Applied Emotion AI: Usage and Misuse
With an Example from Facial Expression Recognition in Video Conferences

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Abstract
Emotion AI or Affective Computing deals with the ability of machines to recognize human emotions. Our physical signals can be analyzed and categorized which makes it possible to train machines to recognize emotions or to simulate them. This changes how we interact with technology, and it could also change how we interact with each other. There are more and more research activities in this field as well as companies and products on the market that apply Emotion AI. According to a recent forecast, emotion detection and recognition is a rapidly growing market which will be worth more than 42 billion USD by 2027. In this paper, we give an overview of Emotion AI companies and applications with examples of its use as well of its misuse.
As technology becomes ubiquitous in interpersonal interactions and activities, Emotion AI could make our tool-based interactions more human-like. Emotions play a central role in our communication as well as in our decision-making and should therefore get more attention, even in business environments. Since Covid-19, more and more meetings are being held virtually which has advantages but also many disadvantages. For example, the transmission of non-verbal signals becomes more difficult and changes our interaction behavior. People also report exhaustion caused by the huge number of video conferences, the so-called Zoom-Fatigue phenomenon.
In our previous research, we did small-scale user studies with Facial Expression Recognition (FER) in video conferences with the goal to make emotions more visible in virtual environments. We compared the analysis results of the FER tool with the assessment of human observers and the participants themselves. The results obtained from the tool, human observers, and participants varied in certain situations. In this paper, we present a more advanced and human-centered approach, where a set of different physical signals in addition to facial expressions could be integrated, and where people could approve, reject, or stop the tool-based analysis. This is a semi-automated adaptive user interface which would decrease inaccuracies conducted by the tool and provide participants with greater control. Possible usage scenarios could be to make signs of emotions more visible, for example through enhanced facial expressions on an avatar or by depicting emotions using metaphors. This would give people the opportunity to transmit emotions more obvious during video conferences. For this purpose, we use our SitAdapt system, which is an integrated software system for enabling situation-aware real-time adaptations for web and mobile applications. It uses the different APIs of the devices such as eye-tracker, wristband, facial expression, and EEG signal recognition software, as well as metadata from the application to collect data about the user. The included rule editor allows the definition and modification of situation rules, e.g., for specifying the different user states and the resulting actions. The rule editor can use all input data types and attribute values as well as their temporal changes for formulating rule conditions. At the runtime of the application, the rules are triggered by the adaptation component for adapting the user interface, if the conditions of one or more rules apply.
In addition to presenting our approach with SitAdapt, we aim to give an overview of Emotion AI with its applications and examples of companies, products, and misuses since these are fast-growing technologies in a fast-growing market which raises important ethical questions.

Keywords
Emotion AI, Affective Computing, Emotion Recognition, Human-Centered AI, Business Context, Video Conferences, Virtual Collaboration, Adaptive Systems

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1. Emotion AI

As emotions play a powerful role in rational decision-making, in human perception, in human interaction, and in human intelligence, the research of emotions and detecting them is of great interest [1], [2]. Recognizing human emotions automatically through artificial intelligence (AI) or emotionally intelligent and human-like machines is a topic explored in various films and science-fiction movies as for example in *2001: A Space Odyssey*, *Matrix*, *Blade Runner, Surrogates, Ex Machina, Her* or *Lie to Me.* The series *Lie to Me* focuses on solving crimes by detecting lies through the identification of emotions using micro-expressions[2], the Facial Action Coding System (FACS)[3] and computer-aided analyses of facial expressions or voice. In the movie *Her* an intelligent operating system acts as a virtual assistant and builds relationships with its customers. Even though these are movies, some of the featured functionalities and behaviors have already become possible through modern Emotion AI technologies.

1.1. Definition and Development

Physiological signals that indicate emotions can be analyzed and categorized which makes it possible to train machines to interpret emotions and respond to them or simulate those signals. There are different terms for technologies that deal with such abilities. The term **Emotion AI** (EAI) often refers to technologies detecting and analyzing physical signals associated with emotions, such as physiological and behavioral activities like speech, voice, facial expressions, and other muscle activities signals [4]. Therefore, these technologies can recognize emotions from data sources such as text, audio, images, and videos [5]. The term **Emotional AI** refers to technologies that *sense, learn about and interact with human emotional life* [6].

In a broader sense, the differentiated field of research and development in which affects and emotions are used, explored, or even directly influenced in human-computer interaction (HCI) is called **Affective Computing** or **Emotional Computing**. Other terms such as **Intelligent Interaction**, **Affective Technologies**, **Mood Management**, but also **Cognitive Computing** are also common [7]. The broad field of Affective Computing can be distinguished into two major domains. One is *emotion recognition* which aims to automatically detect human emotions. The second area is *emotion simulation,* which deals with simulating human emotions and using them for the interaction with chatbots, avatars, or robots [8].

The term "Affective Computing" can be traced back to Rosalind W. Picard who published a paper in 1995 and a book in 2000 under the same name [2], [9]. Picard defines Affective Computing as *"computing that relates to, arises from, or deliberately influences emotions"*[2]. The concept of automatically recognizing human emotions, e.g., based on speech or facial expressions goes back even further. For example, the first patent for emotion recognition from speech dates back to 1978. In 1992 a paper about a neural network to recognize basic emotions from faces was published [10], [11], [12]. Since then, the underlying technologies have evolved. For example, sensor development advanced significantly in 2009 and 2010, making these years a turning point for Affective Computing by providing a suitable technical basis. The *Transactions on Affective Computing* of the IEEE have also been published since then, integrating the field as an independent area in larger specialist societies [7]. Another important breakthrough came with the emergence and growing use of deep learning and other novel approaches to machine learning and artificial intelligence. Affective computing can be seen as an early adopter of such novel techniques [13].

1.2. Differentiation of Emotional Intelligence and Emotion AI

Emotional Intelligence (EI) involves not only recognizing emotions in others but also recognizing and managing one's own emotions. EI according to Salovey and Mayer means *"a set of skills*

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[2] Unintended, spontaneous facial expressions that occur within a fraction of a second according to the PaulEkmanGroup
[3] A system published by Ekman and Friesen which divides the face into so-called Action Units to classify facial expressions [3]

hypothesized to contribute to the accurate appraisal and expression of emotion in oneself and in others, the effective regulation of emotion in self and others, and the use of feelings to motivate, plan, and achieve in one's life" [14]. The term EI already appeared in 1964 in a paper by Michael Beldoch [15], but got popular when Daniel Goleman published a book under the same name in 1995. He refers to the definition of Salovey and describes five areas of EI:

1. *Knowing one's emotions*
2. *Managing emotions*
3. *Motivating oneself*
4. *Recognizing emotions in others*
5. *Handling relationships* [16]

In these definitions, one's own emotions and managing them are important parts of the concept EI. When we look at Emotion AI, however, it is not about computers being able to feel emotions, but about the computer-based recognition and simulation of human emotions. According to Schuller and Schuller, the term **Artificial Emotional Intelligence (AEI)** however includes a third domain besides emotion recognition and emotion generation which is *emotion augmentation of AI (such as applying emotion in planning, reasoning, or more general goal achievement.)* Concepts of incorporating the principles of the amygdala, an important area in the brain for emotional processes [17], into AI would follow in the footsteps of artificial neural networks inspired by neural networks of mammals. Yet, there has been limited discussion of emotion augmentation in the literature so far [12].

The paper at hand refers to Emotion AI as a set of technologies that try to recognize or generate expressions for emotions.

There are more and more research activities in this field as well as products on the market that apply Emotion AI. According to a recent forecast, emotion detection and recognition is a rapidly growing market which will be worth more than 42 billion USD by 2027 [18]. It is important to note that those technologies do not measure feelings or experiences, but signals that are connected to the underlying emotions, as Picard stated [4].

1.3. Emotion AI Companies

Picard, who coined the term "Affective Computing", co-founded two companies in this field that originated from MIT's Media Lab in Cambridge, Massachusetts. One is called **Empatica**[4], founded in 2013, and creates wearable sensors, software, and algorithms to understand human behavior and improve health. The other firm is **Affectiva**[5] which was founded in 2009 by Rosalind Picard and Rana El Kaliouby. As part of her doctoral dissertation, El Kaliouby developed a framework for machine perception and mental state recognition by measuring and interpreting head and facial signals [19]. The research of El Kaliouby and Picard was the basis for the foundation of Affectiva. The business develops technology that measures emotions through facial expressions and claims to have pioneered and established the innovative technology field of Emotion AI. They offer affective AI for media analytics, the automotive sector, and biometric research.

Another company in this area is **Smart Eye**[6] which was founded in 1999 in Sweden. They now brand themselves as a *global leader in Human Insights AI*. Smart Eye acquired Affectiva in 2021 [20], [21]. A similarly named business, called **Real Eyes**[7], was founded in 2007 at Oxford University. They claim to be the *global leader in AI that understands human behavior* using webcams to measure attention and emotions. Another company which calls itself *the world's premier provider of human insights software* is **iMotions**[8]. Their software analyzes data such as facial expressions, skin

[4] https://www.empatica.com/en-eu/company/
[5] https://www.affectiva.com/
[6] https://smarteye.se/about-us/
[7] https://www.realeyesit.com/company/about-us/
[8] https://imotions.com/

responses, eye-tracking, heart- and brain- activity. For facial expression analysis, they use *AFFDEX* [22]. AFFDEX is the toolkit Affectiva [23]. Smart Eye, which acquired Affectiva in 2021, acquired iMotions in the same year. They partner with other firms as with the above-mentioned company Empatica [24].

Noldus[9] is another business which offers Emotion AI products for behavioral research. It was founded in 1989 and in 2007 they released the *FaceReader*[10], which they call *the most robust software for facial expression analysis* [25]. **Emotient** offered the Facial Expression Recognition (FER) product *Facet* which was distributed by iMotions, but was bought in the year 2017 by **Apple** and is no longer commercially available [26]. Other firms that offer FER software are e.g., **Morphcast**[11]**,** or **Visage Technologies**[12]. **Microsoft** offers the *Face API* on its Azure platform which is described to be able to detect emotions[13] and Amazon's Rekognition includes face analysis[14].

The companies referenced are not the only players, and as previously stated, the market in this field is expanding quickly resulting in more and more businesses selling Emotion AI products or services. Some of the organizations were once small start-ups but have now grown into million-dollar companies.

1.4. Areas of application

Emotion AI has various areas of research and application. In the following some of them are briefly described with a few examples.

Healthcare: One application for this technology is in the healthcare sector, where it can be used in several ways. An example is using videos of a person to detect their heart rate or respiration rate. Moreover, the technologies can assist in detecting psychological issues like anxiety, major depression, and autism [5]. For example, Picard's team is researching the prediction of depression symptoms by developing algorithms to detect patterns in data measured with the Empatica wristband and a phone app [4].

There is also the potential that Emotion AI offers benefits in the therapy and the treatment of mental health issues with virtual, empathic therapists that know the moods and behaviors of the persons [27]. One example of an Emotion AI which is designed to support mental health is the Voice AI, also called Voice Bot, of clare&me[15]. This is done by providing a safe space to share thoughts and fears, reflect on feelings, and offer guidance through appropriate mental exercises and techniques. It is possible to have a conversation with the AI on the phone or via chat using WhatsApp. The company advertises the service on its website by saying *„You can talk about your worries without judgment, at any time and anywhere".* A similar example is the app Wysa[16], an AI coach which responds to expressed emotions for mental health and wellbeing support.

The advantage that an AI is available immediately and 24/7 is, e.g., important in countries where there are not enough psychotherapists or therapy places available. In Germany, for example, almost half of the patients (40%) must wait three to nine months for a therapy place once the need for a treatment has been assessed. The average waiting time in 2019 was almost five months [28]. Another benefit of the constant availability of the AI tools could be that individuals who have no one to talk to in a particular situation, such as paramedics after a night shift in which they have witnessed a traumatic event, can at least talk to a Bot immediately to process their experience [29].

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[9] https://www.noldus.com/
[10] https://www.noldus.com/facereader
[11] https://www.morphcast.com/
[12] https://visagetechnologies.com/
[13] https://learn.microsoft.com/en-us/xamarin/xamarin-forms/data-cloud/azure-cognitive-services/emotion-recognition
[14] https://docs.aws.amazon.com/rekognition/latest/dg/faces.html
[15] https://www.clareandme.com/
[16] https://www.wysa.com/

Another application in the healthcare sector is to support people with autism. Autism is characterized by communication and social interaction difficulties, restricted interests, and repetitive behavior [30]. One of the diagnostic criteria is *"marked impairment in the use of nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction"*[31]. Picard, El Kaliouby, and Baron-Cohen published a paper in 2006 in which they argue that Emotion AI tools can assist people with autism to navigate through social interactions and to better understand the socio-emotional world. Two examples of wearable affective technologies they present in the paper are the so-called *expression glasses* and the *self-cam.* The latter is a video camera that can be worn and points at one's face. Facial expression recognition (FER) software identifies the wearers gestures and emotional states in real-time and communicates it visually or via audio. The results can be shared with others. This approach can be used to support people with autism in recognizing emotions and thus in social interactions [19]. The *expression glasses* measure and analyze meaningful facial expressions, which can be communicated to a computer, software agents, or other people. For example, it differentiates between expressions of interest or surprise and confusion or dissatisfaction, which can be reported anonymously [32]. The initial prototype was built years before the development of technologies like Google Glass, which was introduced in 2013 [33].

Human-Computer-Interaction and Social Interactions: The above-mentioned technology of the *expression glasses* is an early example of an application for social interaction and human-to-human communication. The approach could be used to report states such as interest or confusion of students to teachers to provide real-time and anonymous feedback automatically. Anonymity can be beneficial in situations where individuals might want to conceal negative expressions because they might, e.g., fear negative consequences. The authors see video lectures where students are in remote locations as an application for use. In this scenario, this technology could be used to share the collective emotional expressions of all participants as a "barometer" [32].

Emotion AI technologies can be used to improve social interactions in computer systems and human-machine interaction for example with cognitive agents that can interact more naturally with the users [34]. Examples for this are **social bots** or **chatbots**. Bots are software robots which can accomplish tasks automatically. Like the mentioned AI tools Clare and Wysa, bots can engage in human-like conversations. While Clare and Wysa are intended to support mental health, other bots are designed to entertain people, to be used in customer support or in social media. When used on social media, they are called social bots, and can automatically create content and interact with humans. They have populated social media platforms for several years. Often it is hard to tell whether profiles or content on social media were created by humans or by social bots. Some of the bots are helpful as they aggregate content or automatically respond to inquiries from real users which is, e.g., used by companies for customer support [35]. Negative examples and misuses of bots are described in Section 1.5. Misuse often occurs when it is not clear that a profile or content is generated by a bot rather than by a human.

Chatbots are not a new invention either, they were envisioned in the 1950s by Alan Turing [35], [36], who is also the name giver of the Turing-Test[17]. This test aims to determine whether individuals can distinguish between interacting with a human or an AI [38]. An early example is the program ELIZA, published in 1966 by Jospeh Weizenbaum at MIT, which was able to have certain kinds of natural conversation between human and computers [39]. ELIZA simulated therapeutic conversations with clients. The system analyzed the customer's conversation for relevant keywords to provide a conclusive response and followed the "client-centered therapy" developed by the psychologist Carl Rogers [40]. Bots are increasingly demonstrating emotional intelligence. Examples for emotionally intelligent bots (besides Clare and Wysa) are Kuki[18], formerly known as Mitsuku, or

[17] In the Turing Test, called the Imitation Game by Turing, an individual interacts with a person and a machine in a separate room. The individual can ask questions to both and then must determine which conversation partner is the machine and which is the real person [36], [37].
[18] https://www.kuki.ai/about

the App Replika[19]. Kuki is a virtual agent and available via an online portal, via messenger apps or on social media like Instagram, or X, formerly Twitter, and as an avatar in the metaverse. It was developed in 2005 and the programmer Steve Worswick won the Loebner Prize, that was awarded for progress in natural language processing (NLP) and passing a Turing-Test, four times in a row, 2016 until 2019. The utilization of such bots has increased since the coronavirus pandemic [29]. In 2022, OpenAI released ChatGPT[20], a chatbot based on a large language model (LLM), called GPT-3, that is capable of processing vast amount of data and generating language content. Within the initial week, more than one million users registered. For many, this was the first time they used Generative AI (GenAI), AI that creates content [41]. This release led to a new wave of chatbots and virtual assistants, like, e.g., Bard[21] from Google, Llama[22] from Meta, or Microsoft Copilot[23], which is based on the LLM GPT-4 from OpenAI.

Media Analytics: In Media Analytics, Emotion AI technologies can be used to measure emotional responses to advertising, videos, and movies as for example promoted by the companies Affectiva and Immersion Neuroscience[24]. For example, according to the CEO of the latter company, the advertising that produced the highest emotional response during a Super Bowl event, was one that people liked the least according to traditional measures, such as self-reporting. The result was obtained by measuring the brain activity of eight participants using wrist-worn sensors and the company's algorithms [42], [43].

Robotics: The mentioned cognitive agents also play an important role in the field of robotics. Robots can be programmed to recognize emotions in humans and express emotions themselves, making them emotionally sensitive which is a current trend in social robotics to improve the human-robot interaction [44]. An exemplary field of application is in elderly homes. “Pepper”, a humanoid robot that can interpret emotions through cameras and microphones, is in use in some care homes in Germany[25] to support residents and nurses. This Pepper-Robot can take over routine tasks, like turning the light on or reminding people to take the medicine, or to drink enough water, and is also able to interact emotionally with humans [45]. A similar example is “Hobbit”, a care robot which aims supporting independent living at home. To express emotions, facial expressions are shown on a display on its “head” [46]. Another product in this area is ElliQ[26], an emphatic table-top stationary robot launched in 2022 by Intuition Robotics, designed to address loneliness and social isolation. It can initiate conversations, read body language, use humor, and motivate to be active [47]. These approaches do not aim to replace human caregivers in elderly care, but rather to provide support in an area where there is a workforce shortage. Japan, for example, has an aging population at an unprecedented speed, simultaneously the population is decreasing and there is a strict immigration policy [48]. The question of care for the elderly is therefore particularly urgent in this “hyper-aging” country and elderly care is a serious problem. Therefore, Japan developed different robots for physically and psychologically elderly care as well as a concept called society 5.0 where robots play an important part in human life. Pepper was also developed in Japan and is used in 500 nursing homes there, along with other robots [49].

Automotive Sector: In the automotive sector, the technologies are, e.g., used to recognize distraction or fatigue of drivers to make bus, truck, and car rides safer. This is for example done with

[19] https://replika.ai/
[20] https://openai.com/chatgpt
[21] https://bard.google.com/?hl=en
[22] https://ai.meta.com/llama/
[23] https://adoption.microsoft.com/en-us/copilot/
[24] https://www.getimmersion.com/v4/homepage
[25] https://www.aerzteblatt.de/archiv/206944/Pflege-Pepper-bezaubert-in-Unterfranken
[26] https://www.intuitionrobotics.com/

the automotive solutions of the company Smart Eye.[27] They provide a driver monitoring system that measures eye, head, and body movements, facial expressions, as well as dangerous behaviors such as using a smartphone while driving, to draw conclusions about the driver's focus, attention, or distraction. The monitoring can also be extended to the whole car to measure, e.g., emotional states of all people inside a vehicle. The company claims this can improve road safety. A very similar approach to that is the Vision AI of the company Eyeris[28] which analyses bodies, faces, objects, and actions in a car.

In the European Union, 20,600 individuals lost their lives due to road accidents in 2022 [50]. Some of the accidents are caused by human error. Safety problems can be directly or indirectly related to emotions. Driving while being anxious or tired, or while having strong emotions such as anger can lead to reduced control or judgement, and therefore to traffic accidents [51].

Overall, Emotion AI has multiple applications in healthcare, such as therapy and mental health, as well as in human-computer-interaction, social interaction, and robotics, to name just a few. Ongoing research aims to expand its capabilities.

1.5. Surveillance, Manipulation, and Misuse of this Technology

Although Emotion AI brings important opportunities in some application areas, there are also examples of how this technology is being misused by certain countries, companies, or application fields. Some examples are described briefly in the following sections.

Manipulation by Social Bots: When social bots spread unverified or wrong information, whether unintentional or intentional, it can have harmful consequences. Some social bots are designed to cause harm by misleading, exploiting, and manipulating social media discourse through the spread of *rumors, spam, malware, misinformation, slander, or even just noise* [35]. Social bots have been active in public policy debates and political elections. For instance, these bots were utilized in Trump's election campaign in the year 2016. During the presidential debate, Trump supporters seemed to be more active on Twitter than supporters of the opposing candidate, but approximately at least one-third of the Twitter interactions from pro-Trump traffic was generated by bots and highly automated accounts whose content resembled that of real users [52]. As social bots become more emotionally intelligent and continue to evolve, distinguishing them from human users is becoming increasingly difficult which may result in damage to society and democracy [35]. It is important to clearly indicate when content is not created by a human to avoid confusion and potential misuse.

Surveillance in China in the education sector: There are examples of schools in China that use cameras and Emotion AI, e.g., FER-technologies, to analyze and detect behavioral and emotional states as well as attention and concentration levels of students. According to an article published by Article19 [53], an international human rights organization, the information is reported for each student and, e.g., available for the teachers and parents. The technologies can also monitor the teachers. There are many different companies and products which offer emotion recognition. One platform offers a teacher user interface which shows warnings of “problem students” that are connected to emotions like sadness or fear. Apparently, Lenovo has sold emotion recognition systems (analyzing speech, gesture, and facial expressions) originally designed for customer service, to Chinese schools. An emotion recognition AI of the company New Oriental was distributed to over 600 classrooms. However, there are not many testimonials available which and how these technologies are used or viewed. One exception is the implementation of emotion recognition in a

[27] https://smarteye.se/solutions/automotive/
[28] https://www.eyeris.ai/technology

school in Hangzhou, which was also a topic in the German news[29]. In 2018, the school presented the "*Smart Classroom Behaviour System"* which they produced together with Hikvision, the worldwide biggest producer of surveillance cameras. The system assigned values to students based on emotional and behavioral analysis and displayed them to teachers. Teachers also got notifications if students were inattentive. Some media reported that the technology was scaled back, others mentioned that it has been removed.
Continuous monitoring and analysis can create pressure and anxiety, as students may worry that their performance will be negatively impacted or that their data will be shared with other organizations [53]. If the data is inaccurate or incorrect, it can be discriminatory and distracting. Surveillance of children can have negative consequences for their development, for their ability to focus and concentrate as well as on their privacy expectations. This may have negative impacts on children's learning experience and capabilities as well as on a free society [54].

Surveillance in US Companies: Other examples of surveillance with this technology takes place in US companies. According to Zickuhr, workplace surveillance, including emotional tracking, will become the new norm in US workplaces [55], [56].

The results of an interview study (n=15) with US workers of Roemmich et al. indicate that participants perceived Emotion AI as a serious violation of privacy, and that the use of such technologies could harm employees. The paper includes examples of how Emotion AI is utilized in US companies, as reported by the participants of the interview study. One participant working in customer service described how the employer monitors emotions in video and call interactions to ensure that service employees maintain a positive attitude. In customer service, the results of the emotion analysis were also used to draw conclusions about the employees' satisfaction and engagement which is included in performance-reviews. A participant described that the data of a colleague indicated that the person was not satisfied with the work. As a result, the management began to doubt whether this employee is the right person for the job. Another participant working in the healthcare sector also reported that the employer uses emotion analytics based on video and audio recordings to monitor interactions of the staff with patients. One more example is a teacher, who reported that her voice and facial expressions were analyzed during remote sessions to measure performance. Some participants have mentioned faking or suppressing their emotions to comply with employers' expectations or to control the analysis results. In some cases, employees' emotions were continuously monitored without transparency regarding the generated information or its usage. One participant reported that the employer requested consent for camera tracking. However, the participant stated that there was little choice if individuals wished to maintain their employment. He reported that a colleague who did not give his consent had to leave the organization [55].

Such examples of surveillance show how Emotion AI technologies can be misused and harm people in the workplace.

Job Applications and Personality Assessments: Some companies claim to be able to recognize not only emotions but also behaviors and personalities with their software products. There are examples of how AI is used in video job interviews to analyze the voice, speech, gesture, and facial expressions of candidates to pre-screen the candidates and to predict personality characteristics. Such tools are often promoted as being less biased than humans, but these tools may still display biases, or may have even more biases. The BR, Bavarian Broadcasting, did some experiments with such a software from Retorio[30], a start-up from Munich, Germany, which resulted from a research group at Technical University of Munich (TUM). The BR recorded videos of the same persons, but, e.g., changed the background, the video quality, or added accessories like glasses or head covering. The analysis results of the software tool differed between the videos with the implemented changes

[29] https://www.deutschlandfunk.de/alles-unter-kontrolle-chinas-intelligenter-schule-entgeht-102.html
[30] https://www.retorio.com/de/ki-video-recruiting?hsCtaTracking=dda552e5-ce3f-4347-b413-d56637ff4206%7C586c6eac-5ccd-428d-a66c-8644c51b8b50

and those without any adjustments. This demonstrates the weaknesses and false promises of such technologies. In this use case, it is very critical as the results of the tool could unfairly impact candidates' job prospects. Nevertheless, the company received several million euros from investors and partners with huge German companies [57], [58]. Despite analyzing behavior from interview videos, the company offered, e.g., Culture Assessment, Personality Analytics, and now seem to be focusing on AI coaching which is based on the video analysis. This might sound promising, but the science behind and ethical considerations are debatable.

A very similar product from HireVue, an US-based company that produces video analysis software, has faced criticism for their use of EAI in job interviews as well. The analysis and results were deemed non-transparent and biased. The product has been withdrawn from the market by the company in 2021[31]. For the emotion recognition they partnered with the above-mentioned company Affectiva [59].

In the US, similar products are being used for several years during the application process which is increasingly being criticized. Roemmich et al. looked at commercially available EAI hiring services (n=229) and conducted a content analysis of the websites. They point out unfair, deceptive mechanisms and pseudoscientific approaches of such services. Some products and companies seemed difficult to be spotted, as some companies do not clearly indicate the technologies and approaches, they use. An example they referred to is the Website of Retorio where the software is described as “behavioral analytics” that can “measure personality” and “revealing” information that is “hidden” instead of explicitly mentioning Emotion AI or similar terms for it (see Section 1.1). Other companies also used very vague and ambiguous language without describing the underlying technology or its use of Emotion AI [60].

Another example for facial personality analytics is Faception[32], a company that claims to be able to classify people into categories like e.g., “High IQ”, “Professional Poker Player”, or “Terrorist” by analyzing videos, recorded or in real-time.

There are more examples of such technologies being misused or not implemented in a human-centered and value-based way. Students, employees, and job applicants should not be subjected to hidden or involuntary measurement of physical signals to draw conclusions about emotions, behavior, or personality characteristics. Such an analysis should not be done without the consent of individuals, and the data must not be used to assess people. Transparency of how and why the analysis is done is important. As previously stated, there are both benefits and risks to the utilization of Emotion AI. Within the same area of application, there can be both positive and negative outcomes, as we show with the example of video conferences.

2. Emotion AI in Video Conferences with FER

In the following, we look at Emotion AI during video conferences which might have critical, but also useful applications.

2.1. Zoom and Emotion AI

In 2022 Zoom[33] planned to include emotion tracking in their video conferencing product. As a reaction to this announcement, human right organizations wrote an open letter to Eric Yuan, CEO of Zoom, and created a campaign page[34] where individuals can sign a petition with the request to Zoom not to implement Emotion AI [61], [62]. In the past, Zoom also had a feature to track the attention level of video call participants, which they removed due to security and privacy reasons

[31] https://www.shrm.org/topics-tools/news/talent-acquisition/hirevue-discontinues-facial-analysis-screening
[32] https://www.faception.com/
[33] https://explore.zoom.us/de/products/meetings/
[34] https://www.fightforthefuture.org/actions/dear-zoom

[63], [64]. On the Zoom Marketplace[35], the official store of Zoom, there are still apps, like e.g., Morphcast[36] or EmotionIQ[37], which promote real-time analysis of participants' emotions, attention, and engagement during a Zoom call [65].

Computer-based analysis of physical signals should not be done automatically and without the consent of all meeting participants. Despite the legitimate objections, however, it may be beneficial to increase the visibility of emotions in virtual meetings because nonverbal communication is often lost in virtual spaces, making communication more difficult.

2.2. Changing Communication in Video Conferences

Due to the Covid-19 pandemic and the push for digitalization including working from home that accompanied it, many meetings are held virtually and according to an analysis of McKinsey, this trend is likely to continue [66]. This has many advantages for companies and employees, for example reducing costs and saving time. When it comes to human communication, however, there is a big difference between virtual and in-person events, especially when it comes to showing and recognizing emotions. In online meetings, only a few human characteristics, such as facial expressions and voice, can be conveyed. Even these few signals cannot always be conveyed clearly due to circumstances such as small tile images or poor quality [67]. Therefore, in virtual environments, the communication of nonverbal signals is severely limited, and displaying or recognizing these nonverbal messages can be difficult or impossible for both the sender and the receiver of the messages [68]. For instance, a strained or annoyed look at an error message on the computer during a video call can be misinterpreted as skepticism or rejection and could send unintentional messages. During virtual business meetings, communication difficulties can lead to planning and coordination problems, ambiguities in the allocation of roles and tasks, reduced decision-making quality, and challenges in building trust within a team [67].

Tools for online communication and collaboration support virtual and hybrid constellations. However, studies have shown that video conferences are more mentally exhausting than meetings using other means of communication [69]. This phenomenon is also known as *Zoom Fatigue*, which generally refers to fatigue caused by video conferences [70]. One contributing factor to this problem is that individuals often find it more challenging to decode and transmit emotions in virtual environments compared to in-person meetings. As video conferences continue to be widespread, Zoom Fatigue is also likely to remain a problem [71].

One behavior that can be observed during longer conferences is that participants often turn off their video cameras. Although this may help combat fatigue, it also eliminates the ability to convey emotions through facial expressions. The quality of communication could be improved by developing procedures to facilitate the recognition and transmission of emotions and making them available to employees during meetings. Such procedures and techniques might also have a positive impact on the well-being of individual team members.

2.3. Potential Human-Centered Applications to Visualize Emotions

We aim to bridge the gap of emotional expression between on-site meetings and video conferences to support nonverbal communication. To achieve this goal, we conducted several experiments with FER to test the accuracy, usefulness, and potential applications [72], [73]. The interpreted emotions of the automated FER tool were not always in alignment with the evaluation of human observers or participants. Even though these were small-scale user studies, FER alone might not be sufficient, and the verification of participants might be needed, also to put the participants in control of the analysis results. That is why we suggest a semi-automated approach in this context (see Section 3.4) and an appealing representation of emotions in order to identify them quickly and easily.

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[35] https://marketplace.zoom.us/
[36] https://www.morphcast.com/app/morphcast-for-zoom/
[37] https://marketplace.zoom.us/apps/J7PTWPkPQo6da_q9gLMu6g

We see potential useful applications to make emotions more visible in virtual meetings which are briefly described in the following.

Visualizing emotions as comic faces or avatars: To make the expressions more visible and to convey emotional information, the facial expressions could be transferred to an avatar or cartoon face [74], [75], [76] with deliberately exaggerated facial expressions, like e.g., in Japanese manga comics or anime. In cartoon faces, emotions are particularly recognizable as they have many ways to transport emotions like exaggerated facial expressions, hand, and arm positions, or elements around the body or face [77]. This could be done on an individual level with one cartoon face per person or on a group level, where one animated cartoon represents the group emotions. In an avatar or comic face representation, it would be sufficient to measure facial expressions of participants and transmit them to this representation. Therefore, no automated emotion recognition which can be error-prone would be needed.

Using colors or metaphors: Other possibilities to visualize emotions in virtual space especially aggregated for all participants, could be using colors, emojis, objects, or metaphors. For example, the system could show an animated landscape view which is changing depending on emotional states. In this metaphor, a sun could represent the emotion "happy", and the more participants feel that emotion, the brighter the sun is shining. Another metaphor could be a virtual tree, whose growth would be influenced by the perceived emotions of participants [78]. Using metaphors, it is important to avoid portraying specific emotions as negative, as all emotions are important and should be valued and appreciated. A simpler approach would be highlighting emojis or changing the background color depending on expressed emotions [79] with an explanation of which colors represent which emotions. Yellow could e.g., represent the emotion "happy", or purple could appear when participants show signs of "sadness".

Sending reactions: Another option would be to send emotional reactions, such as emojis, by the system based on measured expressions.

Such emotion visualizations might be useful in scenarios where individual videos are difficult to recognize due to small tiles, low quality, many people, strong filters or appearance effects on faces or in situations where people are unable or unwilling to share their own video. Moreover, to reduce Zoom-fatigue symptoms it might be beneficial to decrease the hours in which the camera is turned on.

To include other data than facial expressions and to verify the analysis results by the attendees, we designed a new user interface element which we could implement by integrating our SitAdapt System into our solution design. This will be briefly described in the following section

3. SitAdapt System and Integration

The situation analytics platform SitAdapt [80] is based on the current version of the PaMGIS framework [81] and offers a situation analysis and rule model for development as well as runtime support for multiple-adaptive user interfaces. The platform enables to react in real-time to changes in context, in the user's environment, the user's behavior, and emotional states.

3.1. Different categories of adaptation

Three different categories of user interface adaptations are distinguished and can be implemented with SitAdapt [82], [83]:

- **Adaptable user interfaces**: The user customizes the user interface to his or her personal preferences.

- **Semi-automated adaptive user interfaces**: The user interface provides recommendations for adaptations. The user must decide whether he or she wants to accept the recommendation or not.
- **Automated adaptive user interfaces:** The user interface automatically reacts to changes in the context-of-use.

3.2. Different times of adaptations

Depending on the adaptation types and the available data about the user in a situation, the SitAdapt system can modify the user interface at different times:

- Before the first display of the user interface
- While the user interacts with the interface
- When the user later revisits the interface

3.3. SitAdapt Components

For supporting the different types of adaptations of the user interface, SitAdapt uses the following components, as shown in the following Figure:

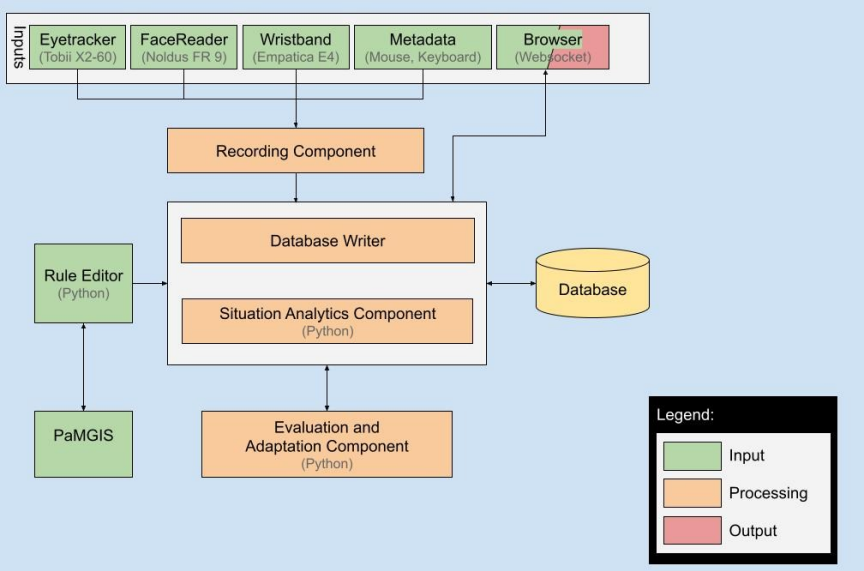

Figure 1: The SitAdapt components architecture

The *data interfaces* use the different APIs of the devices (eye-tracker, wristband, facial expression recognition software, and metadata from the application) to collect data about the current situation and user. SitAdapt uses two different data types for generation and adaptation of the user interface received from the different input devices (Figure 1): atomic data types with constant attribute values (e.g., *glasses* = true) and temporal data types (e.g., *facial expressions = happy*). Temporal data management makes it possible to document and analyze changes in the recorded data by time-stamping these data. This allows to reconstruct, which value was valid at what time, e.g., *blood pressure* or *eye positions*. With the aid of the SitAdapt rule editor (Figure 1), these constant and temporal data can be used to create rules, that influence the adaptation of the user interface.

The *recording component* synchronizes the different input records with a timestamp and the *database writer* stores the data from the recording component and from the application in the database, where sequences of fine-grained raw situations and coarse-grained situation profiles that are extracted from the raw situation sequences are managed. It also controls the communication with the rule editor.

The *rule editor* allows the definition and modification of situation rules, e.g., for specifying the different user states and the resulting actions. The rule can use all input data types and attribute values as well as their temporal changes for formulating rule conditions. At runtime rules are triggered by the situation analytics component for adapting the user interface if the conditions of one or more rules apply.

The *situation analytics component* analyzes situations by evaluating the data in the stored situation profiles. Situation rules are triggered by the situation analytics component when the rule conditions are satisfied.

The *evaluation component* uses the data that are provided by the situation analytics component to decide whether an adaptation of the user interface is currently meaningful and necessary. The *adaptation component* generates the necessary modifications of the currently running interactive application.

3.4. SitAdapt Semi-Adaptive Approach

In the following section, we describe an example using SitAdapt in video conferences to facilitate a semi-automated adaptive approach (see Section 3.1) for emotion transmission.

In this example, the SitAdapt system analyzes the participants' facial expressions during a video conference in the background using the software Facereader from Noldus as Input. The Facereader is trained to classify the six basic or universal emotions described by Ekman [84]. These are happy, sad, angry, surprised, scared, and disgusted. The recognized emotions during a video conference get a timestamp and the SitAdapt Database Writer stores this combined information in the database. Application developers can create individual rules with the Rule Editor for adaptations based on the various inputs and determine how they are executed. In this example, the goal is to express emotions more prominently to other participants during a video conference. Therefore, the user interface part to visualize emotions (e.g., a comic face or animated landscape, see Section 2.3) would adapt, depending on the emotional states. To trigger this adaptation, the following simplified example rule for *Happy* was created:

```
if ((emotion == Happy) and (duration >= 2) and (accuracy >= 0.8) :
        show_approval_popup()
```

According to this example rule, the pop-up (Figure 2) should be displayed after the emotion Happy is recognized with a duration of more than two seconds and an accuracy rate over 80 percent. The situation analytics component checks the rule against the values from the database and passes this information to the situation and evaluation component. This component triggers the adaptation when the conditions apply. The pop-up would appear for the user who can then decide to share this emotion or not. The user therefore would have the control over whether he approves the analysis result or not and whether the interface (e.g., the cartoon face) should be adapted accordingly or not (semi-adaptive).

Figure 2: Pop-up for approving and sharing emotions based on the system analysis

If the analysis or pop-ups are considered as distracting in certain situations, it can be stopped by the participant (see Figure 2). With the SitAdapt system, also additional data other than the facial expressions could be included to improve the system-based analysis results, if desired and activated by participants. The questions whether this semi-automatically approach to measure and visualize emotions would be helpful or too distracting would need to be evaluated in further research.

It is important to mention that facial expression analysis should be voluntary and there should always be the possibility to turn the analysis off. Moreover, it is important to consider data protection rules and ethical considerations, as well as incorporating value-based design.

4. Discussion and Conclusion

We discuss our research approach and the development, usage, and accuracy issues of Emotion AI briefly in the following.

4.1. Presented Research Approach in Video Conferences

We faced challenges regarding the subjectivity of the results and the complexity of emotions in our previous research, where we compared the recognized emotions of a FER tool, with the assessments of human observers and the statements of the participants in video calls. Our presented semi-adaptive approach would put people in control of the analysis results with the possibility to approve or reject the emotion estimation of the system. A disadvantage of such a semi-automated approach might be that people need to react which could also be distracting. Moreover, further research would be necessary to test whether the transmission of emotions with objects, such as cartoon faces or avatars, or metaphors would improve emotion recognition issues in virtual set-ups.

As stated, it is important that the use of such an assistance should be an individual decision. Problematically, there is a concern regarding true voluntariness in the professional environment, as mentioned briefly in Section 1.5 with the example of surveillance in US companies.

To conclude, facial expressions are difficult to capture in online meetings, but for an effective communication, the transmission of emotions is essential since they have a powerful role in interaction and decision-making. There are issues with the correctness, but evolving technologies may lead to more accurate tools in the future.

4.2. Development and Utilization of Emotion AI

Emotions are crucial to human intelligence and rational functioning, as research in psychology and neuroscience has shown [1]. Therefore, the development of emotionally intelligent machines could improve how we interact with machines, but also how we interact with each other in computer-mediated communication. As presented in Section 1, Emotion AI is a huge market with many different application areas. There are examples of the benefits of these technologies and areas where they are useful (Section 1.4). However, it is important to consider potential negative effects. As with each invention and new technology, there is a risk of misuse and abuse. The problem is not the technology itself, but what people do with it. How technology is used and how products and artificial intelligence are designed, are decisions made by humans. When developing or using Emotion AI, it is important to assure to not harm people and focus on value-based as well as human-centered solutions. To ensure this, the clarification of ethical, legal, and social issues (ELSI) is important. Many of Emotion AI products are developed, tested, or used in the USA or China. The question of how to ensure European values in this development is crucial. To decrease misuse (e.g., with mentioned intelligent chatbots) and to ensure privacy, data protection, and democracy, regulations are needed.

The recently published European Artificial Intelligence Act (AI Act) aims to balance innovation and risk protection and is *designed to ensure that AI developed and used in the EU is trustworthy, with safeguards to protect people's fundamental rights* [85]. Most provisions of the AI Act will apply from

August 2026. AI systems intended to identify emotions are considered as high-risk AI systems in this Act and should be prohibited *to be used to detect the emotional state of individuals in situations related to the workplace and education* [86].

The mentioned examples of surveillance with Emotion AI technologies in the workplace in the USA or in schools in China would not be possible like that in Germany due to legal requirements, such as data protection laws. However, this could change and has been different in the past. In the former German Democratic Republic (DDR), the Stasi spied on individuals, leading to self-censorship. Currently, Germany opposes government surveillance more than other Western countries. Surveillance poses a significant threat to the fundamental rights of a functioning democracy [54].

The more intelligent and human-like bots and virtual agents get, the more manipulative they can become. Since the use of such technologies in business and private life will have major impacts on humans and since the technology is already there with various products on the market, it is essential to have diverse perspectives in the development, in the evaluation and in ethical discussions of such technologies. Therefore, people need to know and to care about these developments.

As the examples have shown, Emotion AI technologies are already in use in the USA, and this is becoming more and more common in Europe as well. Despite the increased usage, there are still technological and scientific challenges.

4.3. Issues with Accuracy and Scientific Foundation

There are legitimate criticisms of these technologies and their use. Technical and scientific difficulties are for example the complexity of emotions. The universality of the so-called basic emotions and their expressions, the basis for FER, has been questioned and criticized [87], [88].
This is also addressed in the above-mentioned European AI Act [86]:

> *"There are serious concerns about the scientific basis of AI systems aiming to identify or infer emotions, particularly as expression of emotions vary considerably across cultures and situations, and even within a single individual. Among the key shortcomings of such systems are the limited reliability, the lack of specificity and the limited generalisability. Therefore, AI systems identifying or inferring emotions or intentions of natural persons on the basis of their biometric data may lead to discriminatory outcomes and can be intrusive to the rights and freedoms of the concerned persons."*

As Picard pointed out, the technologies do not measure emotions, but physiological signals that are connected to the underlying emotions. In the end, the analysis results of the FER tools are just an estimation which emotion it could be. However, some commercially available tools present the results to be absolute truth rather than estimations. This is a problem of transparency and could lead to a phenomenon described by Paul Watzlawick in which people trust machines to be right. Instead of questioning the computer feedback, people may tend to think about possible explanations for the computer-based results which can lead to false conclusions [89].

An example for issues and challenges with the accuracy is the described example of the interview and personality assessments. Retorio e.g., claimed on its website that their AI assessments achieve an accuracy of 90 percent, compared to assessments of human groups. The experiments conducted by BR raise doubts about this. The company also claimed on their website that their software can gain insights that no human coach can give. Nonetheless, the complexity of emotions, behavior, communication, and personalities makes an objective comparison very difficult. What does it say about the software and the methodology if the same person with a different background, video quality, or accessories is rated differently by the algorithms? How trustworthy and useful is such an approach then? Should such products be available on the market and receive financial support? It is very questionable that there are products on the market that analyze videos as part of the job application process although the algorithms and science behind are controversial and not completely transparent. The AI Act could prevent this type of use cases in the EU. The question of which assessment (AI or humans) is more correct or less biased and which tasks an AI should or should not take, remains a topic of debate.

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