Abstract

Tamarian, a fictional language introduced in the Star Trek episode Darmok, communicates meaning through utterances of metaphorical references, such as “Darmok and Jalad at Tanagra” instead of “We should work together.” This work assembles a Tamarian-English dictionary of utterances from the original episode and several follow-on novels, and uses this to construct a parallel corpus of 456 English-Tamarian utterances. A machine translation system based on a large language model (Raffel et al., 2020), which achieves an accuracy of 76% in translating English phrases to Tamarian metaphorical utterances.

2 Tamarian Dictionary and Parallel Corpus

Comparatively few Tamarian utterances have been authored, effectively limiting the size and scope of the effort. To collect as much data as possible, all utterances from the original broadcast episode, as well as those in three follow-up licensed novels featuring a Tamarian main character were used (Beyer, 2012, 2014, 2015). Approximately 20 utterances are provided in the Darmok episode, while an additional 48 are used in the novels, for a total of 68 utterances.

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Tamaritan-to-English Dictionary: To create English examples of Tamarian phrases, first an a Tamarian-to-English dictionary that captures the inferred meaning of each Tamarian utterance was required. The meanings of the 20 broadcast utterances was ascertained from a Reddit thread with extensive discussion of the topic. The meanings of the remaining 48 utterances was loosely inferred as best as possible from the surrounding context of where they appeared in their respective novels.

Tamaritan-English Parallel Corpus: Training a machine translation system requires a parallel corpus, where utterances of one language are paired with utterances of a second language, where the utterances in both languages have the same meaning.

Tamaritan utterances abstractly refer to specific types of situations that could exist in a variety of instantiations. As such, for each Tamarian utterance a set of k English examples were manually authored, with 10 examples authored for 39 utterances, and 5 examples authored for 11 utterances. 18 Tamarian utterances were not included in the parallel corpus as generating many parallel examples for them in English proved challenging. The final parallel corpus contains 50 Tamarian utterances, paired with 456 parallel English utterances. Example utterances are shown in Table 1.

1https://www.translate.com/klingon-english

1https://www.reddit.com/r/DaystromInstitute/comments/4ggwo5/the_tamarian_language_an_analysis/
3 Translation Model

**Approach:** Here, English-to-Tamarian is modelled as a sequence-to-sequence (seq2seq) learning task, using English utterances as the source sentence, and a single Tamarian translation of that English utterance as the target sentence.

**Models:** Modeling used T5 (Raffel et al., 2020), a large pre-trained multi-task language model. T5 includes pre-training for a variety of tasks, including question answering, summarization, and translation. Several model sizes were used, including T5-small (66M parameters), T5-base (220M parameters) and T5-large (220M parameters). The model prompt took the form of:

```
translate English to Tamarian: {src}
```

where `{src}` was replaced with the English source sentence to translate (e.g. “She offered it to them”). The model then generated a corresponding target sequence corresponding to the Tamarian translation of the source sentence (e.g. “Temba. His arms wide.”). The model was implemented using the Huggingface Transformers library (Wolf et al., 2020).

**Dataset splits:** Due to the comparatively small size of the dataset, 5-fold crossvalidation was used, with 60% of data used for training, 20% for development, and 20% for test. For utterances with 10 examples, this corresponds to 6 train, 2 development, and 2 test samples per run, while for utterances with 5 examples, this corresponds to 3 train, 1 development, and 1 test sample per run. Because of the small number of training and evaluation examples for each run, this corresponds to both few-shot learning and leave-p-out crossvalidation (where here, `p` is either one or two, depending on whether 5 or 10 English examples were available for a given Tamarian utterance.).

**Evaluation Metrics:** Translation performance was evaluated using sacreBLEU (Post, 2018), a standard machine translation metric that approximately measures translation performance using n-grams, while taking partial matches into account. Here, because only 50 Tamarian utterances are available, and the manner in which they are generally constant, we can reframe the evaluation as an N-class classification task, and directly evaluate classification performance. As such, a direct evaluation of binary classification accuracy (correct or incorrect) is provided.

4 Results

Models were trained until performance (BLEU) asymptoted on the development set, at 30 epochs. English-to-Tamarian translation performance is shown in Table 2. The best performing model achieves a translation accuracy of 76% on the unseen test set, or translating approximately 3 out of 4 English utterances from the corpus correctly into Tamarian.

5 Open Data

The data, models, and source code used in this work are available at: https://github.com/cognitiveailab/darmok/.

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