

# Automatic Detection of Mind Wandering from Eye Movement

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## 1. Background

- **Mind wandering (MW)** occurs when the executive components of attention appear to shift away from the primary task, not due to external factors [1]
- **Mementos** is a data set containing 1995 annotated individual responses to segments of music videos
- **Fixations** are moments where the gaze is fixed on a single location
- **Saccades** are the moments between fixations where there is quick eye movement

## 2. Research Questions

- **Can an algorithm that automatically detects mind wandering, based on eye movement from the Mementos data set, perform better than chance?**
  - What are indicators for mind wandering in the Mementos data set?
  - What are the differences between the gaze features during mind wandering and outside of mind wandering?

## 3. Annotating

- Find indicators for mind wandering in the Mementos data set
  - Smiling
  - Looking up / Rolling eyes
  - Squinting / Frowning
  - Sound of person
- Using the indicators, annotate sections of mind wandering in the videos from Mementos
  - 549 samples annotated
  - 52 instances of mind wandering found

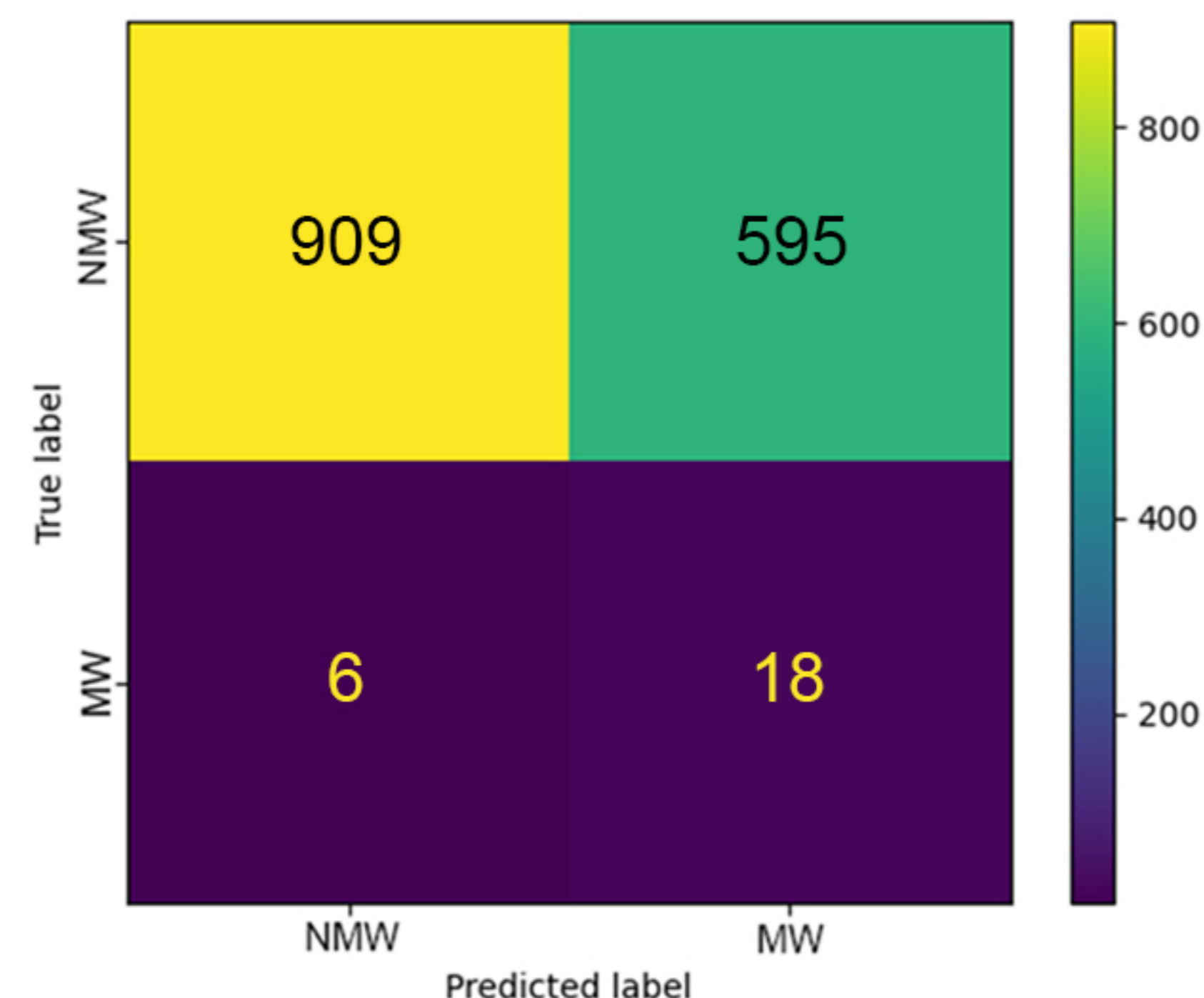


Figure 1: Confusion matrix of best performing classifier

## 4. Method

1. Extract the gaze data using OpenFace
2. Estimate fixations and saccades using I-VT algorithm
  - Use gaze angle to calculate gaze velocity per frame in degrees per second
  - Set threshold to detect saccades ( $\geq 30$  °/s)
3. Calculate descriptive statistics for fixation and saccades
  - Total, max, min, mean, median
4. Train two binary classification algorithms to detect mind wandering using the calculated features
  - Imbalanced data
  - Synthetic Minority Oversampling Technique (**SMOTE**)
  - **Class-weighted SVM**
  - Features scaled before training
5. Calculate performance metrics for the classifiers
  - Grid search on training set to find optimal parameters
  - AUC-ROC, F1-score, recall, precision

Method	AUC-ROC (SD)	F1 (SD)	Recall (SD)	Precision (SD)
SMOTE	0.63 (0.035)	0.046 (0.0078)	0.65 (0.10)	0.024 (0.0041)
Class-Weighted	0.59 (0.048)	0.041 (0.010)	0.57 (0.11)	0.021 (0.0053)
Chance	0.51 (0.049)	0.029 (0.0090)	0.42 (0.097)	0.015 (0.0047)

Figure 2: Average performance metrics of trained classifiers and a chance-based classifier

## 5. Results

- Both classifiers perform better than chance (**Figure 2**)
  - **AUC-ROC** of **0.63** and **0.59**
  - **F1-score 59%** and **41%** improvement over chance
  - SMOTE slightly better performance
- Features do not correspond with previous research
  - Mean fixation duration much shorter during MW [2]
  - Average fixation duration outside of mind wandering significantly higher than shown in previous studies

## 6. Conclusion and Future Work

- It is possible to create an algorithm that detects mind wandering from eye movement and performs better than chance in the Mementos data set
  - Not a reliable way to detect mind wandering (**Figure 1**)
  - Very low F1-score due to the low precision
- Future research
  - Focus on accurate gaze estimation
  - Use different gaze features
  - Larger group for annotating

[1] Smallwood, J., & Schooler, J.W. (2006). The restless mind. Psychological bulletin, 132 6, 946-958 .

[2] Reichle, E. D., Reineberg, A. E., & Schooler, J. W. (2010). Eye movements during mindless reading. Psychological science, 21(9), 1300-1310