

Large Language Models for Low-Resource Languages

Luca Fossen - March 2024 report

This report describes exploratory research conducted in B trimester of 2023 for the AI Institute at Waikato University under the leadership of Te Taka Keegan and Albert Bifet, with the long-term goal of creating language models for Te Reo Māori and its diverse dialects. This research focuses on studying current LLMs understanding of Māori through translation performance. It includes subjective assessments of translation capabilities, a fine-tuning experiment aimed at improving English-Māori translation performance, and a systematic performance evaluation of multiple LLMs on a translation task between English, Norwegian and Māori. Although competitive with conventional machine translation, the findings suggest a significant disparity in translation quality between high-resource and low-resource languages, with models showing better performance for translations involving English, especially when translating to English.

1 Exploration of LLM translation capabilities.....	1
2 LLM fine-tuning for machine translation.....	2
3 LLM translation performance evaluation.....	2
3.1 Results.....	4
4 Findings.....	6
5 Limitations.....	6
6 Conclusion.....	7
References.....	7
Appendices.....	7
Appendix A: English/Te Reo Māori translations.....	7
Appendix B - English/Te Reo Māori translation ratings.....	12
Appendix C: Base- and Fine-tuned ChatGPT on English-to-Māori translation.....	14
Appendix D: LLM translation performance evaluation code repository.....	19

1 Exploration of LLM translation capabilities

To get an initial idea of how GPT-4 performs on Māori, I conducted some tests to determine GPT-4's abilities with Te Reo Māori. I first used the GPT-4 API to perform some back-translation tasks between English and Māori on a range of sentences designed to test the model's robustness (Examples in appendix A). We were impressed by the model's performance¹, and became interested in measuring it quantitatively. This work is detailed in the section "LLM translation performance evaluation".

¹ For example, the model was able to code-switch effortlessly.

We were also interested in methods for gathering translation training data, and I tested whether GPT-4 had the ability to rate its own translations (Examples in appendix B). In an interview with a Māori language expert, the feedback on the ratings was mostly positive. However, the model sometimes gave high scores to translations with errors and was overly strict on small mistakes. The expert noted that the model is better at translating from Māori to English than vice versa, a claim which will be substantiated in our translation test.

2 LLM fine-tuning for machine translation

One avenue we investigated for enhancing translation performance in low-resource languages involved fine-tuning an existing Large Language Model (LLM) using translation examples. I conducted a fine-tuning session on GPT-3.5 for the purpose of translating English to Māori, utilising Meta's NLLB-seed and FLORES-200 datasets (Team et al., 2022) for training and evaluation. Fine-tuning was performed via the OpenAI API (examples and more details in appendix C.). After fine-tuning on 4,955 examples translations for 6 epochs, there was a marginal increase in performance, evidenced by a .003 point increase in BLEU score and a .016 point increase in chrF score.

This minimal improvement could be attributed to two primary factors:

First, instruction fine-tuning may represent a relatively superficial modification to the model, and it may be that the OpenAI fine-tuning API only changes the RLHF weights and does not affect the model's pretrained weights, which is where the Māori language representations likely exist. It may be that training a local model (using an open-source model like Llama) could allow us to fine-tune on the entire set of parameters, and if Stanford's Alpaca project is a valid comparison, it could be performed relatively cheaply, which might be a worthwhile investigation to perform in the future (*Stanford CRFM*, 2023).

Li et al. (2024) explore how fine-tuning machine translation (MT) instruction affects multiple languages when applied to Meta's XGLM-7B model. Their findings indicate that the most significant factors in enhancing MT performance through fine-tuning are the language's similarity to English and the volume of available training data. Unfortunately, the Māori language has neither of these.

3 LLM translation performance evaluation

In order to measure the relative performances of various models and their ability to translate high-and low-resource languages, I set up a test task to facilitate evaluation of these models. The models were prompted to translate English, Norwegian and Māori sentences to each other (English representing a high-resource language, Norwegian a middle-resource language and Māori a low-resource language.)

The sentences that the models were prompted to translate came from the FLORES-200 dataset, which is a multilingual dataset of bitext data. The sentences in this dataset have been manually translated from English to the source language and reviewed by humans. The English sentences were sourced from Wikinews, Wikijunior, and Wikivoyage.

```
Translate the following 5 sentences from {source_lang} to {target_lang}:

Source ({source_lang}): {sources[0]}
Translation ({target_lang}): {targets[0]}
...
Source ({source_lang}): {sources[4]}
Translation ({target_lang}): {targets[4]}

Source ({source_lang}): {source_text}
Translation ({target_lang}):
```

Fig.1: Pseudocode demonstrating the format of our few-shot prompting style.

A 5-shot prompt style was used for all models (fig. 1), where multiple examples of similar tasks are shown before the intended task, and the input sequence ends at the point of the intended translation. Although few-shot prompting is known to improve performance on many tasks, in this case it was done to ensure output consistency. Outputs were also cut off at the first newline character in order to prevent repetitive/hallucinated translations. Model temperatures were set to 0.7.

Performance was measured using chrF and BLEU metrics, which compare differences between a predicted and target translation. They both output scores from 0 to 1, where 1 is a perfect match. ChrF measures differences at the character level, while BLEU measures at the word level.

To accomplish this test, a translation framework was written in Python. Translation prompts for each combination of incoming language and outgoing language were fed through every model. The translated sentences for each of these combinations (eg. “mri_eng_GPT-4”) were processed and saved. These scores were then categorised into different averages, as detailed below.

3.1 Results

From the scores of individual language pair-model combinations, I plotted averages per model, averages per language pair, as well as scores for each model by language:

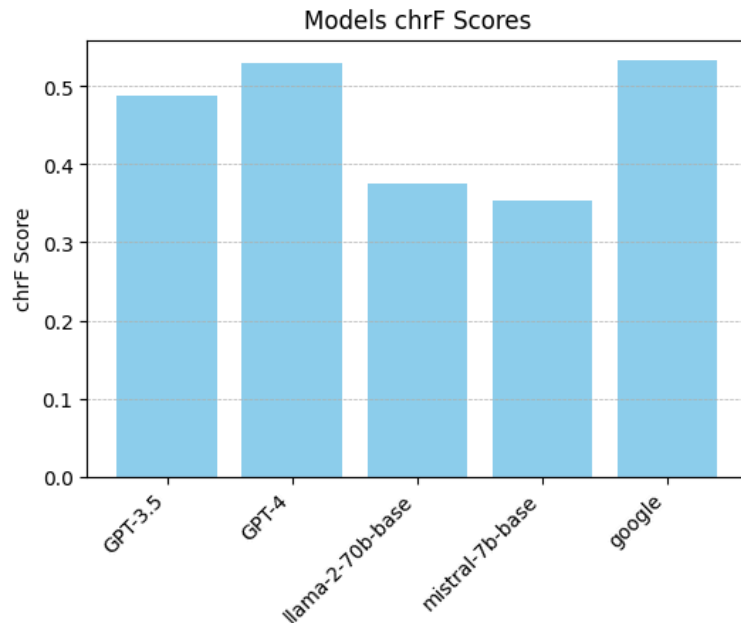


Fig.2: Bar chart with chrF scores of models tested, averaged across language pairs.

Google translate and GPT-4 have very similar chrF scores of 0.533 and 0.530 respectively. GPT-3.5 follows closely with a score of 0.488, and Llama-2-70b and Mistral-7b achieved scores of 0.375 and 0.354 respectively. (Figure 2)

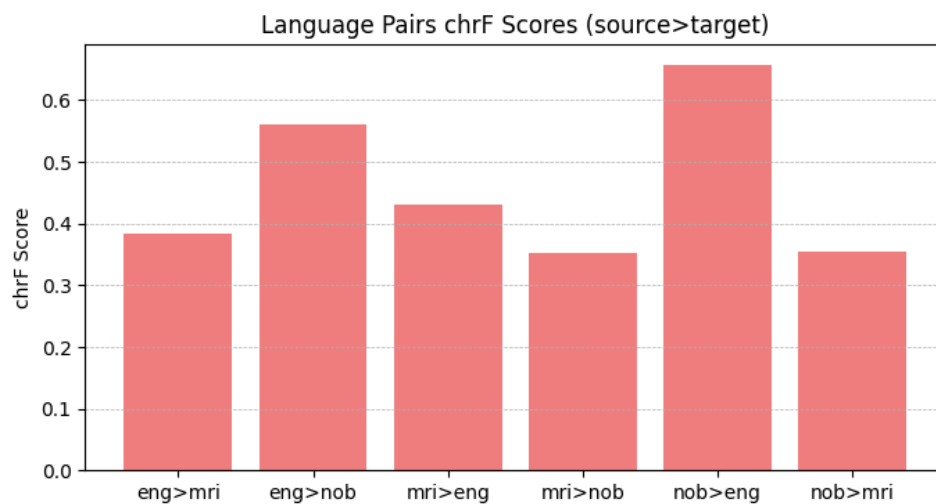


Fig.3: Bar chart with chrF scores of language pairs, averaged across models.

Among language pairs (source>target), chrF scores were as follows: for English to Māori, the average score was 0.383; for English to Norwegian, the average score was 0.561; for Māori to English, the average score was 0.430; for Māori to Norwegian, the average score was 0.352; for Norwegian Bokmål to English, the average score was 0.657; and for Norwegian to Māori, the average score was 0.354. (Figure 3)

The Norwegian to English translation pair exhibited the highest chrF score, whereas the Māori to Norwegian and vice versa pairs showed the lowest chrF scores. As suggested by the Māori language expert, translating to English yielded a higher score than translating from English, for both Māori and Norwegian.

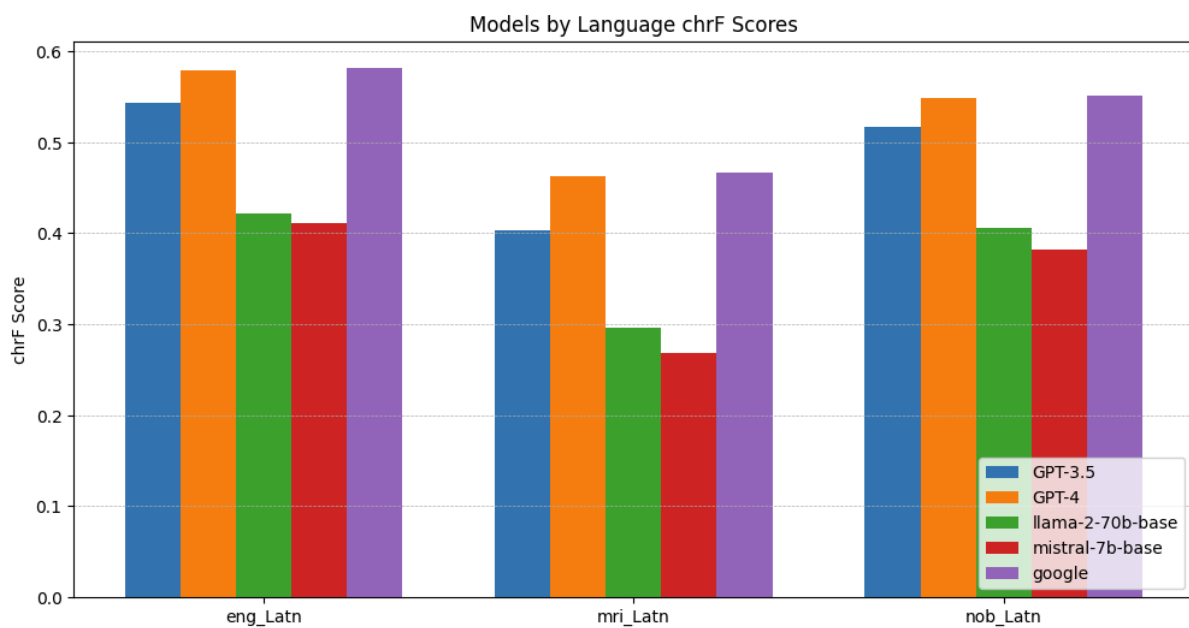


Fig.4: Bar chart with chrF scores of models tested, grouped by languages and averaged across language pairs.

Translation scores for each model by each language are depicted in the table below. The relative differences between models are similar across languages, with Google and GPT-4 leading for all languages. GPT-4 manages to be comparable with Google in all languages tested, including for Māori.(Figures 4 and 5)

Model	eng_Latn	mri_Latn	nob_Latn
GPT-3.5	0.544	0.403	0.517
GPT-4	0.579	0.463	0.548
llama-2-70b-base	0.422	0.296	0.406
mistral-7b-base	0.411	0.268	0.382
google	0.582	0.466	0.552

Fig.5: Table of chrF scores of models tested, averaged across language pairs.

4 Findings

Limited Availability of Data and Benchmarks: There's a significant scarcity of datasets, benchmarks, and resources for low-resource languages like Māori. This is in need of improvement for the development and evaluation of LRL LLMs.

Performance Disparity: LLMs exhibit a considerable disparity in translation quality between high-resource and low-resource languages. Models perform better for translations involving English, which is indicative of a bias towards high-resource languages in LLM training data.

Fine-Tuning Challenges: Instruction-based fine-tuning of LLMs with available datasets shows only marginal improvement in translation performance for Māori. This suggests that simple instruction fine-tuning may not be enough to significantly improve LLM capabilities in low-resource language translation. However, these results are not conclusive and it may still hold that fine-tuning on all weights (not just instruction fine-tuning) using an open model like Llama or Mistral may yield better results.

Comparative Model Performance: Among the models tested, Google Translate and GPT-4 showed relatively better performance in translating between English, Norwegian (a middle-resource language), and Māori than GPT-3.5, Llama-70b and Mistral-7b. However, the overall performance across all models was weaker for Māori, indicating the challenges faced by LLMs with LRLs.

Translation Direction Bias: It is easier for LLMs to translate to English from LRLs than the other way around. This finding, supported by expert feedback and chrF scores, suggests a bias in LLMs towards more efficiently handling translations into English.

5 Limitations

One limitation of the FLORES-200 data used for our translation scores is that the original sentences are all in English, manually translated to the target languages. While this should not impact the grammatical correctness of the translated sentences, it introduces subtle cultural and contextual biases to the content of the sentences.

We have focused mostly on translation performance as a proxy for language understanding, as it is easy to benchmark. However, we would like to explore additional methods of investigating LLM performance on low-resource languages in the future, for example by involving native speakers and cultural experts.

When performing 5-shot prompting for the performance evaluation, all prompts used the same 5 example translations. This may have affected translation performance.

6 Conclusion

In conclusion, this exploratory research into the capabilities of Large Language Models for Te Reo Māori highlights not only the current competitive edge of LLMs against conventional machine translation tools but also the pronounced performance disparities faced by low-resource languages. The study has highlighted some of the challenges of fine-tuning LLMs for better translation accuracy in low-resource languages, suggesting the need for more comprehensive approaches beyond simple instruction fine-tuning. In the future, it will be beneficial to build more specialised datasets for Māori and develop more comprehensive benchmarks. Deeper investigation into LLM potential is also encouraged, such as continuing translation performance evaluations of newer models, testing LLMs on tasks other than translation, as well as a more thorough investigation into model fine-tuning and training. As we look forward, a collaborative effort of technologists, linguists, and native speakers will be necessary in order to bridge the technology gaps we face. I am grateful for the opportunity to have done this research. I personally enjoyed working on this project, learned a lot and found it meaningful.

References

- Stanford CRFM. (2023, March 13). <https://crfm.stanford.edu/2023/03/13/alpaca.html>
- Team, N., Costa-Jussà, M. R., Cross, J., Çelebi, O., Elbayad, M., Heafield, K., Heffernan, K., Kalbassi, E., Lam, J., Licht, D., Maillard, J., Sun, A., Wang, S., Wenzek, G., Youngblood, A., Akula, B., Barrault, L., Gonzalez, G. M., Hansanti, P., . . . Wang, J. (2022, July 11). *No language left behind: Scaling Human-Centered Machine Translation*. arXiv.org. <https://arxiv.org/abs/2207.04672>
- Li, J., Zhou, H., Huang, S., Cheng, S., & Chen, J. (2023, May 24). *Eliciting the Translation Ability of Large Language Models via Multilingual Finetuning with Translation Instructions*. arXiv.org. <https://arxiv.org/abs/2305.15083>

Appendices

Appendix A: English/Te Reo Māori translations

Translations performed with gpt-4 via API.

Prompt (as user message):

```
"Translate from {source_lang} to {target_lang}: {phrase}  
Translation:"
```

Simplicity and Structure:

Initial Phrase: "The cat sat on the mat."

Translation: "Kua noho te ngeru ki runga i te whāriki."

Back Translate: "The cat has sat on the mat."

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: "She likes apples, but he prefers oranges."

Translation: "Ka whai whakaaro ia ki nga āporo, engari ka whai whakaaro a ia ki nga ārani."

Back Translate: "He will think about the apples, but he will think about the oranges."

Source Language: English

Target Language: Te Reo Māori

Compound Sentences:

Initial Phrase: "Although it was raining, they decided to go for a walk."

Translation: "Ahakoa te ua, ka whakatau rātou ki te hīkoi."

Back Translate: "Despite the rain, they decided to go for a walk."

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: "If you finish your homework, you can play outside."

Translation: "Ki te whakaoti koe i āu mahi kāinga, ka taea e koe te tākaro ki waho."

Back Translate: "If you finish your homework, you can play outside."

Source Language: English

Target Language: Te Reo Māori

Tenses:

Initial Phrase: "She will travel to Paris next summer."

Translation: "Ka haere ia ki Pari i te raumati whakamutunga."

Back Translate: "He will go to Paris in the last summer."

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: "They had been studying all night for the exam."

Translation: "Kua whakapau kaha rātou i te ako i te pō katoa mō te whakamātautau."

Back Translate: “They have exerted all their effort studying all night for the exam.”

Source Language: English

Target Language: Te Reo Māori

Idiomatic Expressions:

Initial Phrase: “It’s raining cats and dogs.”

Translation: “E ua ana he nui rawa.”

Back Translate: “It is raining too much.”

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: “He hit the nail on the head.”

Translation: “Patu tika ana ia i te makuku.”

Back Translate: “He is hitting the target accurately.”

Source Language: English

Target Language: Te Reo Māori

Passive Voice:

Initial Phrase: “The cake was eaten by the children.”

Translation: “I kaihia te keke e ngā tamariki.”

Back Translate: “The cake was eaten by the children.”

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: “A new bridge will be built by the city.”

Translation: “Ka whakakotahitia e te taone he whakaruruhau hōu.”

Back Translate: “The town will establish a new shelter.”

Source Language: English

Target Language: Te Reo Māori

Ambiguity:

Initial Phrase: “The old man the boats.”

Translation: “Ko te koroua nga waka.”

Back Translate: “The old man is the canoes.”

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: "Visiting relatives can be tiring."

Translation: "Ka whakapau kaha te toro whanaunga."

Back Translate: "The relative will make a great effort."

Source Language: English

Target Language: Te Reo Māori

Complex Vocabulary and Technical Terms:

Initial Phrase: "The epistemological debate is central to philosophy."

Translation: "Ko te whakataunga mōhiohio he mea matua ki te whakaaroaro."

Back Translate: "The information solution is essential for consideration."

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: "The cardiologist performed a coronary angioplasty."

Translation: "I whakatutuki te kaitātari manawa i te angioplasty koronare."

Back Translate: "The cardiologist performed the coronary angioplasty."

Source Language: English

Target Language: Te Reo Māori

Gender and Agreement:

Initial Phrase: "The boy's sister is eating an apple."

Translation: "Kei te kai āporo te tuahine a te tama."

Back Translate: "The boy's sister is eating an apple."

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: "She found her keys under the table."

Translation: "I kite ia i ōna kī i raro i te tēpu."

Back Translate: "He found his keys under the table."

Source Language: English

Target Language: Te Reo Māori

Cultural References:

Initial Phrase: "Thanksgiving is celebrated on the fourth Thursday of November in the United States."

Translation: "Ka whakanuia te Thanksgiving i te Rāpare tuawhā o Whiringa-ā-rangi i te Whenua o te Whītiki."

Back Translate: "Thanksgiving is celebrated on the fourth Thursday of November in the United States."

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: "Diwali, the Festival of Lights, is a significant holiday in India."

Translation: "Ko Diwali, te Hakari o nga Rama, he hararei nui i Inia."

Back Translate: "Diwali, the Festival of Lights, is a major holiday in India."

Source Language: English

Target Language: Te Reo Māori

Long sentences:

Initial Phrase: "The history of the United States is long and complex, with many different events and people shaping the country over time. From the arrival of the first Native American tribes to the present day, the United States has undergone significant changes and challenges."

Translation: "He roa, he whakararuraru hoki te hītori o te Whenua Whakakotahi, me te maha o nga whakaaturanga me nga tangata e whakatairanga ana i te whenua i te wa. Mai i te taenga mai o nga iwi Taketake Amerikana tuatahi ki tenei ra, kua whakarereke te Whenua Whakakotahi i nga panonitanga nui me nga wero."

Back Translate: "The history of the United States is long and complex, with many events and people promoting the country at the time. From the arrival of the first Native Americans to this day, the United States has undergone major changes and challenges."

Source Language: English

Target Language: Te Reo Māori

Initial Phrase: "Ko ngā iwi Māori me ngāi Māori whānui ngā kaitiaki i te reo Māori. He kawenga tātaki anō tā te Karauna i roto i ngā mahi whakarauora – māna e whakatairanga ngā whāinga rautaki, māna anō e whakaawe te umaraha o Aotearoa. Heoi anō, me mātua mahi ngātahi te katoa ki te āta whakatāiri i te mōhio ki te reo Māori me te kōrerotanga o te reo."

Translation: "The Māori people and the wider Māori community are the guardians of the Māori language. The Crown also has a leadership role in revitalisation efforts - it is responsible for promoting strategic objectives and for awakening the consciousness of New

Zealand. However, everyone must work together to carefully increase knowledge of the Māori language and its use.”

Back Translate: “Ko te iwi Māori me te hāpori whānui o te Māori ngā kaitiaki o te reo Māori. He tūrangā ārahi hoki tā te Karauna i ngā mahi whakarauora - he whakahaere tāna i ngā whāinga rautaki me te whakarauora i te hinengaro o Aotearoa. Heoi, me mahi tahi tātou katoa ki te whakapiki i te mōhio ki te reo Māori me tōna whakamahi, me te whakapau kaha.”

Source Language: Te Reo Māori

Target Language: English

Appendix B - English/Te Reo Māori translation ratings

Each translation was rated 15 times by gpt-4 (scale from 1 - 10). Model temperature was set to 0.7. The average rating and standard deviation of those 15 ratings are included here.

Prompt (as user message):

“The following is a machine translated sentence, translated from English to Te Reo Māori.

You must rate the quality of this translation with a single number, on a scale of 1 to 10.

Initial phrase: {initial_phrase}

Translation: {translation}

Rating:”

Examples:

1:

Initial Phrase: The history of the United States is long and complex, with many different events and people shaping the country over time. From the arrival of the first Native American tribes to the present day, the United States has undergone significant changes and challenges.

Translation: He roa, he whakararuraru hoki te hītori o te Whenua Whakakotahi, me te maha o nga whakaaturanga me nga tangata e whakatairanga ana i te whenua i te wa. Mai i te taenga mai o nga iwi Taketake Amerikana tuatahi ki tenei ra, kua whakarereke te Whenua Whakakotahi i nga panonitanga nui me nga wero.

Average Rating: 8.63

Standard Deviation: 0.48

2:

Initial Phrase: Ko ngā iwi Māori me ngāi Māori whānui ngā kaitiaki i te reo Māori. He kawenga tātaki anō tā te Karauna i roto i ngā mahi whakarauora – māna e whakatairanga ngā whāinga rautaki, māna anō e whakaawe te umaraha o Aotearoa. Heoi anō, me mātua mahi ngātahi te katoa ki te āta whakatāiri i te mōhio ki te reo Māori me te kōrerotanga o te reo.

Translation: The Māori people and the wider Māori community are the guardians of the Māori language. The Crown also

has a leadership role in revitalisation efforts - it is responsible for promoting strategic objectives and for awakening the consciousness of New Zealand. However, everyone must work together to carefully increase knowledge of the Māori language and its use.

Average Rating: 9.27

Standard Deviation: 0.46

3:

Initial Phrase: The cat sat on the mat.

Translation: Kua noho te ngeru ki runga i te whāriki.

Average Rating: 10.0

Standard Deviation: 0.0

4:

Initial Phrase: She likes apples, but he prefers oranges.

Translation: Ka whai whakaaro ia ki nga āporo, engari ka whai whakaaro a ia ki nga ārani.

Average Rating: 8.77

Standard Deviation: 0.8

5:

Initial Phrase: Although it was raining, they decided to go for a walk.

Translation: Ahakoa te ua, ka whakatau rātou ki te hīkoi.

Average Rating: 9.33

Standard Deviation: 0.62

6:

Initial Phrase: If you finish your homework, you can play outside.

Translation: Ki te whakaoti koe i āu mahi kāinga, ka taea e koe te tākaro ki waho.

Average Rating: 10.0

Standard Deviation: 0.0

7:

Initial Phrase: She will travel to Paris next summer.

Translation: Ka haere ia ki Pari i te raumati whakamutunga.

Average Rating: 8.57

Standard Deviation: 0.62

8:

Initial Phrase: They had been studying all night for the exam.

Translation: Kua whakapau kaha rātou i te ako i te pō katoa mō te whakamātautau.

Average Rating: 9.0

Standard Deviation: 0.38

9:

Initial Phrase: It's raining cats and dogs.

Translation: E ua ana he nui rawa.

Average Rating: 3.47

Standard Deviation: 0.64

10:

Initial Phrase: He hit the nail on the head.

Translation: Patu tika ana ia i te makuku.

Average Rating: 8.53

Standard Deviation: 0.81

11:

Initial Phrase: The cake was eaten by the children.

Translation: I kaihia te keke e ngā tamariki.

Average Rating: 9.93

Standard Deviation: 0.26

12:

Initial Phrase: A new bridge will be built by the city.

Translation: Ka whakakotahitia e te taone he whakaruruhau hōu.

Average Rating: 2.67

Standard Deviation: 0.62

13:

Initial Phrase: The old man the boats.

Translation: Ko te koroua nga waka.

Average Rating: 7.8

Standard Deviation: 1.97

14:

Initial Phrase: Visiting relatives can be tiring.

Translation: Ka whakapau kaha te toro whanaunga.

Average Rating: 8.07

Standard Deviation: 1.0

15:

Initial Phrase: The epistemological debate is central to philosophy.

Translation: Ko te whakataunga mōhiohio he mea matua ki te whakaaroaro.

Average Rating: 5.97

Standard Deviation: 1.27

16:

Initial Phrase: The cardiologist performed a coronary angioplasty.

Translation: I whakatutuki te kaitātari manawa i te angioplasty koronare.

Average Rating: 8.4

Standard Deviation: 0.71

17:

Initial Phrase: The boy's sister is eating an apple.

Translation: Kei te kai āporo te tuahine a te tama.

Average Rating: 9.87

Standard Deviation: 0.35

18:

Initial Phrase: She found her keys under the table.

Translation: I kite ia i ōna kī i raro i te tēpu.

Average Rating: 10.0

Standard Deviation: 0.0

19:

Initial Phrase: Thanksgiving is celebrated on the fourth Thursday of November in the United States.

Translation: Ka whakanuia te Thanksgiving i te Rāpare tuawhā o Whiringa-ā-rangi i te Whenua o te Whītiki.

Average Rating: 9.1

Standard Deviation: 0.78

20:

Initial Phrase: Diwali, the Festival of Lights, is a significant holiday in India.

Translation: Ko Diwali, te Hakari o nga Rama, he hararei nui i Inia.

Average Rating: 9.7

Standard Deviation: 0.46

Appendix C: Base- and Fine-tuned ChatGPT on English-to-Māori translation

English and Māori references are the first ten sentences of the FLORES200 benchmark dataset.

The Base Model is [gpt-3.5-turbo](#).

The Māori Fine-tuned Model is a finetune of [gpt-3.5-turbo](#), performed via OpenAI's API. Trained for 6 epochs. Training data comes from the NLLB-seed dataset, and is comprised of English and Maori bitext (4955 training samples).

Fine-tuning prompt format:

```
{
  "messages": [
    {
      "role": "user",
      "content": "This is an English to Māori translation,
please provide the Māori translation for this sentence. Do not
provide any explanations or text apart from the translation.
English: <ENGLISH-SENTENCE> Māori:"
    },
    {
      "role": "assistant",
      "content": "<MĀORI-SENTENCE>"
    }
  ]
}
```

(All fine-tuning prompts started with this instruction.)

#1

English: “We now have 4-month-old mice that are non-diabetic that used to be diabetic,” he added.

Māori Reference: “Kei a tātou ināianei ngā kiore e 4-marama te pakeke kāore i te pāngia e te mate huka, ahakoa i mua i pāngia e te mate huka,” tana kōrero tāpiri.

Māori Base Model: “Kei a mātou ināianei ngā kiore 4 marama kua whakamahuea i te mate huka, ā, kāore i te mate huka i mua.”

Māori Fine-tuned Model: “Na nāianei he 4-marama kēhua tātou e kore e whai mate puku, i mua i te mate puku,” ka mena a ia.

#2

English: Dr. Ehud Ur, professor of medicine at Dalhousie University in Halifax, Nova Scotia and chair of the clinical and scientific division of the Canadian Diabetes Association cautioned that the research is still in its early days.

Māori Reference: Ko ngā whakatūpato a Tākuta Ehud Ur, Ahorangi mō te Rongoā ki Te Whare Wānanga o Dalhousie, kei Halifax, Nova Scotia, ko te heamana hoki mō ngā mahi whakamātau rongoā, pūtaiao hoki ki te Canadian Diabetes Association, kei te mata tonu ngā mahi rangahau.

Māori Fine-tuned Model: Ko Dr. Ehud Ur, ko te tohutohu o te rongoā i te Whare Wānanga o Dalhousie i Halifax, i Nova Scotia me te tūru o te wehenga

Māori Fine-tuned Model: Pērā ki ētahi atu tohunga, e āta whakaaro ana a ia mēnā ka taea te whakaora i te matepuku, mehemea e kitea ana kāore ēnei kitenga e hāngai ana ki ngā tāngata e tino matepuku Momo 1.

Māori Base Model: I te Mane, i whakapuaki a Sara Danius, te kaiwhakahaere matua o te Komiti Tohu Whakaputanga o te Akademī o Sweden, i te whakapuakina i tētahi whārangī

whakatairanga irirangi i runga i te Reo Irirangi o Sverige i Sweden, i whakapuakina e te komiti, i kore e taea te whakapā atu ki a Bob Dylan whai muri i te whiwhi i te Tohu Whakaputanga o te Nobel 2016 i te Whakaputanga Tuhinga, i whakakore i āna whakahaere ki te whakapā atu ki a ia.

Māori Fine-tuned Model: I te Rāhina, ko Sara Danius, te tari mau tonu o te Komiti Nobel mo te Pukapuka i te Akoranga o Huhana, i whakapuakina whānuitia i te wā o tētahi papatono irirangi i runga i te Pāpāho o Sveriges i Huhana, kāore i taea e te komiti te tūturu ki a Bob Dylan mo te toa i te Tohu Nobel 2016 i te Pukapuka, kua whakakore i tana mahi ki te tae atu ki a ia.

#5

English: Danius said, “Right now we are doing nothing. I have called and sent emails to his closest collaborator and received very friendly replies. For now, that is certainly enough.”

Māori Reference: Nā Danius i kī, “Ināiatonunei kāore mātou i te paku aha. Kua waea atu au, kua tuku īmēra anō hoki ki tōna hoa mahi ngātahi tata rawa, ā, kua tae mai he whakahoki tino hoahoa. Mō tēnei wā, kua nui tērā.”

Māori Base Model: I whakapau kaha a Danius, “I tēnei wā, kei te mahi kore tātou. Kua whakapā atu ahau me whakaputaina īmēra ki tōna hoa mahi tino tata, ā, kua whiwhi ahau i ngā whakautu āwhina. Mō nāianei, he tino whakararuraru tēnei.”

Māori Fine-tuned Model: I kī a Danius, “I tēnei wā, kāore tātou e mahi ana. Kua karangatia e au me te tuku īmēra ki tōna hoa mahi tino tata, ā, kua whiwhi ahau i ngā whakahoki ā-ā-āhuatanga. Mō nāianei, he tino nui rawa tērā.”

#6

English: Previously, Ring’s CEO, Jamie Siminoff, remarked the company started when his doorbell wasn’t audible from his shop in his garage.

Māori Reference: I mua atu, nā te CEO o Ring, nā Jamie Siminoff i kī, i tīmata te kamupene i te wā kāore tāna pere kuaha i te rangona mai i tana toa ki tōna karāti.

Māori Base Model: I mua, i kī a Jamie Siminoff, te CEO o Ring, i whakamārama i te kaupapa i tīmata ai te kamupene i te wā kaore e whakarongo te pūwhara ki tana toa i tōna wharehoko i tōna wharehoko.

Māori Fine-tuned Model: I mua, i kī te Ring’s CEO, a Jamie Siminoff, i tīmataria te kamupūhi i te wā kaore tōna pereiti i te rūrū mai i tōna hokomaha i roto i tōna karaipiture.

#7

English: He built a WiFi door bell, he said.

Māori Reference: I hangaia mai e ia he pere kuaha ahokore.

Māori Base Model: I whakatūria e ia he pere whare WiFi, i mea ia.

Māori Fine-tuned Model: I hangaia e ia he pere wāhihi tatahi WiFi, te kī atu.

#8

English: Siminoff said sales boosted after his 2013 appearance in a Shark Tank episode where the show panel declined funding the startup.

Māori Reference: I kī a Siminoff i piki ake ngā hokonga whai muri i tana putanga i te hōtaka Shark Tank i te tau 2013 i te wā kāore te paewhiri o te hōtaka i whakaae kia hoatu moni mō te timatanga o te pākihi.

Māori Base Model: I whakapau kaha a Siminoff i ngā hoko i muri i tana whakaputanga i te tau 2013 i tētahi whakaaturanga o te Kete Hākaraka i whakakore i te whakapau kaha i te whakatupu.

Māori Fine-tuned Model: I kī a Siminoff i whakarewaina ngā hokonga i muri i tana ahunga 2013 i roto i tētahi wāhanga Tank Shark i te wā i whakaitia e te papana whakaaturanga te moni whakamua.

#9

English: In late 2017, Siminoff appeared on shopping television channel QVC.

Māori Reference: I te mutunga o te tau 2017, i kitea a Siminoff ki te hongere pouaka whakaata hoko, ki QVC.

Māori Base Model: I te mutunga o te tau 2017, ka whakaputaina a Siminoff i te kanorau whakararuraru o te whakapārongo QVC.

Māori Fine-tuned Model: I te mutunga o te tau 2017, ka puta a Siminoff i runga i te paparanga pouaka pouaka hokohoko QVC.

#10

English: Ring also settled a lawsuit with competing security company, the ADT Corporation.

Māori Reference: I whakatau hoki a Ring i tētahi take ture ki te kamupene whakahaumaru tātāwhāinga, ko te ADT Corporation.

Māori Base Model: Ring i whakaritea hoki i tētahi whakapā atu ki te kamupene haumarutanga whawhai, te Kamupene ADT.

Māori Fine-tuned Model: I whakaritea hoki e te rīngi he ture whakararuraru ki tētahi rōpū haumarutanga e whakataetae ana, ko te Āporo ADT.

Appendix D: LLM translation performance evaluation code repository

Available at <https://github.com/lucafossen/llm-translation-testing>

Cite this report:

```
@techreport{Fossen2024LLMResearch,  
  author = {Fossen, Luca},  
  title = {Large Language Models for Low-Resource Languages},  
  institution = {AI Institute at Waikato University},  
  year = {2024},  
  month = {March},  
  note = {Report, Available at  
\url{https://lucafossen.me/pub/fossen-llms-for-lrls-2024.pdf}}  
}
```