
ad + dict + ion → addiction
pre + dict → predict
dict + ion → diction
dict + ate → dictate
dict + ate / + or → dictator

Olszewski, Abbie . "Group Literacy Intervention Using Structured Word Inquiry: A Tutorial." 17 Nov. 2023, ASHA 2023 Conference, Boston, MA

TOOL DEMO

TOOLS

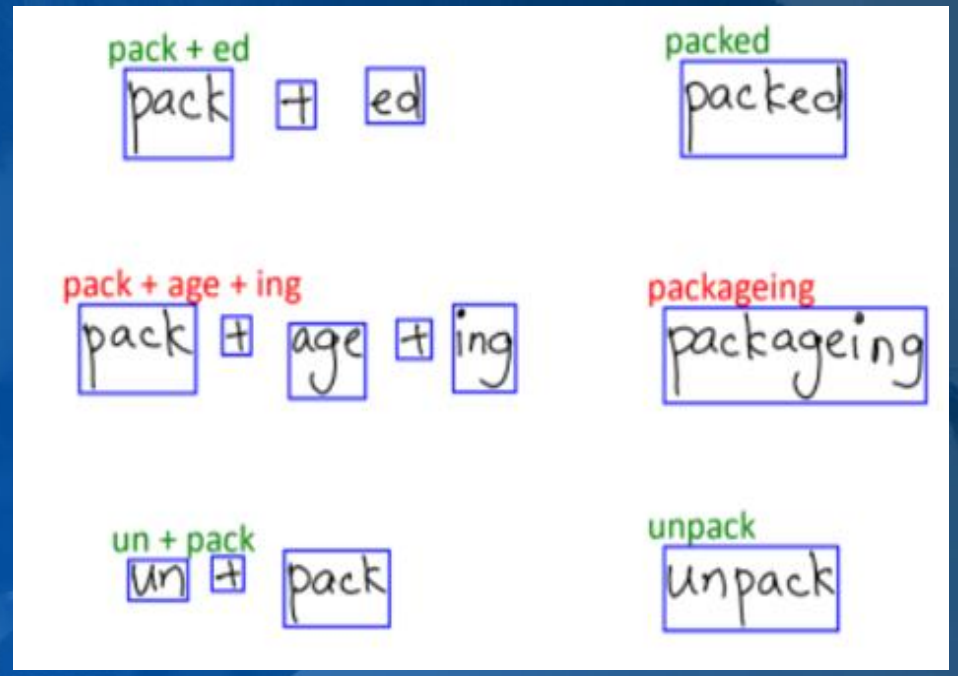
Word Matrix			
re un	**pack** *say, declare*	s er ing ed	
		age	es ing ed
		et	s

1) pack + ed → packed

2) pack + age + ing → packageing

3) un + pack → unpack

4) _____ → _____



WORD SUMS from < pack > matrix

RESULT

» Some of the answers may be wrong.

FEEDBACK

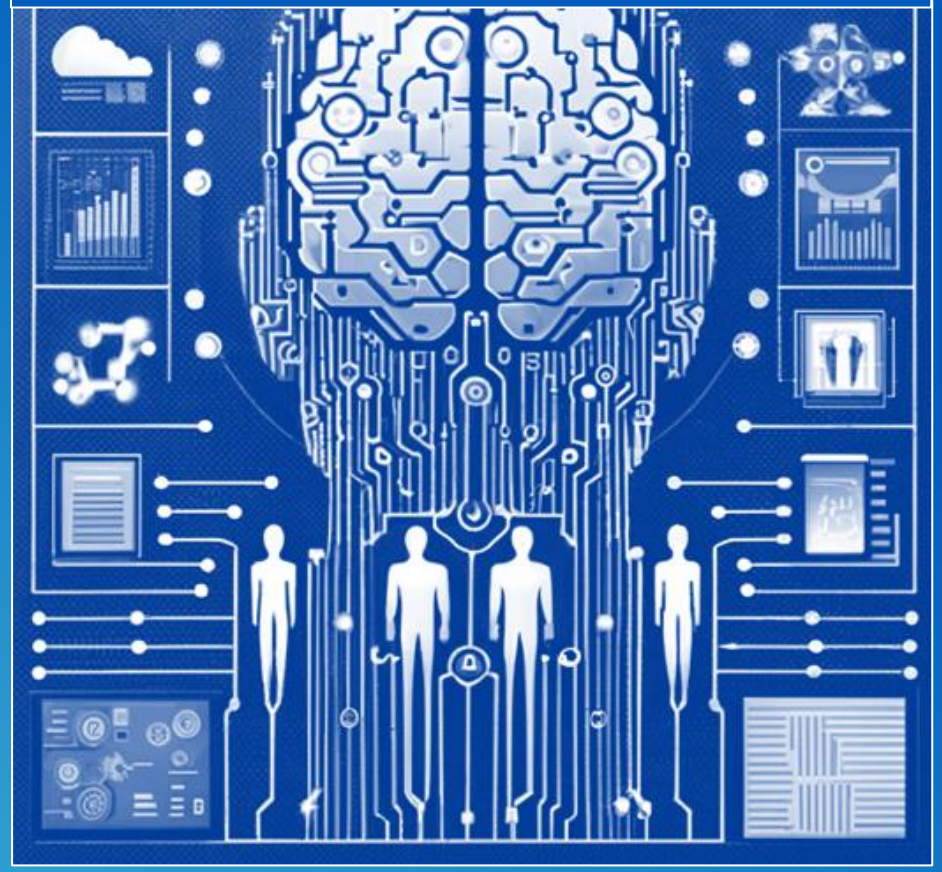
» **1 – The word sum is correct.** The word ‘packed’ is part of the word family!

» **2 – The LHS word ‘packaging’ does not match the RHS word ‘packaging’.** The ‘e’ at the end of a word should be dropped when adding ‘ing’.

» **3 – The word sum is correct.** The word ‘unpack’ is part of the word family!

Human Edge

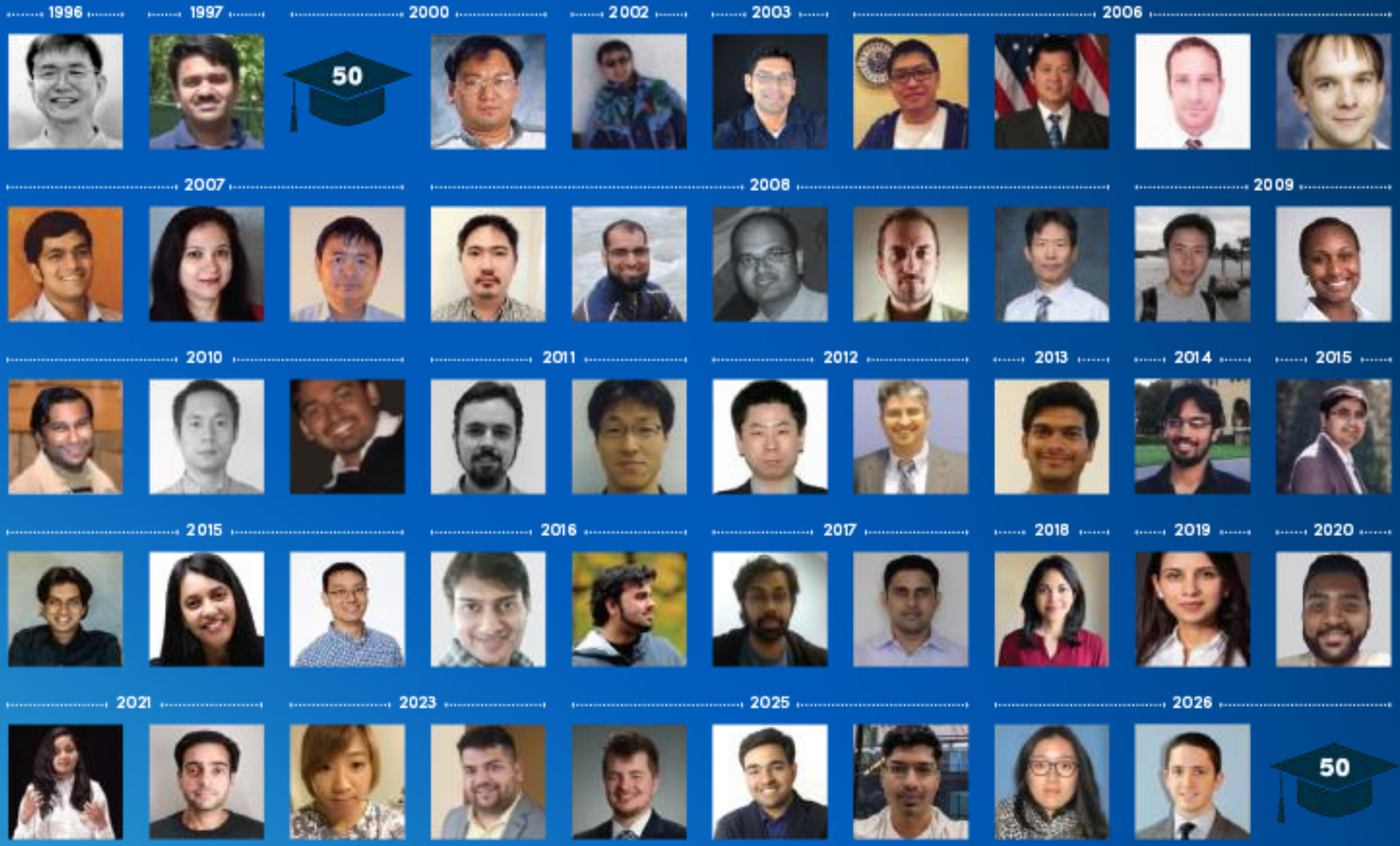
HUMAN SKILLS
THAT AI CAN'T MATCH
your key to success



- When humans **adapt context dynamically**, it reflects **millions of years of evolutionary processes** deeply embedded in how we think, perceive, and act.
- AI's **reliance on datasets** representing end results limits its ability to replicate this adaptive capacity, as **AI misses the intermediate reasoning and learning processes** humans experience.

Acknowledgment

50 PhD Students




THANK YOU!
लोकाः समस्ताः सुखिनो भवन्तु |