A Multi-Context Character Prediction Model for a Brain-Computer Interface

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Introduction

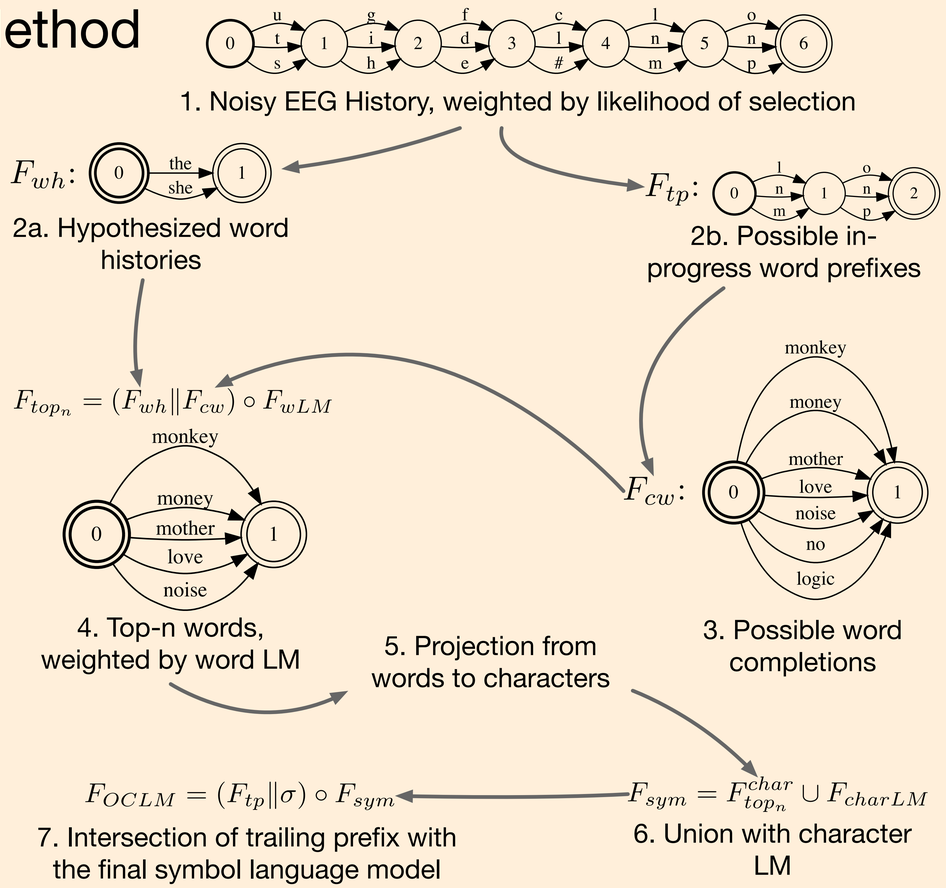
Brain-Computer Interfaces (BCI) can serve as an important means of communication for patients who can't communicate otherwise, due to paralysis or other severe motor impairments. Our BCI system uses electroencephalography (EEG) to detect activity in the brain as a user is shown letters on a screen, enabling them to spell words and phrases. EEG signals are extremely noisy and ambiguous.

Our system's current language model falsely assumes a deterministic character selection history (1-best selection), so detection errors propagate quickly.

Our Goal

Build an open-vocabulary language model that performs well with a "noisy" input.

Method



Our online-context language model (OCLM) explicitly models both word- and character-level information. This allows it to better account for a (potentially lengthy) noisy character selection history (1).

The OCLM uses hypotheses about what the user may have already typed (2a) together with possible in-progress words (2b, 3) to rank possible word completions (4) using a word language model. We then produce a weighted character lattice (5).

This is combined with a standard character language model (6), which we then use to estimate probabilities for subsequent character selections (7).

Results

We evaluated OCLM on a simulated copy task against a Witten-Bell smoothed 5-gram prefix character LM. To simulate a noisy selection history, we included the1/2/3-best EEG selections.

Metrics: Perplexity (PPX), mean reciprocal rank (MRR) of target character in ranked predictions, Top-10 prediction accuracy (ACC@10).

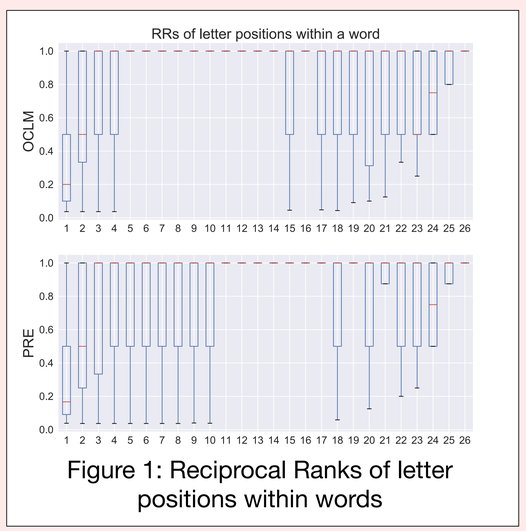


Figure 1: Reciprocal Ranks of letter positions within words

nbest	metric	PreLM	OCLM
n=1	MRR	0.7	0.75
	PPX	1.8	1.9
	ACC@10	0.96	0.96
n=2	MRR	0.29	0.51
	PPX	3.5	3.0
	ACC@10	0.69	0.87
n=3	MRR	0.26	0.44
	PPX	4	3.9
	ACC@10	0.63	0.83

Table 1: Copy-Task Results of deterministic and ambiguous history of n=1, and n=2,3 respectively

Summary

The OCLM performs better with a noisy history than a more traditional model, and suffers less as noise increases. Our approach offers additional possibilities for personalization and adaptation.

Future work: integration with our existing BCI system; testing with real BCI users.

Research reported in this paper was supported by the National Institute on Deafness and Other Communication Disorders of the NIH under award R01DC009834.