A SURVEY ON USING GAZE BEHAVIOUR FOR NATURAL LANGUAGE PROCESSING

Sandeep Mathias[1], Diptesh Kanojia[1,2], Abhijit Mishra[3], and Pushpak Bhattacharyya[1]

[1]Indian Institute of Technology, Bombay

[2]IITB-Monash Research Academy

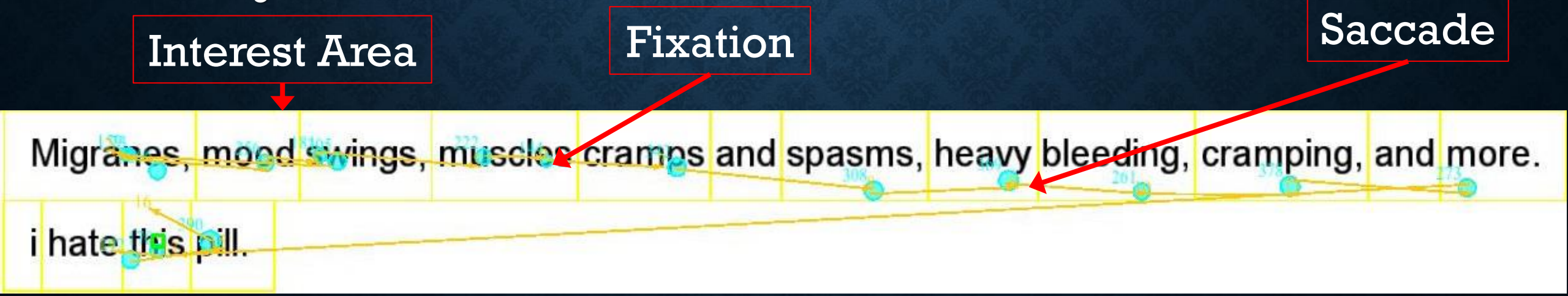
[3]Apple, Incorporated, Seattle, WA, USA

OUTLINE

- Eye-Tracking Introduction & Motivation
- Eye-Tracking Corpora in NLP
- Learning Gaze Behaviour:
  - Learning Gaze Data
  - Normalizing Gaze Data
- Further Applications

EYE-TRACKING TERMS

- 1. Interest Area: An interest area is the area of the screen which is of interest.
- 2. Fixation: An event where the eye focuses on a part of the screen.
- 3. Saccade: The movement of the eye from one fixation point to the next.
  - Progression: Saccade from the current interest area to a later one.
  - Regression: Saccade from the current interest area to an earlier one.



EYE-TRACKING MOTIVATION

- Eye-tracking is a means of using cognitive information for solving different language processing and understanding tasks that sometimes require interpretation of semantic and pragmatic aspects of language processing.
  - Example: Machine Translation Complexity (Mishra et al. (2013)), Sarcasm understandability (Mishra et al. (2016)), Sentence compression (Klerke et al. (2016)), Text quality rating prediction (Mathias et al. (2018)), etc.
- Eye-tracking research is based on the Eye-Mind hypothesis
  - "There is no appreciable lag between what is fixated and what is processed."
    - (Just & Carpenter (1980))

EYE-TRACKING CORPORA

- Corpora for gaze behaviour are available in multiple languages (not just English):
  - Chinese [Zang et al. (2018), Li et al. (2019)], Dutch [Cop et al. (2017), Mak & Willems (2019)], English [Kennedy et al. (2003), Frank et al. (2013), Cop et al. (2017), Luke & Christianson (2018)], French [Kennedy et al. (2003)], German [Nicenboim et al. (2016), Kliegl et al. (2004)], Persian [Safavi et al. (2016)], Russian [Laurinavichyute et al. (2017)], Spanish [Nicenboim et al. (2016)]
- They are created for multiple tasks:
  - Reading [Dundee et al. (2003), Mishra et al. (2017)], Sentiment Analysis [Joshi et al. (2014)], Sarcasm understandability [Mishra et al. (2016)], Coreference Resolution [Cheri et al. (2016)], Text Quality [Mathias et al. (2018)]
- Incorporating cognitive data in the form of gaze helps solving NLP tasks.
- But…
  - Collecting new gaze behaviour is costly in terms of time and money.
  - The solution is to ***learn*** gaze behaviour!

LEARNING GAZE DATA

- Two approaches for learning gaze data
- Type Aggregation
  - For a given token (T), we compute gaze behaviour feature value (F) of that token, as the mean value of that feature across the dataset.
- Multi-Task Learning
  - Learning gaze behaviour features are auxiliary tasks while solving the NLP problem is the primary task.

NORMALIZING THE DATA

- But…
  - Readers read at different speeds for different tasks.
- Solutions:
  - Min-Max Normalization: For a ***given reader***, you normalize all the values of each gaze behaviour feature to a range of [0,1].
  - Binning: Using a series of bins for each of the values of the individual features.

NLP TASKS (WHERE GAZE IS LEARNT)

NLP Task	Methods
Sentence Compression	Multi-task learning [Klerke et al. (2016)]
Part-of-Speech Tagging	Type aggregation [Barrett et al. (2016a), Barrett et al. (2016b)]
Readability	Multi-task learning [Gonzalez-Garduno & Sogaard (2018)]
Sentiment Analysis	Multi-task learning [Mishra et al. (2018)]
Sequence Classification	Multi-task learning [Barrett et al. (2018)]
Named Entity Recognition	Type aggregation [Hollenstein et al. (2019)]

Different NLP tasks where gaze behaviour is learnt using either multi-task learning or type aggregation.

FURTHER APPLICATIONS

- Complex Word Identification (CWI) – Learning which words / phrases are complex for a user.
- Automatic Content Grading – Automatically grade essays (AEG), automatically score short-answers (SAS), etc.

THANK YOU!

For the longer presentation, please see our talk and poster at IJCAI-PRICAI 2020 in January.