UNIVERSITY OF CAMBRIDGE

Automated Learning Teaching and Assessment Spoken Language Processing Technology Project

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ALTA Institute, Machine Intelligence Lab, Cambridge University Engineering Department

18th June 2024

Cambridge ALTA
Institute for Automated Language Teaching and Assessment

Cambridge Automated Language Teaching and Assessment Institute

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Cambridge ALTA
Institute for Automated Language Teaching and Assessment

- Virtual Institute for

  cutting-edge research on second language (L2) English assessment

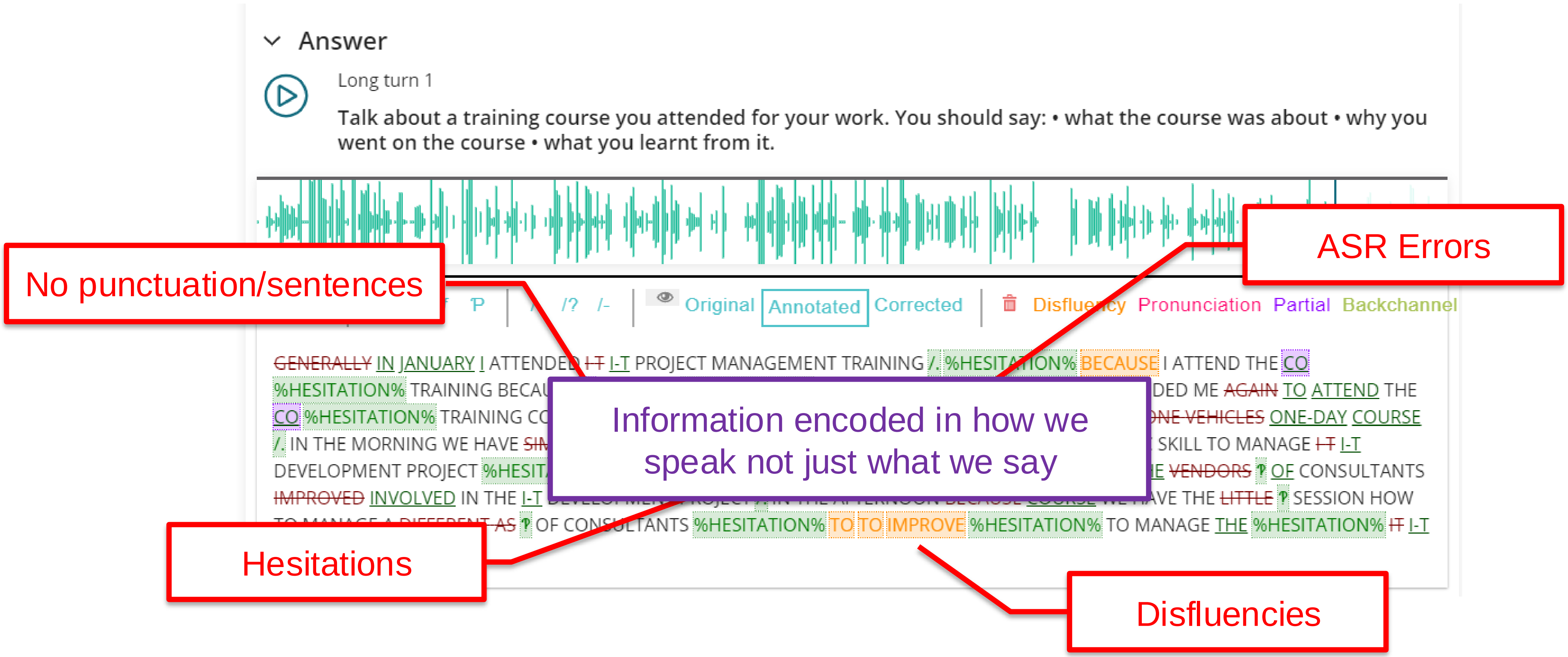
  - Machine Learning and Natural Language Processing
  - Develop technology to enhance assessment and learning
  - Look to benefit learners and teachers worldwide

ALTA SLP Project Team

- Principal Investigators: **Dr Kate Knill**, **Prof Mark Gales**
- Postdocs: **Dr Mengjie Qian, Dr Stefano Bannò**, **Dr Simon McKnight, Dr Hari Vydana**
- Research Assistant: **Siyuan Tang**
- PhD students: Charles McGhee, **Rao Ma**, Yassir Fathullah, **Adian Liusie**, Potsawee Manakul, Vatsal Raina, **Vyas Raina**
- 4th year Engineering students
- Public webpage: http://mi.eng.cam.ac.uk/~mjfg/ALTA/index.html

Bold = (part)-funded by ALTA

L2 learner speech data is challenging!

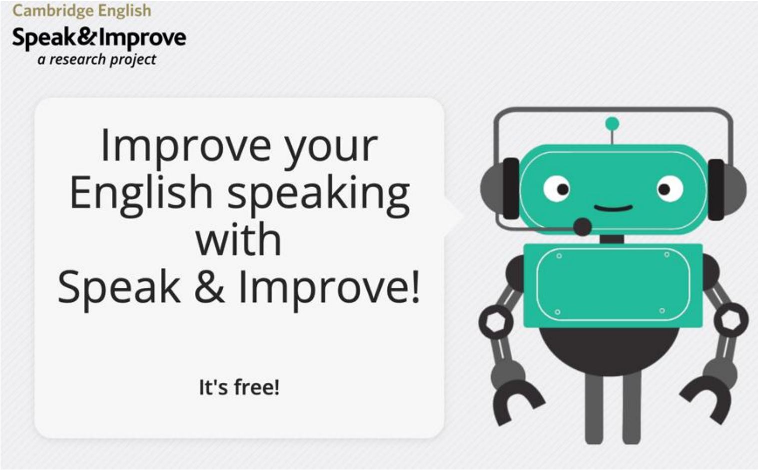


ALTA Spoken Language Processing Technology Project

Linguaskill

Upskill from Cambridge

>300k SUBMISSIONS
April 2023



https://speakandimprove.com

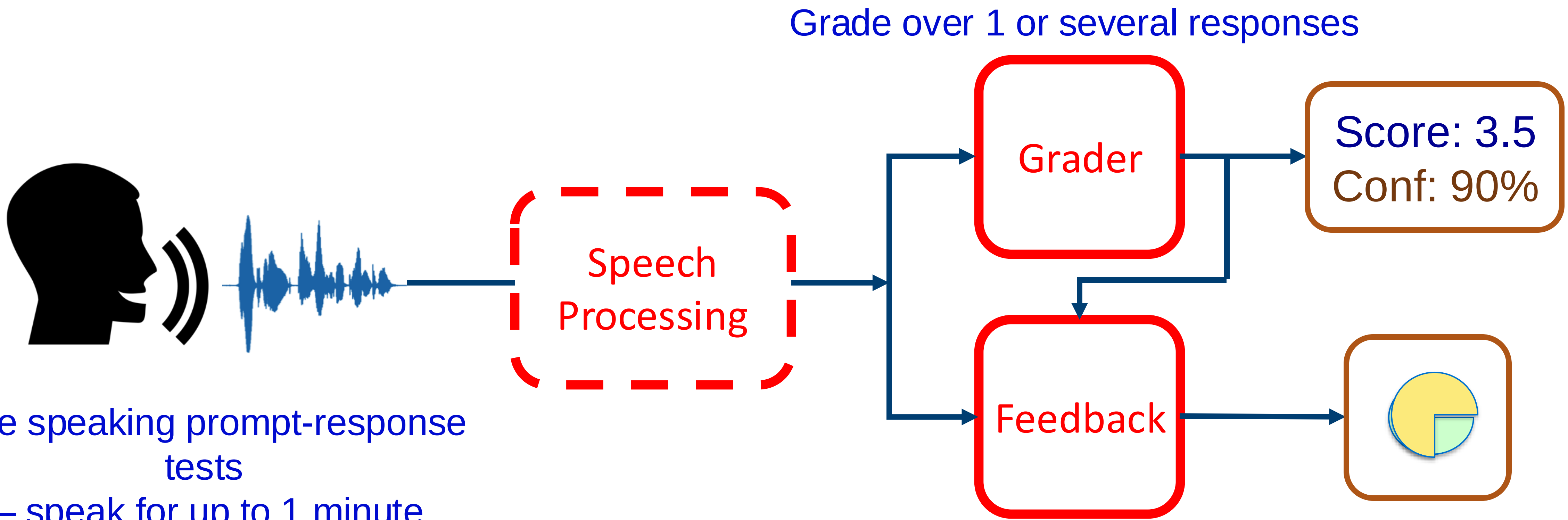
> 150 COUNTRIES

> 400k CANDIDATES / VISITORS

>9M SUBMISSIONS
June 2022

- Achieved through medium to long-term research at ALTA SLPTP
  - with technology transfer and collaboration with CUP&A and technology partners

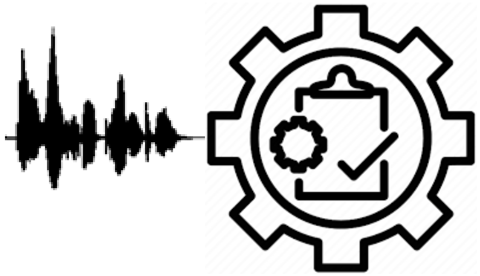
Spoken Language Assessment and Feedback Pipeline



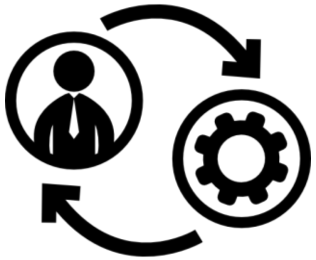
Free speaking prompt-response tests
– speak for up to 1 minute

Analytic – holistic feedback across all speech
Fine-grained – feedback on specific errors in words/phrases

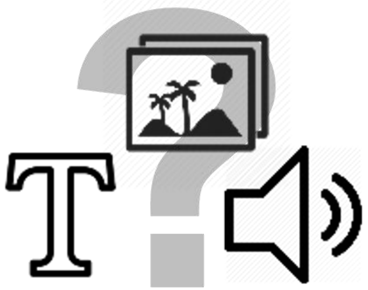
ALTA SLPTP Research Strands



SPEAKING ASSESSMENT



LEARNER ORIENTED FEEDBACK



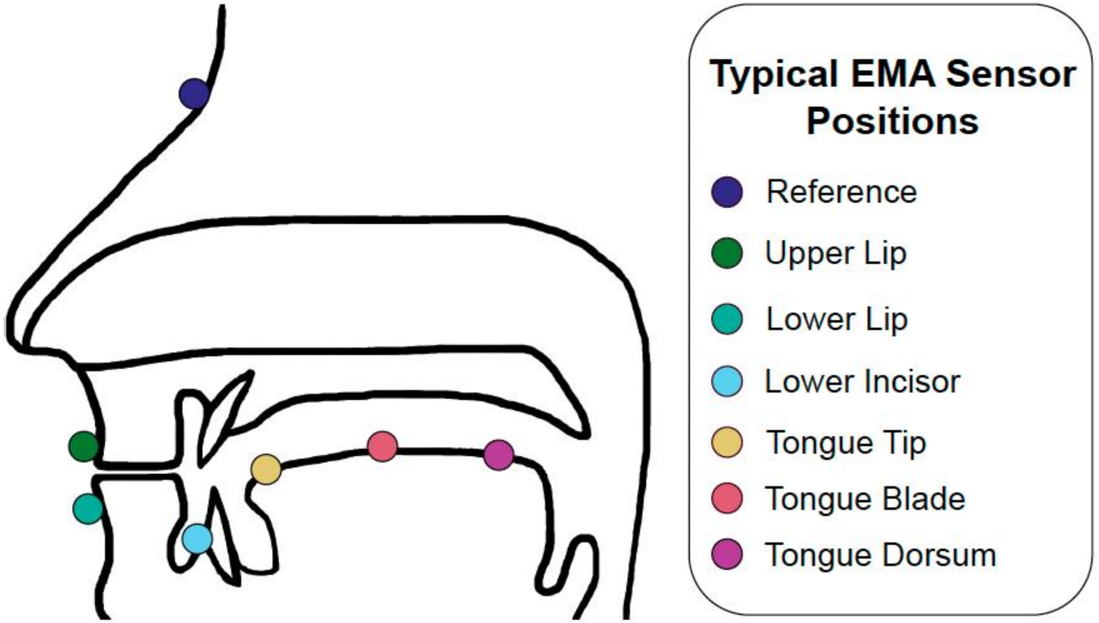
CONTENT CREATION

CORE TECHNOLOGY

Learner Oriented Feedback

Pronunciation Training

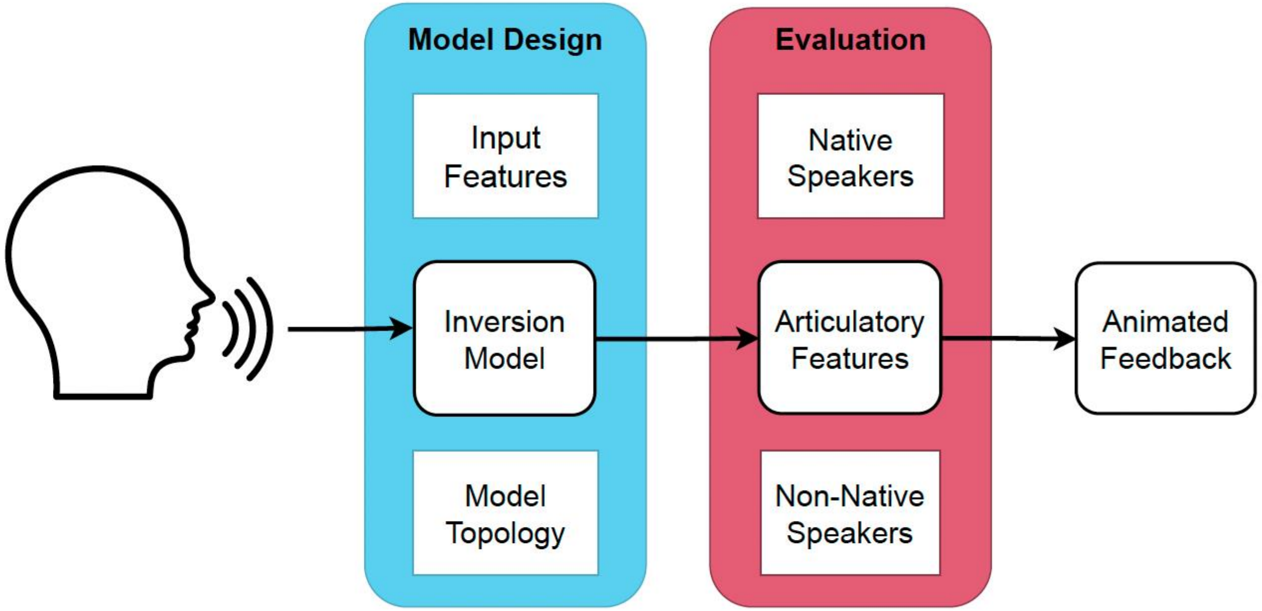
- Objective
  - Show an English language learner movement of their tongue, lips and jaw to aid non-native (L2) speech sound acquisition
- Problem
  - Measuring articulatory movements with sensors, as in Electromagnetic Articulography (EMA), can be invasive and expensive
  - EMA, ultrasound etc not suitable for general practice e.g. through web-based app



Pronunciation Training

- Solution (Charlie McGhee)
  - Use Acoustic-to-Articulatory Inversion (AAI) to predict articulatory features, such as EMA positions, from speech
  - Provide learner with animated feedback

- What we would like to learn about:
  - How best to animate?
  - What is most useful?
  - What to avoid?
  - Real-time or on playback?



McGhee, Charles, Kate Knill, and Mark Gales. "Towards Acoustic-to-Articulatory Inversion for Pronunciation Training." in *Proc. of Speech and Language Technology in Education (SLaTE)*. Workshop 2023.

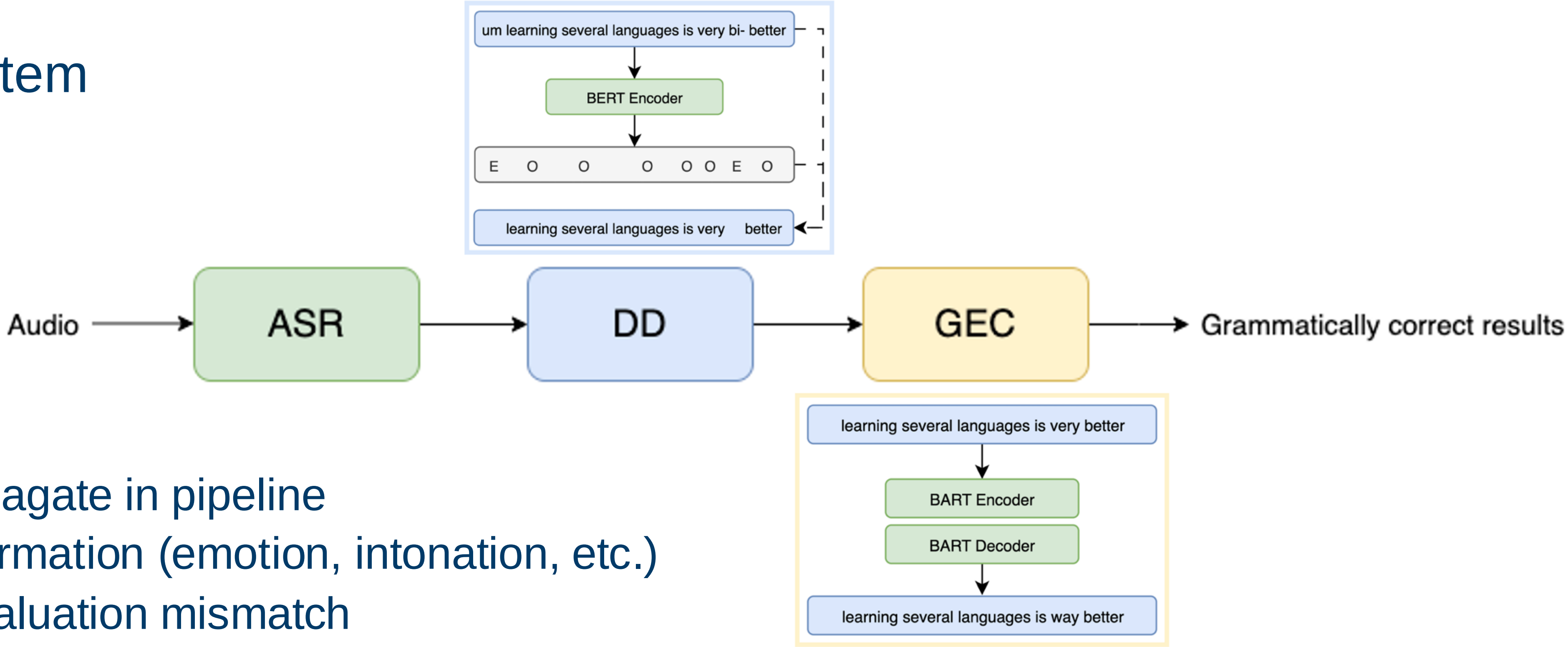
Spoken Grammar Error Correction (Spoken GEC)

- Objective
  - Correcting errors within spoken language
  - Typical approach:
    - step1: automatic speech recognition (**ASR**) system
    - step2: disfluency detection (**DD**) module
    - step3: **GEC** model

- Written GEC:
  - **Original:** Learning several languages is very better.
  - **Corrected:** Learning several languages is way better.
- Spoken GEC:
  - **Original:** um learning several languages is very bi- better
  - **Fluent:** learning several languages is very better
  - **Corrected:** learning several languages is way better

Spoken Grammar Error Correction (Spoken GEC)

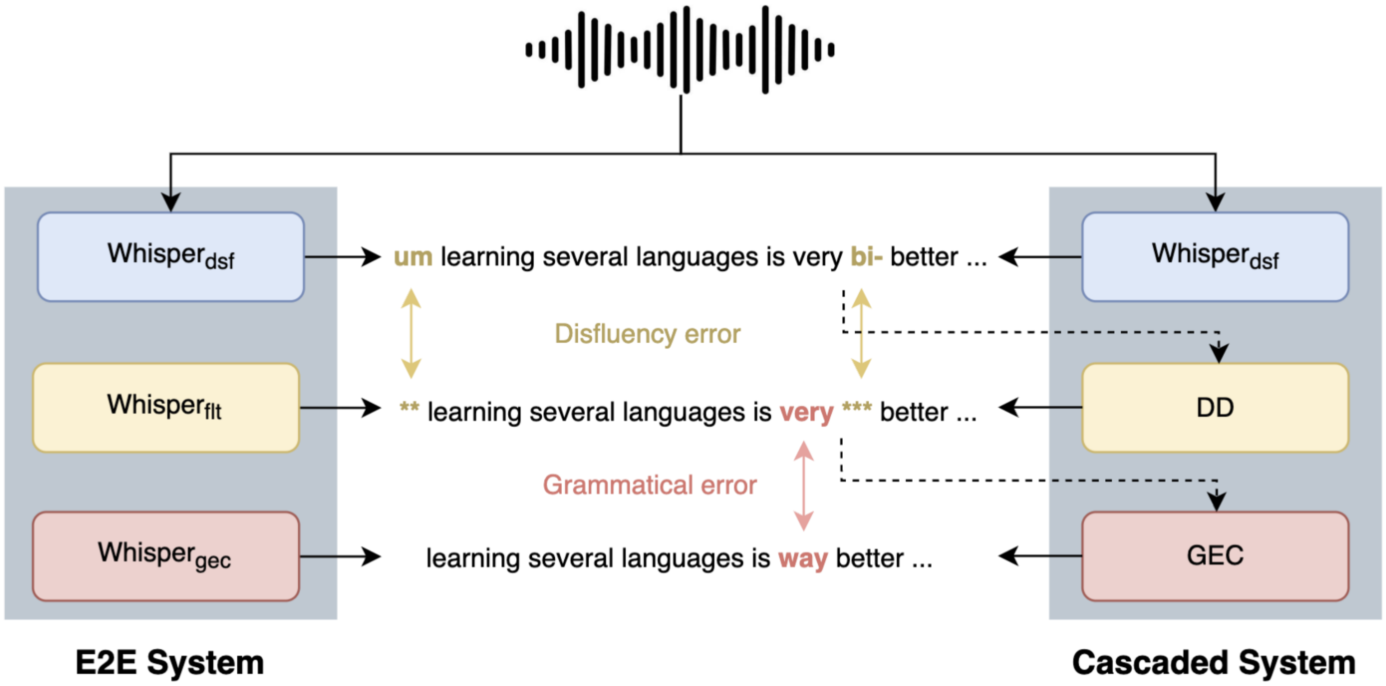
- Cascaded system



- Problem
  - errors propagate in pipeline
  - loss of information (emotion, intonation, etc.)
  - training-evaluation mismatch

Spoken Grammar Error Correction

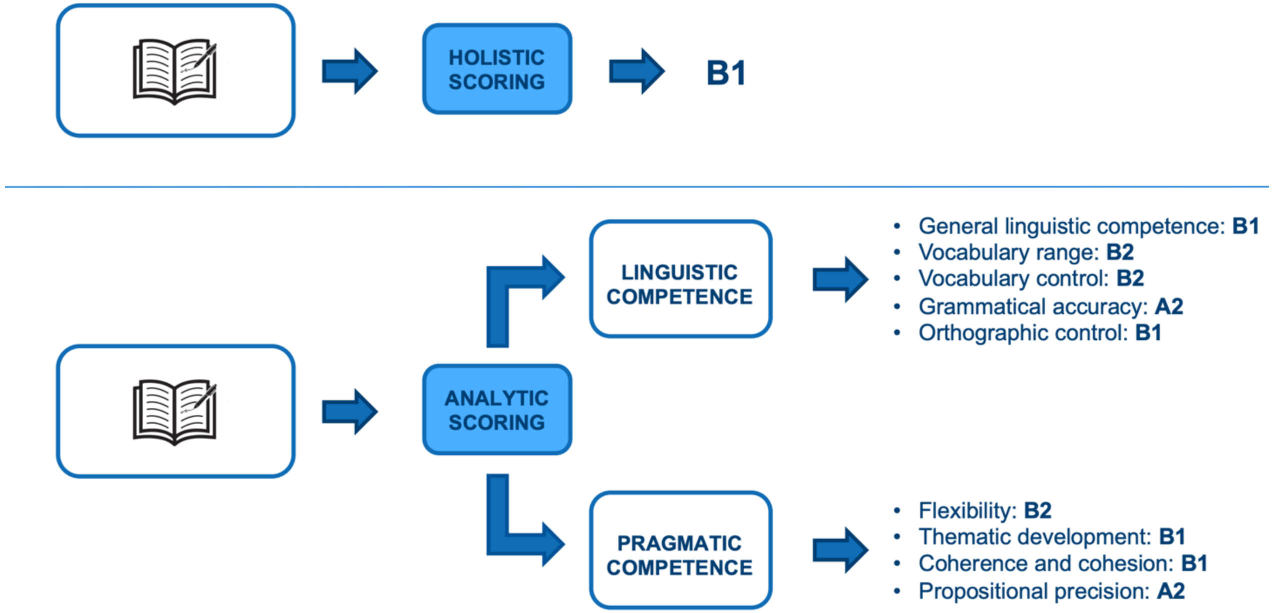
- Solution (Dr Stefano Bannò, Rao Ma, Mengjie Qian)
  - Whisper foundation model
    - Fine-tune to target targets
  - End-to-end spoken GEC
    - Translate audio to GEC text
  - Also
    - E2E disfluency detection and correction model
    - Disfluent speech recognition



Bannò, Stefano, et al. "Towards end-to-end spoken grammatical error correction." in *ICASSP*.

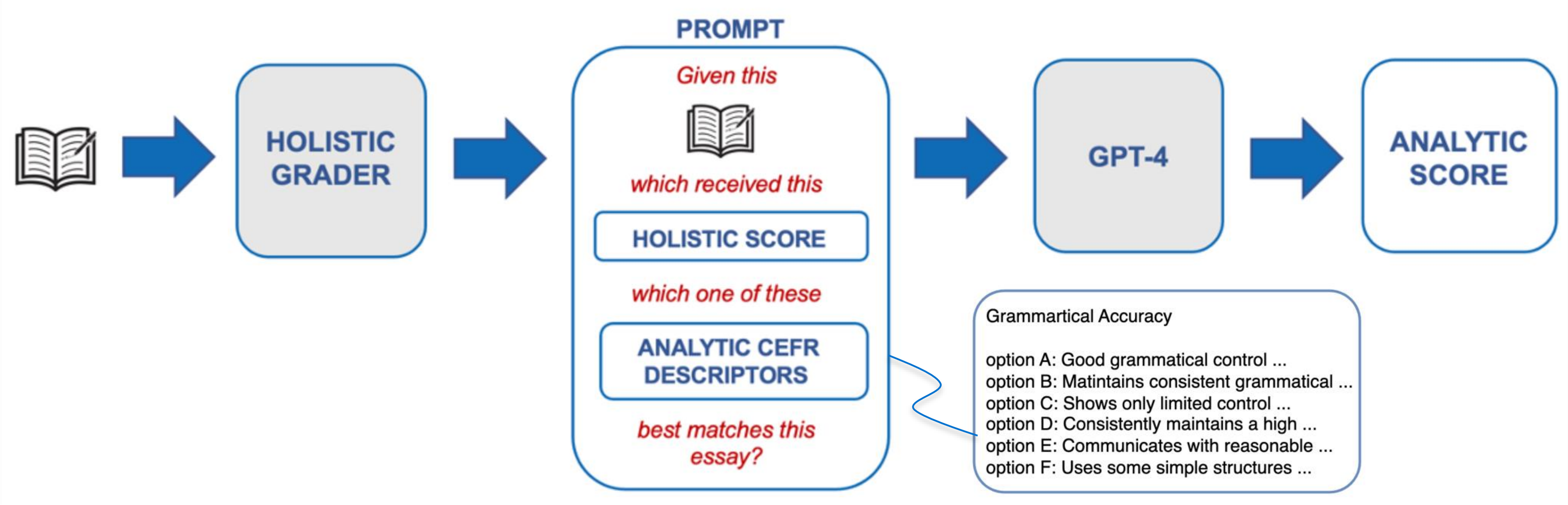
Can GPT-4 do L2 analytic assessment?

- Objective
  - Analytic assessment allows for a more detailed evaluation and more informative feedback
  - Can enhance scoring validity
- Problem
  - Less time efficient and more cognitively demanding than holistic assessment
  - Halo effect: raters may fail to distinguish between different aspects
  - No L2 learner datasets annotated with analytic scores available



Can GPT-4 do L2 analytic assessment?

- Solution (Dr Stefano Bannò)
  - Extract information about analytic aspects from L2 learner essays and their assigned holistic scores using GPT-4?
- What we would like to learn about
  - Can GPT-4 perform L2 analytic assessment?



Bannò, Stefano, et al. "Can GPT-4 do L2 analytic assessment?." *arXiv preprint arXiv:2404.18557* (2024).

Speaking Assessment

Comparative Assessment

- Objectives
  - Natural language generative assessment
  - Automatic Speech Recognition: Single reference

 → the cat sat on the mat

  - Neural Machine Translation: many valid references

你还好吗? → How are you? / Are you okay?

  - Summarization: Vast number acceptable summaries

 → Man enters burning house to save child / Heroic person saves young boy / Home burns, child makes it out safe / ...

Comparative Assessment

News article: A G4S security van has been robbed outside a branch of royal bank of Scotland in Glasgow city centre. Police said three armed men took a five-figure sum from the vehicle in the city's Sauchiehall street on Monday at about 21:45. A spokesman said no-one had been injured [...]

→ Summary Generation System →

Summary: Two security guards have been threatened during a bank robbery in Scotland.

Manual assessment

1	2	3	4	5	6	7

costly

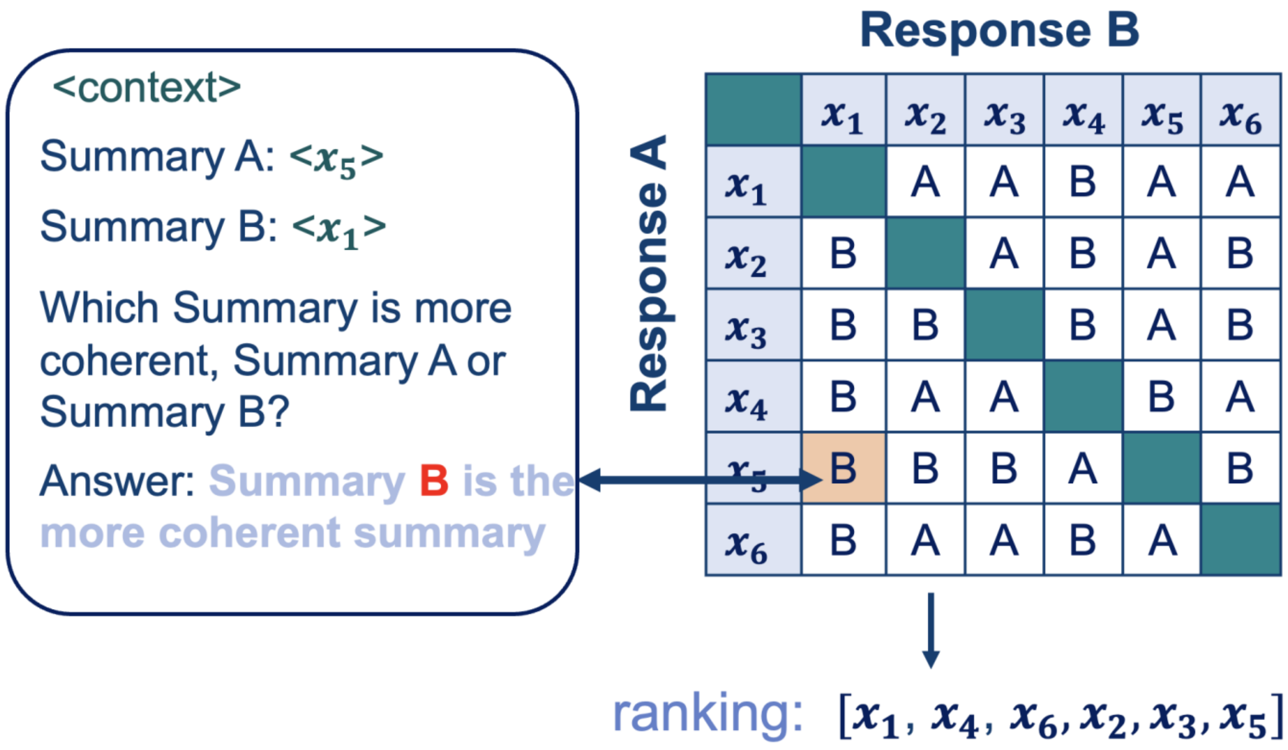
manual

time-intensive

Can we replace manual evaluation with effective automatic methods?

Comparative Assessment

- Solutions (Adian Liusie, Potsawee Manakul)
  - Prompt LLM to make pairwise comparisons for NLG assessment
    - Debias
    - Win-ratio / average probabilities



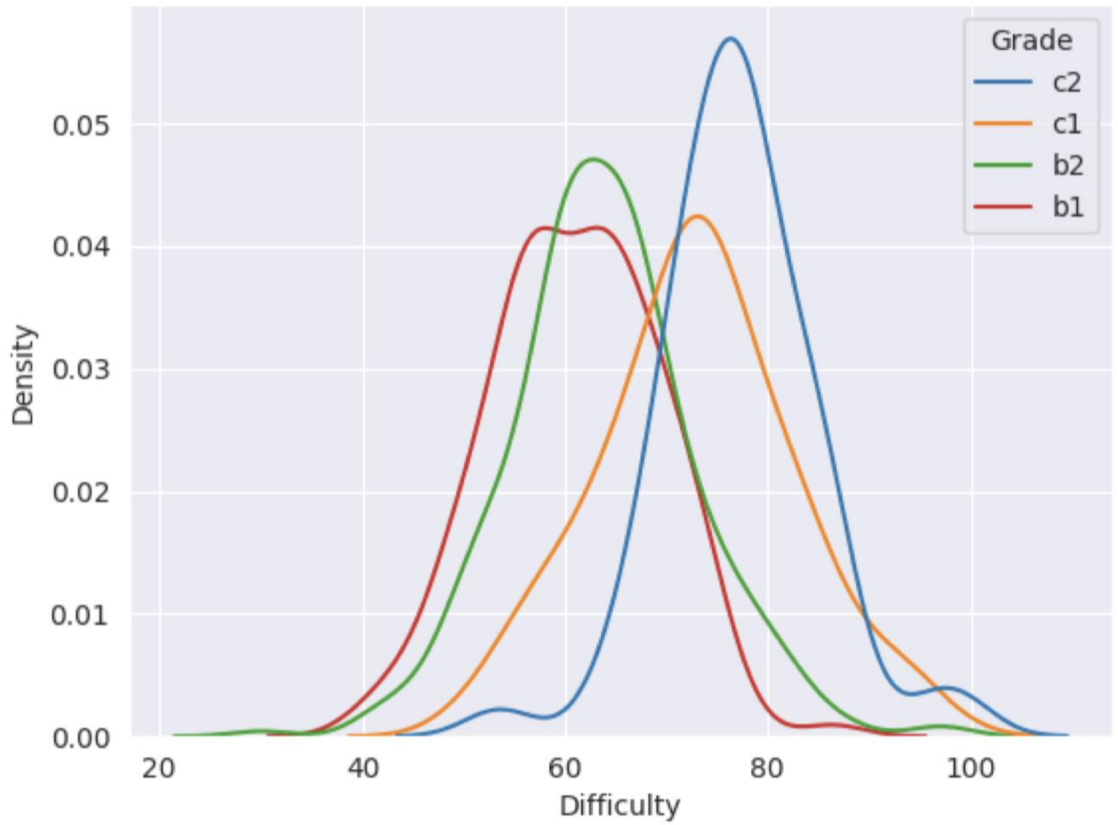
	x_1	x_2	x_3	x_4	x_5	x_6
x_1		A	A	B	A	A
x_2	B		A	B	A	B
x_3	B	B		B	A	B
x_4	B	A	A		B	A
x_5	B	B	B	A		B
x_6	B	A	A	B	A	

Liusie, Adian, et al. "LLM comparative assessment: Zero-shot nNLG evaluation through pairwise comparisons using large language models." In *Proceedings of the 18th Conference of the European Chapter of the Association for Computational Linguistics (Volume 1: Long Papers)*, pp. 139-151. 2024.

Core Technology

Question Difficulty Ranking

- Objectives
  - Multiple-choice (MC) tests are efficient to assess English learners
  - Rank candidate MC questions by difficulty
- Problems
  - Determining the difficulty level of questions with human test taker trials is expensive and not scalable



Question Difficulty Ranking

- Solutions (Vatsal Raina)
  - Task transfer

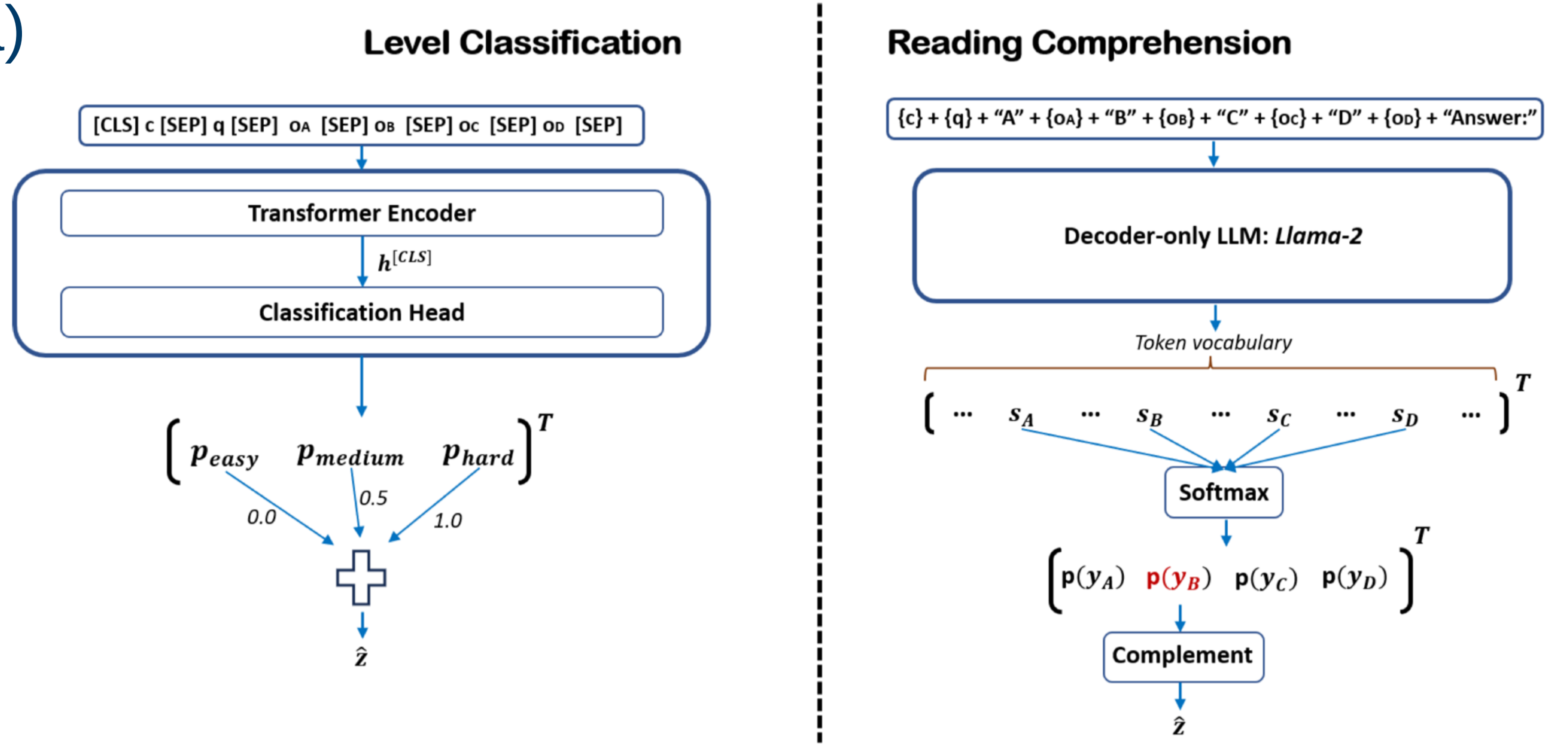
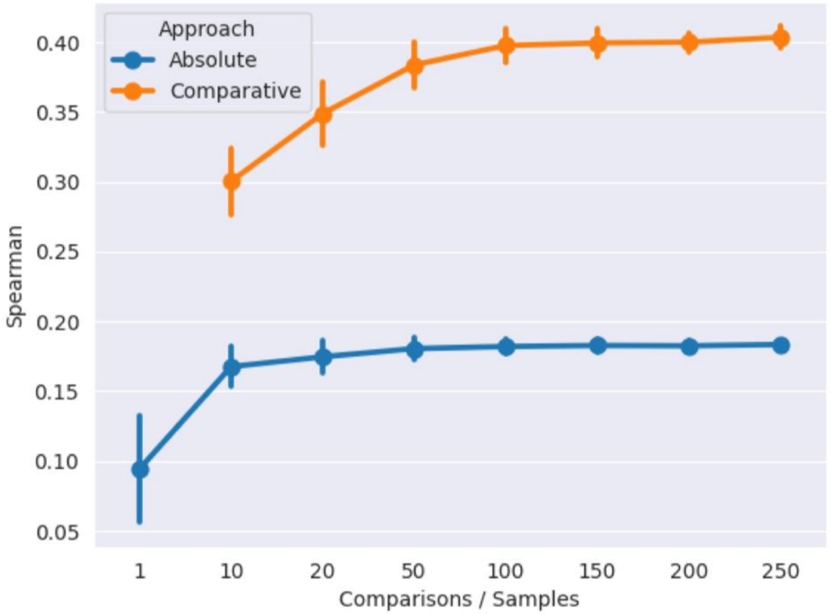


Figure 1: Task transfer for difficulty estimation with context, c, question, q and options, o.

Raina, Vatsal, and Mark Gales. "Question Difficulty Ranking for Multiple-Choice Reading Comprehension." *arXiv preprint arXiv:2404.10704* (2024).

Question Difficulty Ranking

- Solutions (Vatsal Raina)
  - Zero-shot with ChatGPT



Absolute

{context}

{question}
A) {option_A}
B) {option_B}
C) {option_C}
D) {option_D}

Provide a score between 1 and 10 that measures the difficulty of the question. Return only a single score. ”

Comparative

1:
{context_1}

{question_1}
A) {option_A_1}
B) {option_B_1}
C) {option_C_1}
D) {option_D_1}

2:
{context_2}

{question_2}
A) {option_A_2}
B) {option_B_2}
C) {option_C_2}
D) {option_D_2}

Which reading comprehension question is more difficult, 1 or 2? Return only 1 or 2. ”

Conclusions

- ALTA SLP Technology Project aims to advance language assessment using Machine Learning and Natural Language Processing techniques

- Research on speaking assessment, learner-oriented feedback, and core technology

- On-going work leverages foundation models to develop more robust and efficient approaches

Questions?

Thanks to:

Diane Nicholls and the Humannotator team at ELiT for Linguaskill Speaking annotations.

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ALTA SLPT Project publications can be found at: http://mi.eng.cam.ac.uk/~mjfg/ALTA/index.html

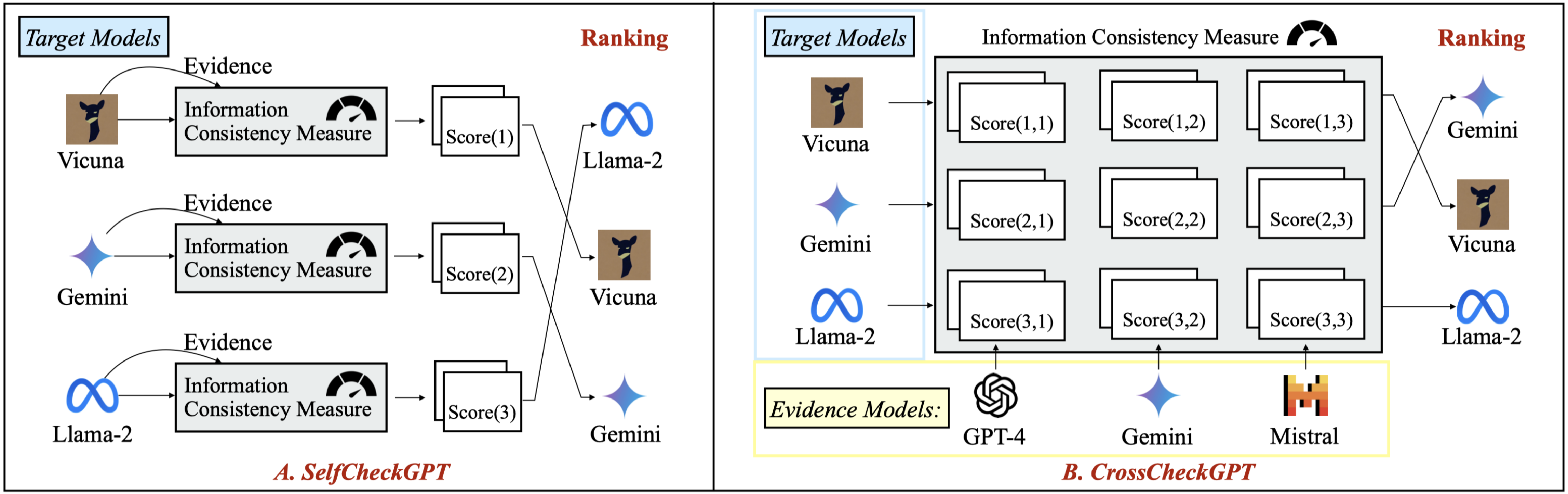
Appendix

SelfCheckGPT and CrossCheckGPT

- Objectives
  - Foundation models “hallucinate”
    - the generated outputs, while seemingly credible, are either inconsistent with the provided context or contradict established factual knowledge
  - Quantify a system’s susceptibility to hallucination
- Problems
  - Current benchmarks are designed for particular tasks
  - Assume access to gold-standard labels

SelfCheckGPT and CrossCheckGPT

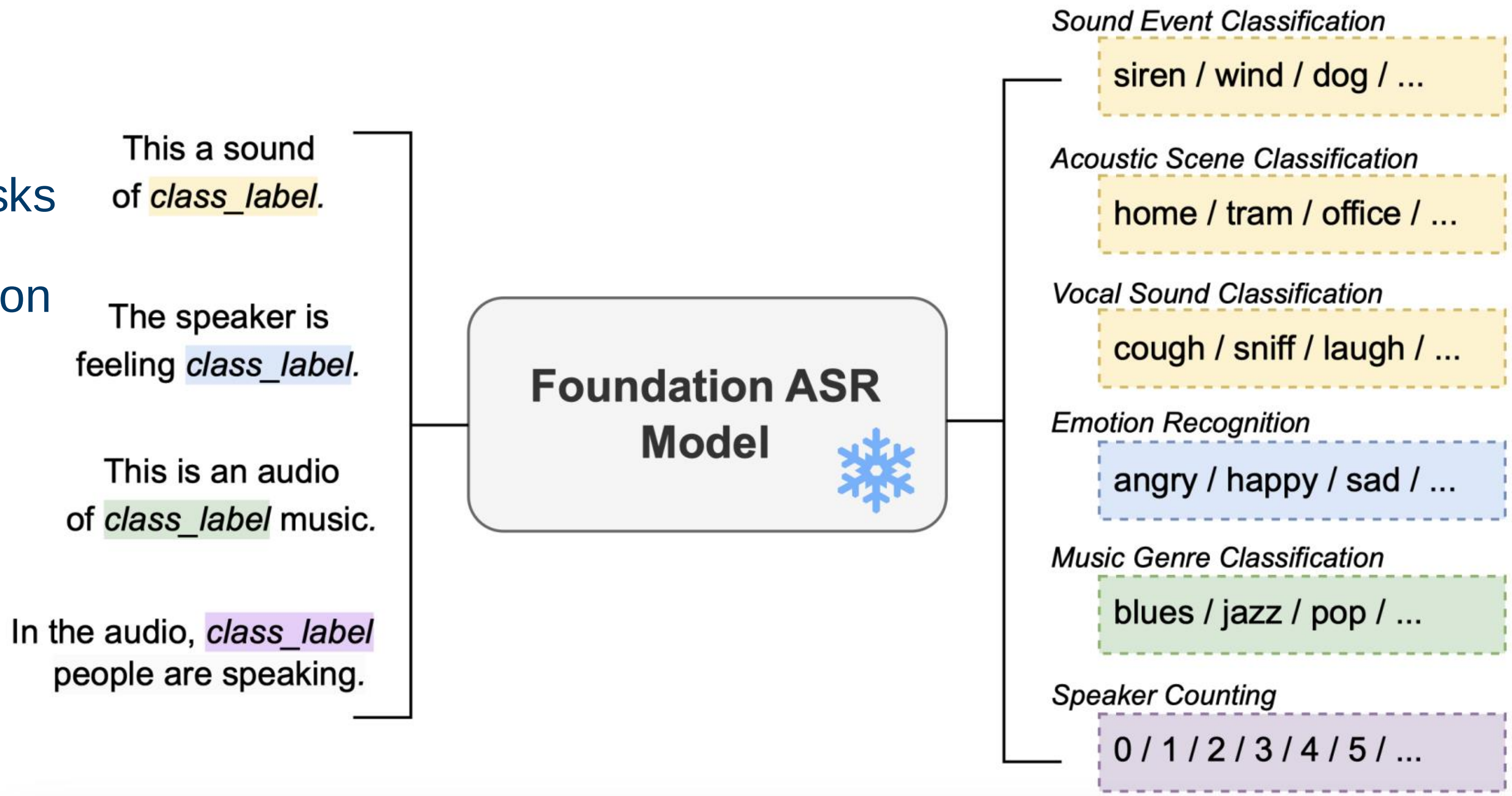
- Solution (Potsawee Manakul)



Sun, Guangzhi, Potsawee Manakul, et al. "CrossCheckGPT: Universal Hallucination Ranking for Multimodal Foundation Models." *arXiv preprint arXiv:2405.13684* (2024).

Emergent Audio Classification Ability of Whisper

- Objective
  - OpenAI whisper trained on ASR, speech translation tasks
  - Emergent ability of foundation speech models?



- Solution (Rao Ma)
  - Zero-shot prompting of Whisper models

Ma, Rao, et al. "Investigating the Emergent Audio Classification Ability of ASR Foundation Models." *arXiv preprint arXiv:2311.09363* (2023).

Emergent Audio Classification Ability of Whisper

- Solution (Rao Ma)
  - Zero-shot prompting of Whisper models