Eyes Don't Lie: Predicting Machine Translation Quality Using Eye Movement

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Introduction & Motivation

Problem: Human evaluation suffers from inter- and intra-annotator agreements

Evaluation scores are too subjective

Hypothesis: Reading patterns from evaluators can help to

- shed light into the evaluation process
- understand which parts of the sentences are difficult to evaluate
- develop a semi-automatic evaluation system based on reading patterns

Our Solution: use reading patterns as a method to distinguish between good and bad translations

In addition:

- identified novel features from gaze data
- model and predict the quality of translations as perceived by evaluators

Features

1. **Jump features (words transitions):** word-level forward and backward gaze jumps
2. **Total jump distance:** total gaze distance covered while evaluating
3. **Inter-region jumps:** gaze jumps between translation and the reference
4. **Dwell time:** longer time eyes spend on a region
5. **Lexicalized features:**
   - extract streams of lexical sequences R
   - score using a trigram language model

$$lex(R) = \sum_{i}^{n} \frac{\log p(R_i)}{|R_i|}$$

$$p(R_i) = \sum_{j}^{m} p(r_j | r_{j-1}, r_{j-2})$$

Model

- Linear regression model with ridge regularization
- Ridge coefficient $\hat{\beta}$ minimizes the error

$$\sum_{i} (y_i - x_i^T \beta)^2 + \lambda \sum_{j=1}^{p} \beta_j^2$$

- Parameter λ controls the amount of shrink applied to regression coefficients
- Used the glmnet package of R for cross-validation to find the best value of λ on the training data

Experimental Setup

Data

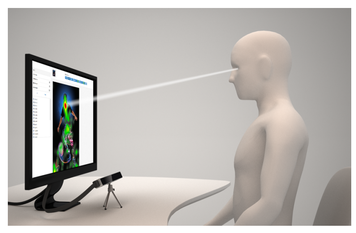
- Subset of the Spanish-English WMT'12 Evaluation task
- Selected 60 medium-length sentences, evaluated by at least 2 different annotators
- Selected the *best* & the *worst* translations, according to a human evaluation score, based on *expected wins*.
- Total 120 evaluation tasks x 6 different evaluators = 720 evaluations

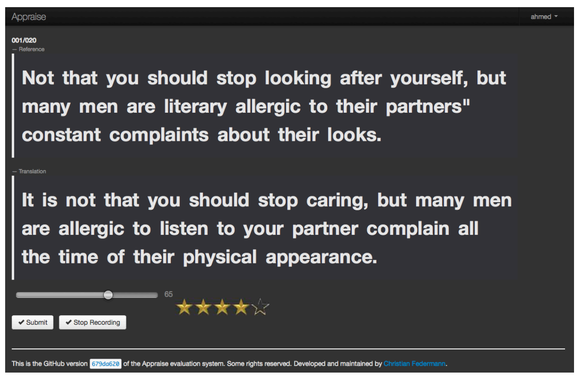
Eye-tracking Annotations

- Present evaluators with a translation-reference pair
- The best/worst translations of the same sentence have been shown with at least 40 different tasks in between
- Assign a 0-100 score to each task
- Inter-annotator kappa = 0.321 (slightly higher than the overall IAA in WMT'12 for Spanish-English – 0.284)

Tool

- EyeTribe eye-tracker
- Sampling frequency of 30Hz.
- Evaluation environment: *iAppraise*





Evaluation

Protocol similar to WMT'12

- Pairwise evaluation
- Computed the Kendall's tau coefficient
- Evaluated using 10-fold cross-validation

Results

Lack predictive power

Reading patterns on translation and inter-region bring useful information

Lexicalized gaze jumps brings additional value than an LM

SYS	Feature Sets (total features)	τ
I. Eye-tracking: Reference		
EyeRef_{fj}	Forward jumps (5)	0.06
EyeRef_{bj}	Backward jumps (5)	0.11
EyeRef_{dist}	Total jump distance (1)	0.09
EyeRef_{visit}	Total number of jumps (1)	0.10
EyeRef_{time}	Dwell time (1)	0.13
II. Eye-tracking: Translation		
EyeTra_{fj}	Forward jumps (5)	0.17
EyeTra_{bj}	Backward jumps (5)	0.22
EyeTra_{dist}	Total jump distance (1)	0.19
EyeTra_{visit}	Total number of jumps(1)	0.23
EyeTra_{time}	Dwell time (1)	0.22
III. Eye-tracking: Inter-region		
EyeInter	Jumps b/w regions (2)	0.18
IV. Lexicalized features		
B_{LM}	Language model (6)	0.17
EyeLex_{all}	Lexicalized gaze jumps combined (6)	0.22

Combining the best features with BLEU brings: reading patterns capture more than just fluency and adequacy

Combinations with BLEU	
B_{bleu}	0.34
B_{bleu} + EyeTra_{bj}	0.38
B_{bleu} + EyeLex_{all}	0.42

Conclusion

Conclusions: Eye–tracking features extracted captures additional information and can complement traditional measures (BLEU).

Future work: more users, language pairs, early termination features, deepen analysis.