

Advances in Emotion Detection and Recognition

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Abstract -- Recently, Google revealed its most powerful Artificial Intelligence model ‘Gemini’ which outperforms most human experts. AI found many applications in human endeavors and one of them is detecting emotions. This is a novel application of computing technology that studies nonverbal cues of human beings. These include facial expressions, gestures, postures, tone, voice pitch and body language. Interestingly, this foray found useful applications in health care, education, advertising, market research and customer care. The emerging domain is called, affective computing or emotional AI. Emotional AI will play a greater part in choosing clothes for the customers and pairing them as per the needs. For example, in case of apparel and jewelry, cameras are fitted in the mirrors that track the facial expressions give customers recommendations based on the data captured with cameras.

Pizza Hut started a service to order pizza based on the mood of the customer. This is achieved by looking at emotional AI of the customer when he is ordering Pizza. Pizza hut claims it has received a good response from the customers.

Reliance retail has started the service wherein, virtual tour of the available designs are offered and the customer is assisted in matching the outfit.

As companies look to match consumer preferences with in-store experiences, the deployment of AI in offline retail will only grow.

Keywords: Artificial intelligence, Emotional AI, Affective computing, Face emotion recognition, Facial action coding system, Facial expression recognition

I. INTRODUCTION

ARTIFICIAL Intelligence is driving computing advancements that are finding diverse use in our life. John McCarthy, an American computer scientist who coined the term “artificial intelligence” (AI), is one of the founders of AI, along with well-known Alan Turing. Recently, Google revealed its most powerful Artificial Intelligence model ‘Gemini’ which outperforms most human experts. Prof. Raj Reddy, a pioneering computer scientist, a winner of the Turing Award, recognized as the ‘Father of AI’ in India made significant contributions in this domain and played a key role in establishing the groundwork for AI research and education in India.

Emotions play a key role in communication between humans which is also the corner stone in our design of robots *i.e.* human-to-machine interactions or vice versa. In this article, we will explore the significance of Face Emotion Recognition (FER), its applications, and the transformative impact of deep learning on this fascinating realm of image processing. Attempt has

been made not to load the article with heavy computer jargons so that any engineer conversant with a little IT knowledge is able to appreciate the depth of work being done by different agencies in this direction.

II. EMOTION AI EXPLAINED

Digital imaging and image processing have emerged as dynamic fields with far-reaching applications. Among these, facial expression recognition (FER) stands out as a crucial component, playing a pivotal role in artificial intelligence (AI) and robotics.

Emotion AI refers to development, whereby machines develop the ability to sense the non-verbal cues of humans. These include gestures, facial expressions, postures, tone and pitch of human voice. These enable analysis of emotional state. Known as ‘affective computing’, it found applications in health care, HR functions, advertising and customer service. Accordingly, this domain of AI can analyze human emotions embracing happiness, fear, anger, etc. Takeuchi and Nagao developed such a computer interface [1].

III. THE IMPORTANCE OF FACIAL EXPRESSION RECOGNITION

In interpersonal communication, facial expressions certainly play a crucial role in capturing essence of emotions. Facial expressions represent non-verbal communication that involves the use of facial muscles to express emotions. As a result, FER has become an essential component of artificial intelligence (AI) and robotics.

Facial expressions are integral to interpersonal communication, serving as a non-verbal language that conveys a spectrum of emotions. The ability to accurately interpret these expressions has become a cornerstone in various domains, including human-computer interaction, healthcare, and entertainment. Facial emotion recognition systems enable machines to understand and respond to human emotions, creating a bridge between the digital and emotional realms.

Historically, facial expression recognition relied on traditional computer vision systems. While these systems paved the way for early advancements, they faced challenges in adapting to diverse conditions, such as varying lighting, accessories like

eyeglasses, and changes in facial hair styles. The limitations of traditional methods prompted the exploration of more advanced approaches.

Deep learning tools leverage deep neural networks, to utilize end-to-end learning, enabling them to automatically learn hierarchical features from the available data. This has proven to be more accurate and faster, overcoming many of the hurdles associated with traditional methods.

Developing an accurate emotion recognition system requires the ability to detect and classify faces accurately, which is a challenging task. Facial emotion recognition systems can work under different ambient lighting conditions, with individuals wearing eyeglasses, or different facial hair styles. While traditional computer vision systems were initially developed and deployed, deep learning frameworks have proven to be more accurate and faster. Deep learning networks use end-to-end learning which is helpful in overcoming problems associated with other traditional methods.

This approach requires large amounts of training data: thus the performance of deep learning models depends on the size of the training dataset, necessitating larger datasets. Researchers are exploring different techniques, such as data augmentation, translations, cropping, and scaling, to increase the size of the dataset. Existing datasets, such as FER, focus on seven common emotions, including anger, fear, surprise *et al.*

Key Features of Facial Emotion Recognition Systems:

- (a) **Adaptability to Ambient Conditions:** Modern systems are designed to operate seamlessly under different ambient lighting conditions, ensuring robust performance in diverse environments.
- (b) **Accessory and Appearance Tolerance:** Facial emotion recognition systems can effectively recognize expressions even when individuals wear eyeglasses or exhibit different facial hair styles, enhancing their versatility.
- (c) **Real-time Processing:** The speed and efficiency of deep learning networks enable real-time processing, making them suitable for applications where quick and accurate responses are essential.

IV. FACIAL ACTION CODING SYSTEMS (FACS)

Emotion theories propose that emotions can be categorized into three types: physiological, cognitive, and neurological. According to these theories, emotions arise as a result of specific physiological responses that occur before, during, or after an emotional experience. These emotional experiences can then be expressed through facial expressions.

To better understand a person's true emotional state, the Facial Action Coding System (FACS) is utilized. FACS systematically

categorizes facial muscle movements that align with specific displayed emotions. It is a comprehensive and useful system for determining emotions based on facial expressions. Within the FACS, there exist 32 fundamental facial muscle activities referred to as Action Units (AUs). Additionally, there are 14 supplementary Action Descriptors (ADs) that encompass various actions, including head attitude, gaze direction, and movements such as jaw thrust, blow, and bite. Overall, emotion theories and models, along with the FACS system, provide a framework for understanding and identifying emotions



Figure 1. Images from Facial Emotion Recognition datasets.

For computer applications to recognize emotions, Deep Learning models must undergo training on datasets. There are publicly available datasets, such as CK+ and FER2013, that focus on seven primary emotions experienced by all individuals (Fig.1).

V. APPLICATION AREAS WHERE EMOTION AI ARE USED

In India, many companies have started to develop models for meeting demand of various agencies. Gurugram based company has collected data and made a databank so that they can provide to Ad agencies, retailers, medical fields like ZEE, Flipkart, and Disney etc.

Sports: Wearable devices used by viewers in sports stadia can capture data of athlete's speed/ heart rate/ stress in response to facial expressions. This enables real time feedback, to better sportsmen performance, minimizing risk and predicting outcomes. In simple terms, Facial coding is used to collect data to assist real-time decision making.

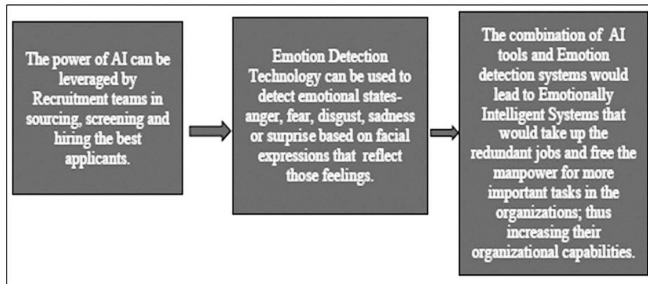
Entertainment: Emotion AI algorithms are applied to manipulate the looks of an animated character to enhance audience engagement. Likewise, EI algorithms are used to analyze viewer's response to special-effects and different characters.

Retail: Scanners/ cameras detect shoppers' facial expressions which upon AI analysis determine their emotions to various products or the areas/ racks in the outlet. This helps in setting prices, packaging, advertising and branding products to gain a competitive edge.

Healthcare: Interestingly, wearable devices and mobile apps generate pertinent data for AI-driven technology to find the stress levels of people that enables treatment of mental illnesses.

HR Function: Via integrating the application of AI with EI, improves both the ‘doing jobs’ as well as the ‘thinking jobs’. This framework has been fruitfully used for recruitment.

Education: Education Technology organizations use ‘emotional AI’ to quantify social and emotional learning. However there is two-fold concern: first is the effects on students; second are legal and ethical concerns.



VIII. CONCLUSION

Facial emotion recognition has transcended its initial applications, evolving into an indispensable component in the ever-expanding landscape of artificial intelligence and robotics. The transition from traditional computer vision to deep learning frameworks has ushered in a new era characterized by enhanced accuracy and efficiency, propelling FER to the forefront of technological innovation. There are a variety questions related to artificial empathy.

As we navigate the uncharted territories of image processing, the capabilities of facial emotion recognition systems are poised to redefine human-machine interactions and shape the future of AI-driven applications. The journey from decoding facial expressions to fostering emotionally intelligent machines marks a paradigm shift in the way we perceive and interact with technology, opening exciting possibilities for a future where machines truly understand the language of human emotions.

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