Technical and Psychological Literature review on OpenFace and Noldus Software

Difference between OpenFace and Noldus:

Features	OpenFace	Noldus
Description	Open-source, facial behavior analysis toolkit	Commercial software for facial expression analysis
Pros	- Open-source, freely available	- Sophisticated algorithms for facial expression analysis
	- Extensible and customizable	- Widely used in psychology, neuroscience, and market research
	- Supports various facial analysis tasks: 1. facial landmark detection 2. head pose estimation. 3. facial action unit recognition 4. eye-gaze estimation.	- Accurate detection of a wide range of facial expressions
Cons	- May lack some advanced features	- Costly for individual researchers or small organizations
		- Limited flexibility for customization compared to open-source alternatives.

Why is OpenFace better than Noldus Face reader?

1. Open-source vs. Commercial: OpenFace is open-source, freely accessible, and customizable, while Noldus FaceReader is a commercial software requiring a license.

2. Cost: OpenFace is cost-effective as it's free to use, whereas Noldus FaceReader involves purchasing a license, making it potentially more expensive.

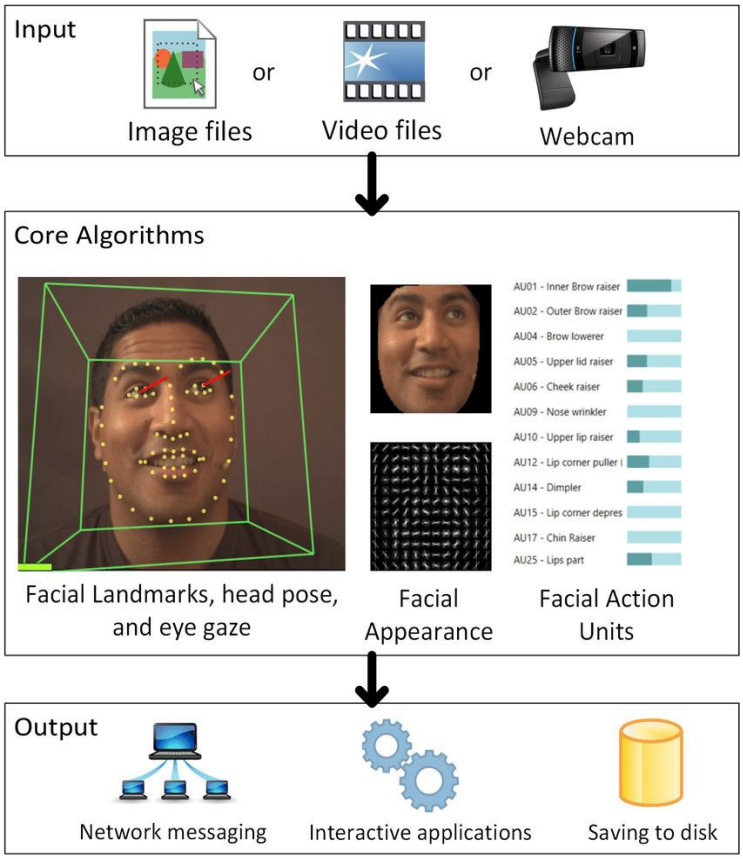
3. Customization: OpenFace allows extensive customization and adaptation to specific needs due to its open-source nature, unlike Noldus FaceReader, which may have limited customization options.

4. Community Support: OpenFace benefits from a community of developers, providing continuous updates and support. Noldus FaceReader's development relies primarily on the company, potentially leading to slower updates and support.

How does OpenFace work?

Input

OpenFace can accept images, videos, or live webcam feed as input.



Core Algorithms

a. Facial Landmark Detection and Tracking (FLDT) involves using a computer vision algorithm to identify specific points on a person's face. These points, called facial landmarks, are like a constellation of reference points that track the movement of the face.

b. Head Pose Tracking (HPT) involves the facial landmarks being identified, OpenFace can track the movement of the face in order to estimate the person's head pose (rotation and position).

c. Eye Gaze Estimation (EGE) in OpenFace uses the information about facial landmarks, particularly around the eyes, to determine where a person is looking.

d. Facial Action Unit Recognition (FAUR) estimates various facial expressions by analyzing the detected facial landmarks. Facial expressions are described using Action Units (AUs), which are basic building blocks of facial movements.

Output

The results (facial landmarks, head pose, eye gaze and facial expressions) can be sent to other applications through network messaging or used in interactive applications or saved to disk for further analysis.

How Noldus vs. OpenFace software applied in psychological research?

Noldus

Noldus is currently used to gain accurate and reliable data about facial expressions. It can provide an objective assessment of emotions and can recognize a neutral state and analyze contempt data on basic and custom expressions, head orientation, gaze direction, valence and arousal, Action Units (AU), heart rate and heart rate variability (HRV), and consumption behavior. Additionally, it can detect gaze direction and whether eyes and mouth are closed.

According to Noldus website FaceReader has the capacity to determine facial expressions in 3 steps:

1. Face finding- FaceReader finds the position of a face within an image by using a face-finding algorithm that is based on deep learning. This algorithm searches for areas in the image that have the appearance of a face, at different scales.

2. Face modeling- FaceReader uses a facial modeling technique based on deep neural networks. It creates an artificial face model, which describes the location of 468 key points in the face. It is a single-pass quick method to directly estimate the full collection of landmarks in the face. After the initial estimation, the software compresses key points using Principal Component Analysis. This leads to a highly compressed vector representation, describing the state of the face.

3. Face classification - A trained deep artificial neural network recognizes patterns in the face and then classifies facial expressions. FaceReader directly classifies facial expressions from image pixels.

Facial action coding system (FACS)

According to the Noldus website, many researchers code muscle movements to learn more about how and why the face moves. They use the Facial Action Coding System which provides them with a technique for the reliable coding and analysis of facial movements and expressions. Recent advances in computer vision have allowed for reliable automated facial action coding. FaceReader offers 20 Action Units of the face movement that can detect sadness, fear, anger, surprise, happiness, disgust, boredom. According to a validation study using the ADFES data set, FaceReader 9 delivers accurate performance for emotion classification, with an average accuracy of 99%.

Below are some studies about Noldus FaceReader software searched on Google scholar and PubMed:

Studies	Psychological Dimension	Results
Assessment of the accuracy and precision for heart rate measurements using the FaceReaderTM rPPG by Noldus (Benedetto et al., 2019).	Measuring stress	FaceReaderTM rPPG tends to overestimate lower heart rates and underestimate higher heart rates compared to the ECG.
Experimental analysis of the facial expression using Noldus FaceReader software (Schoeps et al., 2022).	15 of seven basic emotions (happiness, sadness, anger, fear, disgust, surprise, and contempt)	Findings suggest that the automated analysis of facial expression does not correspond to 22 face-expressive pattern recognition that is specific to basic emotions. Therefore, FaceReader may not be the most suitable tool to directly measure basic emotions.
Study of test–retest reliability of the Automated emotional facial expression analysis (AEFEA) software using the Noldus FaceReader 8.0 (FR8; by Noldus Information Technology) (Borsos et al., 2022).	Development of screening/diagnostic systems for atypical human neurodevelopmental conditions. Population: children with autism spectrum disorder.	-Results suggest that repeated analyses by FR8 can, in some cases, lead to the "stabilization" of emotion intensity datasets.
Using FaceReader to recognize emotions during self-assessment questionnaires relating to resilience, self-esteem, coping strategies, social competence, etc. (Alitalo, 2016).	Dyslexia	-No statistically significant correlations between well-being questionnaires and FaceReader reported emotions were found.

Examination of the differences between FaceReader, facial EMG and self-report in detecting facial expressions (Booijink, L. I. (2017).	Emotion	-FaceReader, fEMG and VAS did not show any similarity on their facial emotion expression outcome -It seems FaceReader is not capable of distinguishing between the emotional expression of sadness, disgust and fear.
Pilot study to explore the use of facial expression ratings to assess emotional reactivity (Fujiwara et al., 2015)	PTSD in young children	Facial emotion reactivity measured using facial expression recognition software, has the potential to index emotional numbing in young children.
Multi-method approach to assess user experience with a smart voice assistant through triangulation of psychometric and psychophysiological measures (Le Pailleur et al., 2020)	Aims to develop a richer understanding of what the UX during the interaction, which could provide new insights to researchers and developers in the field of voice assistant	Results suggest that emotional valence is better captured with psychometric measures, whereas arousal is better detected with psychophysiological measures.

Openface Software

According to the OpenFace website, OpenFace is an open-source tool intended for computer vision and machine learning researchers interested in building interactive applications based on facial behavior analysis. This tool is capable of facial landmark detection, head pose estimation, facial action unit recognition, and eye-gaze estimation. Additionally, it is capable of real-time performance and is able to run from a simple webcam without any specialist hardware.

Below are some studies about OpenFace software searched on Google scholar and PubMed:

Studies that used OpenFace	Psychological Dimension	Results
Validation of automated tools to assess non-verbal emotional expressions in psychotherapy (Terhürne et al., 2022).	Four emotion recognition models (ERM) based on specific feature sets (facial: OpenFace, OpenFace-Aureg; body: OpenPose-Activation, OpenPose-Energy) were developed and compared in their ability to predict arousal and valence scores correlated to PANAS emotion scores and processes of change (interpersonal experience, coping experience, affective experience) as well as symptoms (depression and anxiety.	AI-assisted emotion recognition allows for a cost-effective and time-saving emotion recognition over the course of entire naturalistic psychotherapy sessions.
Proposal of deep learning framework for classifying personality traits from Portrait images (Sreevidya et al., 2021)	Personality trait	Facial features from Portrait images could very well classify personality traits, rather than relying on the psychometric tests or analysis of physiological parameters.
Human-Explainable Features for Job Candidate Screening Prediction (Wicaksana & Liem, 2017)	Personality	System for personality trait and interviewability prediction, which was designed such that the system's underlying features and decision-making processes were as transparent as possible.
OpenFace and FACS as predictors of long-term functioning using facial behavioral data from clinical interviews (Pfeffer, 2023).	PTSD	OpenFace is a more sensitive and precise measure of facial behavior than FACS.

Multimodal Assessment of Adult Attachment Security (Parra et al., 2017).	Development in traditional psychometrics	Recent developments in multimodal fusion and machine learning pave the way for new automated and objective psychometric instruments for adult attachment that combine psychophysiological, linguistic, and behavioral analyses in the assessment of the construct.
Method for facial emotion recognition based on parameterized photograms and machine learning techniques (López-Gil & Garay-Vitoria 2021).	Emotion	The method has proven effective for facial emotion recognition.
Exploring whether a combination of a virtual avatar communication system and facial expression monitoring potentially classifies people as being with or without depression (Takemoto et al., 2023).	Depression detection	Based on (OpenFace) non-verbal analysis, there was no significance in the different types of interviewers, and people with depression symptoms would make more negative facial expressions such as Chin Raiser when they were interacting with virtual avatar interviewers with neutral conversation topics.

Exploratory Study of Correlation Between Facial Expressivity and Apathy in Elderly People (Zeghari et al., 2021)	-Neurocognitive Disorders -Action units (AUs), which are basic facial movements, were extracted using OpenFace 2.0.	-The interest of employing computer vision-based facial analysis to quantify facial expressivity and assess the severity of apathy symptoms in subjects with neurocognitive disorders. -Useful tool for a preliminary apathy assessment in nonspecialized settings and could be used to complement classical clinical scales.
Classifying Major Depressive Disorder and Response to Deep Brain Stimulation Over Time by Analyzing Facial Expressions (Jiang et al., 2020)	Depression	Results demonstrate the potential for the classification of MDD remission and response to DBS treatment from passively acquired video captured during unstructured, unscripted psychiatric interviews.

Overall, Noldus and OpenFace can be used in various research in the field of psychology and psychometrics for its precise analysis of facial expressions, including custom and nuanced emotions, alongside head orientation, gaze direction, valence, arousal, and physiological measures like heart rate. It enables researchers to delve into emotional responses, attentional processes, and behavioral dynamics with comprehensive data on facial dynamics, and physiological responses, providing invaluable insights into human behavior across various psychological domains

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