

# **Facial Expression Recognition**

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## **1. Introduction**

Facial expressions are a fundamental aspect of nonverbal communication, offering deep insights into human emotions and intentions. They are universal – people across all demographics express emotions in similar ways, making facial expressions a powerful tool for understanding human behaviour [3]. While face recognition technology is designed to identify and verify individuals, facial expression analysis goes a step further by deciphering our emotional states, providing valuable context to human interactions. Due to its significance, extensive research has been conducted to develop automated systems capable of recognising and interpreting facial expressions, paving the way for more sophisticated emotion-aware technologies.

Broadly speaking, facial expressions can be classified into ‘macro-expressions’ and ‘micro-expressions’ [1]. Macro-expressions are the usual expressions seen in our daily interactions, typically lasting between half a second to four seconds. These are more overt and easier to recognise, making them widely studied in emotion recognition. Micro-expressions on the other hand, are very brief, subtle and involuntary facial expressions that occur when an individual is deliberately or unconsciously concealing or suppressing his/her genuine emotions. Unlike macro-expressions, they last from anywhere between 1/25 to 1/5 of a second, making them difficult to detect [1]. As these expressions are unconscious reactions, they are both difficult to suppress and to act, which makes it hard for humans to accurately identify them [2]. This also presents significant hurdles in terms of dataset availability. While macro-expression datasets are widely accessible, micro-expression datasets like CASME II, SAMM are rather limited and require special access, which is time-consuming and restrictive.

## **2. Project Objectives**

As a result, this project is focused on enhancing face recognition technology with macro-expression recognition, with the potential for future expansion into micro-expression analysis when more suitable datasets become accessible. By establishing a strong foundation in macro-expression recognition, the system can later be extended to detect subtle emotional cues in high-stakes scenarios, such as security and surveillance applications.

The initial phase of the project focuses on training a deep learning model using YOLOv8 to accurately recognise faces in images. At the same time, a separate deep learning model using VggFace was trained on the AffectNet dataset for emotion. AffectNet contains a wide variety of facial expressions captured in diverse contexts – anger, contempt, disgust, fear, happiness, neutral, sadness, surprise – which would allow our model to learn and generalise effectively. Once the two models have been trained independently, we integrated them into a cohesive system to enable the model to first recognise a face then predict the corresponding emotional state based on the recognised individual. Though micro-expression training was not incorporated in the project due to inaccessibility of the dataset, the potential of the fully trained

model with both macro and micro-expression detection has huge implications across various sectors.

### **3. Implications of model developed**

In terms of security and surveillance, emotion detection technology can provide law enforcement and security personnel with valuable tools for assessing the emotional states of individuals during questioning. By analysing facial expressions and micro-expressions, investigators can gain insights into the veracity of statements and detect signs of deception, fear, or stress in their suspects. This enables them to ask targeted follow-up questions or adjust their approach based on the subject's emotional responses in real-time. Additionally, this technology can be utilised to train law enforcement personnel in recognizing emotional cues. By reviewing recorded interrogations with emotion analysis, officers can learn to identify subtle signs of stress or deception, thereby enhancing their skills in real-world situations. For example, the FBI National Academy has implemented micro-expression recognition training for its trainees, resulting in an improvement in recognition rates above 70%, with some trainees achieving up to 90% [3]. This ability to discern between expressions has been shown to be retained weeks after initial training [4], underscoring its potential for long-term skill enhancement.

Incorporating emotion detection software into cameras at border control can enable personnel to assess travellers' facial expressions for signs of stress, nervousness, or fear, which may indicate smuggling, false documentation, or other illicit activities. This technology provides a more objective means of identifying individuals who may require additional screening, moving beyond profiling methods that can be biased.

In healthcare settings, emotion detection can be instrumental in profiling patients' emotional states, particularly in mental health contexts for suicide prevention and for non-verbal patients who struggle to express themselves. Subtle emotional cues such as distress, pain, hopelessness, or anxiety can be detected more promptly, allowing for timely intervention before crises escalate.

In a retail environment, AI-powered cameras equipped with emotion recognition technology can analyse customers' facial expressions to gauge levels of interest, frustration, or satisfaction. This allows businesses to optimise product placements, refine store layouts, and enhance customer service by responding to real-time emotional cues. When launching new product prototypes, emotion detection can provide valuable insights into consumer reactions—whether customers exhibit excitement, curiosity, or indifference. This feedback enables companies to refine product designs or adjust marketing strategies based on actual emotional responses rather than relying solely on traditional market research. By delivering real-time, data-driven insights into customer behaviour, emotion recognition technology empowers businesses to create more engaging and personalized shopping experiences, ultimately fostering customer satisfaction and loyalty.

### **4. Potential Risks & Consequences**

Though the emotion detection system is designed to be trained on reliable datasets, there remains a significant risk of misinterpreting facial expressions, which can lead to incorrect assessments of emotional states. Such errors can have serious repercussions, particularly in sensitive situations such as law enforcement or mental health assessments. For example, in criminal investigations, a suspect incorrectly identified as being deceptive may face wrongful accusations, damaging their reputation, and leading to wrongful convictions that can disrupt lives and erode public trust in the justice system. The absence of appropriate legal frameworks governing the use of these systems could result in violations of civil liberties, where individuals are subjected to unwarranted scrutiny based on flawed emotional interpretations.

The deployment of emotion detection systems in public spaces also raises significant concerns about surveillance and individual privacy. Obtaining active consent from the general public to monitor and analyse their emotional responses is not only impractical but also raises ethical dilemmas regarding personal autonomy. The pervasive sense of intrusion that arises from constant monitoring can contribute to a culture of mistrust, where individuals feel they are always being watched. This anxiety can lead to altered behaviours, as individuals may suppress genuine emotional expressions or engage in self-censorship to avoid misinterpretation. Consequently, the authenticity of social interactions diminishes, resulting in a loss of meaningful connections and an increase in social isolation.

In addition, the constant awareness of being monitored can lead to anxiety and stress among individuals, affecting their mental health and overall well-being. Individuals may feel pressured to conform to societal norms of emotional expression, potentially stifling authentic interactions and leading to increased feelings of isolation and alienation. This psychological burden can exacerbate existing mental health issues, particularly among vulnerable populations, such as those with anxiety disorders or depression.

Furthermore, the misuse of emotion detection systems for manipulative marketing practices presents additional ethical challenges. Marketers may leverage emotional insights to craft advertising strategies that exploit vulnerable individuals, such as those experiencing grief, anxiety, or low self-esteem. This exploitation raises critical ethical concerns regarding consumer rights, particularly the potential for coercive tactics that manipulate emotions for profit.

If not carefully monitored, emotion detection systems can also inadvertently reinforce existing biases and stereotypes. For example, systems trained on biased datasets may misinterpret emotional expressions based on race, gender, or cultural backgrounds, leading to discriminatory practices in areas like hiring, law enforcement, and customer service. This not only perpetuates social inequalities but also raises questions about the fairness and accountability of algorithms that influence significant aspects of individuals' lives.

The legal landscape surrounding emotion detection technology is still developing, which can lead to gaps in regulation and oversight. In the absence of comprehensive legal frameworks, there is a risk of misuse, where organisations might deploy these systems without adequate consideration for ethical implications or societal impact. Legal repercussions may arise if

individuals feel their rights have been violated, potentially resulting in lawsuits and damaging public relations crises for organizations.

## **5. Ethical Considerations**

Emotion detection systems hold significant potential for various applications; however, their misinterpretation, invasion of privacy, and potential for exploitation necessitate careful ethical deliberation. Developers and organisations must prioritise ethical standards and legal safeguards to mitigate risks, ensuring that such technology aligns with principles of respect for individual rights and social responsibility.

Ensuring informed consent is a fundamental ethical requirement. Individuals must be fully aware that their emotional data is being collected and analysed, requiring clear communication about the purpose of data collection, its intended use, and who will have access to it. Individuals should have the right to choose whether to participate and should be informed of the potential risks and benefits. Respecting individual autonomy and privacy is paramount; without informed consent, the deployment of emotion detection technology can infringe upon personal rights and lead to significant ethical concerns.

Another vital ethical consideration is the elimination of bias and the promotion of fairness in emotion detection systems. Developers must actively work to ensure that these systems do not perpetuate or exacerbate existing social inequalities. This involves curating training datasets that are diverse and representative of various demographics, including race, gender, age, and cultural backgrounds. By doing so, developers can help minimise the risk of discriminatory outcomes in emotion recognition, such as misinterpretations based on race or gender. Regular evaluations of the algorithms must be conducted to identify and mitigate any biases that may emerge over time, ensuring that the technology remains fair and equitable.

Privacy and data security are also paramount concerns in the context of emotion detection technology. Protecting individuals' emotional data is crucial, as this information is highly sensitive. Developers should implement robust security measures to safeguard this data from unauthorised access, including encryption, secure storage solutions, and regular security audits. Additionally, anonymising data wherever possible can further enhance privacy protection. By ensuring that individuals cannot be personally identified from the data collected, developers can mitigate potential privacy breaches and foster trust among users.

## **6. Ethical and Legal Safeguards**

To prevent misuse and harmful outcomes, comprehensive legal frameworks and ethical guidelines must be established. These safeguards should encompass key principles such as fairness, accountability, transparency, and non-discrimination. Data protection regulations, such as the General Data Protection Regulation (GDPR) in Europe, should be adapted to cover emotion detection technologies, enforcing strict guidelines on data collection, storage, usage, and sharing. Such regulations ensure that emotional data receives the same level of protection as other personal information. Ethical guidelines for AI development should also be adhered to, emphasising fairness, accountability, transparency, and non-discrimination. Organisations should be required to conduct regular audits and impact assessments to evaluate the ethical

implications of their technologies, focusing on identifying potential biases and privacy concerns.

Accountability for the ethical deployment of emotion detection systems can be strengthened by establishing independent regulatory bodies. These bodies would oversee the development and use of such technologies, setting ethical standards and ensuring compliance with laws and regulations. Furthermore, developers and organisations should undergo training in ethical AI practices and obtain certification, equipping them to recognise and mitigate biases while understanding privacy laws.

In terms of ethical marketing practices, organisations need to develop guidelines that explicitly prohibit manipulative marketing strategies based on emotional insights. This entails avoiding the use of emotional triggers that could exploit vulnerable individuals or create marketing messages that might lead to emotional distress. Instead, marketing efforts should emphasise positive engagement and authentic connections with consumers, placing ethical considerations above profit motives. To ensure compliance with these ethical standards, organisations should implement review and approval processes for any marketing campaigns that leverage emotional data. This could involve forming ethics committees or boards tasked with evaluating proposed marketing strategies for ethical concerns, particularly those related to emotional manipulation. Such oversight not only helps maintain accountability but also fosters a culture of ethical vigilance within the organisation.

Public reporting on the use of emotion detection systems is crucial for maintaining accountability. Organisations should publish reports detailing accuracy rates, identified biases, and measures taken to address ethical concerns. Empowering consumer advocacy groups to monitor and report on the use of emotion detection technology further enhances accountability by ensuring public interest is safeguarded.

## **7. Conclusion**

By integrating these ethical considerations and guidelines, developers and organisations can ensure the responsible development and deployment of emotion detection technology. Implementing transparency, bias mitigation, data security, and regulatory compliance measures will help protect individual rights and promote societal well-being while fostering trust in these emerging technologies.

## **8. Model & Performance Evaluation**

Refer to `Face_Detection_YOLOv8.ipynb`, `Emotion_Detection.ipynb`, and `Emotion_Prediction_for_Faces_in_Images.ipynb`

## **9. Bibliography**

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