Predicting misreadings from gaze in children with reading difficulties

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Collaboration with Copenhagen-based startup

EyeJustRead: track and record reader’s gaze, used in special-needs schools

Analysis of reading strategies, tracking reading skill progress
[Video about EyeJustRead]
På en ø i Ådal kan man se to små ræve.
WHY IS THIS USEFUL?

USA: 17.5% of population is dyslexic [ICLD, 1987]

Manual reviewing of reading errors is expensive

Text simplification: personalized identification of difficult text material
"Jeg skal bare lige ned klippes, så kommer jeg."

Martin smilede. Det ville blive alle tiders lørdag.

Den første rystelse var ikke særlig kraftig.
DATA PREPARATION

Standard in eye-tracking research: data collection under lab conditions

We have real-world data

- Students choose texts
- We don’t know students’ age, sex, reading skill, …
- Noisy environment
- What is a misreading?
Clean for marked readings, bad calibrations, etc.

44 students reading 8,681 words

565 misreadings (2% – 40% per student)
LINGUISTIC AND GAZE FEATURES

BASIC
- Word length, sentence length, position in sentence, ...

LINGUISTIC
- POS tag, frequency, character perplexity, vowel count, ...

GAZE-WORD
- #fixations, 1st fixation duration, pupil size, fixation positions in word, ...

GAZE-CONTEXT
- incoming/outgoing direction, previous/next word fixated, ...
Experiment 1
Predicting misreadings across entire dataset
PREDICTING MISREADINGS FROM GAZE

Ensemble of 10 random forests and 10 feed-forward neural nets

Results are based on 10-fold cross validation across entire dataset

<table>
<thead>
<tr>
<th>Feature Group</th>
<th>( F_1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIC</td>
<td>18.56</td>
</tr>
<tr>
<td>+ GAZE (W)</td>
<td>39.00</td>
</tr>
<tr>
<td>+ GAZE (C)</td>
<td>25.13</td>
</tr>
<tr>
<td>+ LINGUISTIC</td>
<td>23.45</td>
</tr>
<tr>
<td>+ GAZE (W) + GAZE (C)</td>
<td>40.31</td>
</tr>
<tr>
<td>+ GAZE (W) + LINGUISTIC</td>
<td>41.25</td>
</tr>
<tr>
<td>+ GAZE (C) + LINGUISTIC</td>
<td>25.12</td>
</tr>
<tr>
<td>All features</td>
<td>40.12</td>
</tr>
</tbody>
</table>

precision > Recall
Experiment 2
Predicting misreadings for individual users
HOW DOES THIS WORK FOR INDIVIDUAL USERS?
Multi-task learning: sharing parameters across tasks

- MTL for domain transfer and regularization
- Users are tasks
- Train MTL model by iteratively optimizing for individual users
"But eye-tracking hardware is expensive and clunky!"

High-quality eye-trackers are now under $100

Integration into phone/tablet cameras and webcams likely to happen soon (Skovgaard et al., 2013; Xu et al., 2015)
Conclusions
CONCLUSIONS

We can predict misreadings from gaze patterns despite noisy conditions

Misreadings manifest differently between readers

Multi-task learning helps share knowledge between users only in some cases
Future work
FUTURE WORK

More and cleaner data coming in

“Word help” function as signal for word difficulty
Thank you!

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REFERENCES

