RTI INTERNATIONAL

LAB 58

Facial Emotion Recognition

Lab 58 Market Research Brief

The Facial Emotion Recognition (FER) market is expected to grow rapidly in the next few years, with the greatest anticipated growth rate of the technologies included in the $21.6B emotion recognition market.[1] Many companies have seen opportunities to get involved in FER, but a few key players still dominate the market. We see companies combining technologies, often bundling multiple services together in their pricing models, in the affective computing area (e.g., facial emotion, recognition, and emojis in ad space) along with voice and natural language processing for emotions. Pure plays for FER are limited in the marketplace.

The Difference Between Emotion Recognition and Facial Recognition

In the current environment, many companies have divested or restricted the use of their facial recognition software (e.g. IBM[2], Microsoft and Amazon[3]). To clarify, FER and facial recognition are separate technologies and their use has different implications on ethics and privacy; however, willingness to invest in and use FER may reduce in lockstep with facial recognition, as they are often bundled together in service packages.

Facial Emotion Recognition Market

FER is a subset of emotion detection (which includes facial expression recognition, biosensing software tools and apps, speech and voice recognition, and gesture and posture recognition). The market numbers below help to put n context.

Market Size*

$21.6B
2019

*Market size presented is for the "emotion detection and recognition" market and includes facial expression recognition, biosensing software tools and apps, speech and voice recognition, and gesture and posture analysis.[1]

*Multiple reports show different market sizes: $21.6B (2019)[1], $5.8B (2017)[4], and $17.19B (2020).[5]

Compound Annual Growth Rate (CAGR)*

21.9%
2019–2024

*CAGR is for the "Emotion detection and recognition" market and includes facial expression recognition, biosensing software tools and apps, speech and voice recognition, and gesture and posture analysis. Facial expression recognition (the topic of this market research brief) is expected to have the largest growth rate out of the technologies listed above.[1]

*Multiple reports show different growth rates: 21.0% (2019–2024)[1], 28.9% (2017–2023)[6], and 18.0% (2020–2025).[7]

Capital Invested for 13 Leading Startup Companies*

$360.5M
2010–2019

* Capital invested is a proxy to understand how much the startup community is investing in this emerging technology. As for most market indicators, it cannot be comprehensive and is best understood by comparing its magnitude in relation to other indicators.

*Capital invested was derived by searching for "facial emotion recognition" companies in PitchBook and adjusting the companies based on our own market knowledge. The timeframe for investment was January 1, 2010–December 31, 2019.

KEY TAKEAWAYS

The FER market is expected to grow at approximately 22.63% CAGR between 2019 and 2024.

Although there are many companies studying and implementing FER technology around the world, the market is fairly consolidated, dominated by just a few major players.

Use cases for FER include: surveys and focus groups, observational studies, and advertising evaluation. It is important to note that current FER technology is most ethically used to gather group response data rather than to assess individuals.

1. "Emotion Detection and Recognition Market." Market Research Firm, www.marketsandmarkets.com/Market-Reports/emotion-detection-recognition-market-23376176.html.
2. Laurenshirsch. "IBM Gets out of Facial Recognition Business, Calls on Congress to Advance Policies Tackling Racial Injustice." CNBC, CNBC, 9 June 2020, www.cnbc.com/2020/06/08/ibm-gets-out-of-facial-recognition-business-calls-on-congress-to-advance-policies-tackling-racial-injustice.html.
3. "We Are Implementing a One-Year Moratorium on Police Use of Rekognition." US Day One Blog, Amazon, 10 June 2020, https://blog.aboutamazon.com/policy/we-are-implementing-a-one-year-moratorium-on-police-use-of-rekognition.
4. Jadhav, Akshay. "Emotion Detection and Recognition Market." Allied Market Research, 2017, www.alliedmarketresearch.com/emotion-detection-and-recognition-market.
5. "Emotion Detection and Recognition Market: Growth, Trends, and Forecast (2020–2025)." Market Research - Consulting, Reports, Advisory, Sizing, 2020, www.mordorintelligence.com/industry-reports/emotion-detection-and-recognition-edr-market.
6. Jadhav, Akshay. "Emotion Detection and Recognition Market." Allied Market Research, 2017, www.alliedmarketresearch.com/emotion-detection-and-recognition-market.
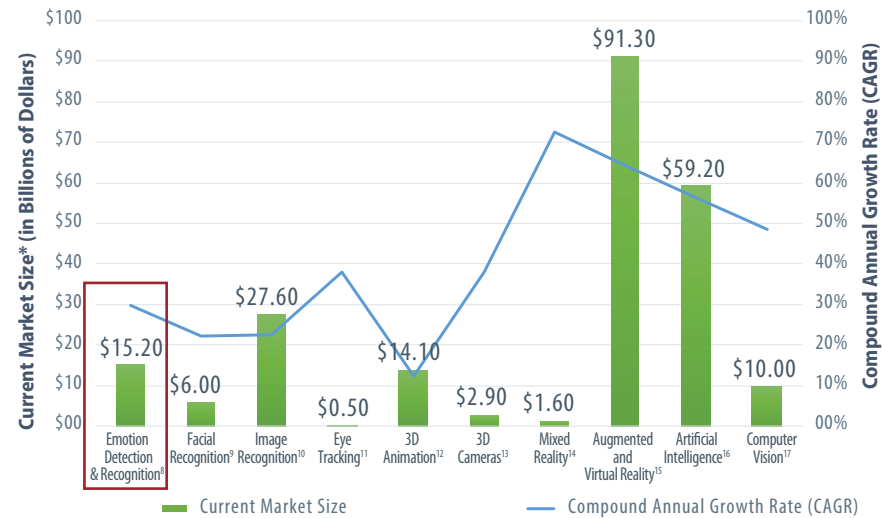7. "Emotion Detection and Recognition Market: Growth, Trends, and Forecast (2020–2025)." Market Research - Consulting, Reports, Advisory, Sizing, 2020, www.mordorintelligence.com/industry-reports/emotion-detection-and-recognition-edr-market.

Emerging Technology Comparisons

Because market indicators about emerging technologies can include a lot of variation, it can be useful to assess technologies in relationship to each other. The graphs below highlight how multiple, current technologies compare to others along a range of measurements.
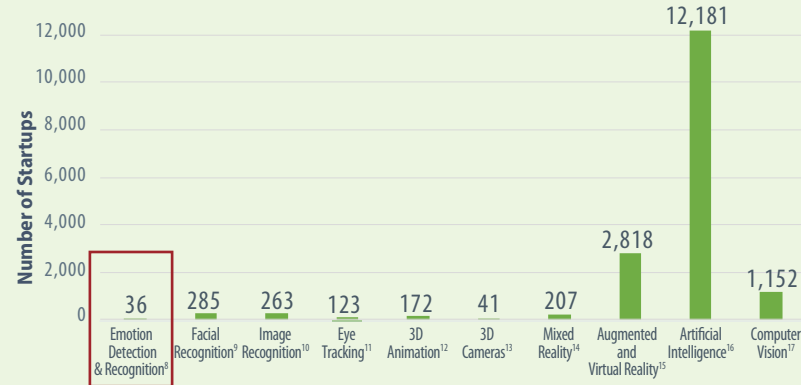
Market Size and Growth Rate

This graph shows the market size and CAGR of the emotion detection and recognition market in comparison to other emerging technology markets. Market size numbers have been normalized to the 2019 market size for comparison. Market sizes are generally based on forward-looking and incomplete data and methodologies. Therefore, market sizes are best viewed as indicators of the magnitude of the market rather than a precise calculation. There are different market definitions, so bundles of technologies will yield different market sizes and growth rates depending on what is included in their unique market definition.

Current Market Size (in Billions of Dollars) / Compound Annual Growth Rate (CAGR)

- Emotion Detection & Recognition[8]: $15.20
- Facial Recognition[9]: $6.00
- Image Recognition[10]: $27.60
- Eye Tracking[11]: $0.50
- 3D Animation[12]: $14.10
- 3D Cameras[13]: $2.90
- Mixed Reality[14]: $1.60
- Augmented and Virtual Reality[15]: $91.30
- Artificial Intelligence[16]: $59.20
- Computer Vision[17]: $10.00

Legend: ■ Current Market Size — Compound Annual Growth Rate (CAGR)
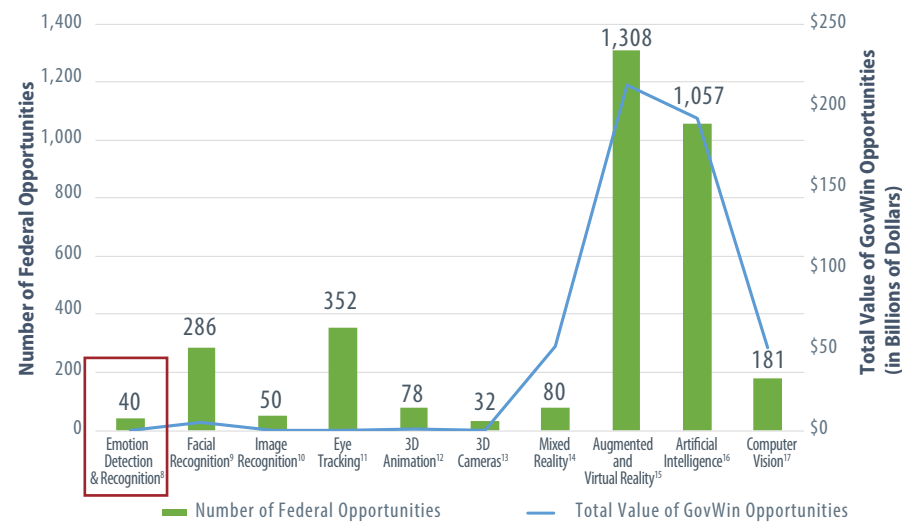
Number of Startups

This graph shows the number of startups identified by searching for each emerging technology by keyword in PitchBook. The result provides a signal of how many companies are tagging themselves with each technology and is indicative of the extent that early-stage growth companies are finding value in incorporating emerging technologies into their market position. As one would expect, artificial intelligence (a much broader category of emerging technology) has far more startups than emotion detection and recognition.

Number of Startups:
- Emotion Detection & Recognition[8]: 36
- Facial Recognition[9]: 285
- Image Recognition[10]: 263
- Eye Tracking[11]: 123
- 3D Animation[12]: 172
- 3D Cameras[13]: 41
- Mixed Reality[14]: 207
- Augmented and Virtual Reality[15]: 2,818
- Artificial Intelligence[16]: 12,181
- Computer Vision[17]: 1,152

Number of Federal Opportunities

This graph shows the number of federal opportunities and the corresponding value of the total opportunities as identified by searching for each emerging technology by keyword in GovWin. Though this search does not accurately capture the exact number of opportunities per technology, it does signal a magnitude of references to a particular technology in the main text of government solicitations. This can be used as a blunt measure to evaluate the rates at which different emerging technologies are being identified in public markets.

Number of Federal Opportunities:
- Emotion Detection & Recognition[8]: 40
- Facial Recognition[9]: 286
- Image Recognition[10]: 50
- Eye Tracking[11]: 352
- 3D Animation[12]: 78
- 3D Cameras[13]: 32
- Mixed Reality[14]: 80
- Augmented and Virtual Reality[15]: 1,308
- Artificial Intelligence[16]: 1,057
- Computer Vision[17]: 181

Legend: ■ Number of Federal Opportunities — Total Value of GovWin Opportunities

8. https://www.alliedmarketresearch.com/emotion-detection-and-recognition-market
9. https://www.alliedmarketresearch.com/facial-recognition-market
10. https://www.alliedmarketresearch.com/image-recognition-market
11. https://www.alliedmarketresearch.com/eye-tracking-market
12. https://www.alliedmarketresearch.com/3d-animation-market-A05975
13. https://www.alliedmarketresearch.com/world-3D-Camera-market
14. https://www.alliedmarketresearch.com/mixed-reality-market
15. https://www.alliedmarketresearch.com/augmented-and-virtual-reality-market
16. https://www.alliedmarketresearch.com/artificial-intelligence-market

Factors Affecting the FER Market

The global market for FER is continuing to grow steadily because of technical and consumer opportunities, but it is also threatened by a few important technical and financial factors.

Opportunities

Many factors will contribute to the significant growth of FER in the near future, including the following:

- **Substantial growth of Internet of Things (IoT) and increased smartphone usage.**[18] Many companies see the ability to integrate FER technology into increasingly available smartphones and IoT sensors. As FER is dependent on increased penetration of enabling hardware into everyday life, incorporating FER technology into more devices and commercial offerings is expected. Major technology companies like Apple have seen great potential in FER for understanding human emotions and optimizing smartphone use.[19]

- **Increased access to data and low-cost computing power.**[20] Access to large and affordable datasets is crucial for training and using FER technology, specifically with neural networks, so this increased data access will allow more companies and organizations to work with FER.

- **Increasing demand for better customer experience and satisfaction.**[20] The customer experience improves for many companies as computers are able to understand human emotion and adjust to increase overall happiness and satisfaction. FER is a crucial part of sentiment analysis that will allow for a better customer experience overall.

- **High demand for large consumer behavior studies.**[20] FER is ideal for large consumer behavior studies because it can quickly generate group response data without the ethical threat behind individual emotion misinterpretation that can be found in other applications, such as job interviews.

- **Demand for increased, automated surveillance.** The increased ability and comfort of remotely monitoring physical spaces and people (e.g., the distance of others during a pandemic) is a driver for increased incorporation of FER and other emotion detection technologies into commercial offerings in the market.

- **Automated automobiles.**[21] The automobile industry has been investing capital into the FER market in hopes of identifying driver safety issues, such as drowsiness. Affectiva's (a technology leader in the FER market) 2019 funding round of $26m

- was led by automotive supplier Aptiv.

Threats

Although the FER market is predicted to continue its rapid growth, there are some concerns regarding threats to the market, including:

- **Misinterpretation in emotion analysis.**[22] Emotion analysis (FER included) is an emerging technology and predicted emotions may be incorrect due to technical considerations or misinterpreted due to the context of the input facial data. There can be large ethical consequences of misinterpreting the emotions of individuals. For this reason, the technology is best used for aggregate, group response data rather than for interpretation of specific individuals at this time.

- **Perception of emotion recognition as same technology as facial recognition.** Because many players bundle emotion recognition services with facial recognition services, it is possible that market demand will slow for emotion recognition as many agencies and clients distance themselves from the ethical implications of facial recognition.

17. https://www.marketsandmarkets.com/Market-Reports/ai-in-computer-vision-market-141658064.html
18. Jadhav, Akshay. "Emotion Detection and Recognition Market." Allied Market Research, 2017, www.alliedmarketresearch.com/emotion-detection-and-recognition-market.
19. https://www.computerworld.com/article/3235424/apples-iphone-x-proves-it-silicon-valley-is-getting-emotional.html
20. "Emotion Detection and Recognition Market: Growth, Trends, and Forecast (2020–2025)." Market Research—Consulting, Reports, Advisory, Sizing, 2020, www.mordorintelligence.com/industry-reports/emotion-detection-and-recognition-edr-market.
21. https://www.mordorintelligence.com/industry-reports/emotion-detection-and-recognition-edr-market
22. Jadhav, Akshay. "Emotion Detection and Recognition Market." Allied Market Research, 2017, www.alliedmarketresearch.com/emotion-detection-and-recognition-market.

Companies

Although there are many companies studying and implementing FER technology, the market is fairly consolidated, dominated by just a few major players.

Prominent players in the industry come from all around the world, but the majority are here in the United States. Affectiva, HireVue, Microsoft, nViso, and Realeyes are the key players that are outlined below. The following section provides a snapshot of how FER is being used in the market. This grouping represents examples of two different ways companies are approaching the market.

Following are companies that package FER as a component into a focused product or solution to a specific customer base:

HireVue

Market: **Human Resources**
Use Case: **Pre-employment testing and video interviewing platform**

How FER is used: **HireVue bundles FER technology (along with word choice and speaking voice) into an overall, automatically generated "employability" score given to each job candidate during online interviews and assessments. This process pre-screens hundreds of applicants before HireVue forwards a select subset to hiring managers at companies.**[23]

HireVue provides an online hiring solution to companies and has "over 700 customers globally, including 1/3 of Fortune 100 companies" and over "1 million job seekers have been analyzed."[23][24] HireVue's value proposition is that it reduces recruiting costs (for example, Unilever credits HireVue for reducing $1m in recruiting costs per year).[23] HireVue and similar companies have faced questions around whether their algorithms automatically screen out people with disabilities or minorities, or provide recommendations that are biased in some way.[25] The use of this technology has caused some advocacy groups to file charges and ask for regulations of the use of artificial intelligence in hiring practices.[24,26]

nViso

Markets: **Insights ADVISE: Finance**
　　　　Insights DEVELOP: Automotive and Healthcare
Use Case: **Financial advising**

How FER is used: **nViso uses FER technology to help understand their clients' feelings about money and financial priorities. Their proprietary software uses convolutional neural networks,**

(delete "(CNNs)" because it's the only instance) fed by millions of image and video datasets, to predict and identify human emotions and behavior.[27] **They include a bundle of related technologies: face recognition, body pose recognition, and emotion recognition (e.g., facial muscle tracking, emotion classification, and action unit detection).**[28]

Insights ADVISE and Insights DEVELOP are the two main services offered by nViso. First, Insights ADVISE offers insights into clients' needs and wants for their personal finances so that financial advisors can better help them identify and achieve their financial goals. On the other hand, Insights DEVELOP is an SDK that can be adjusted to many applications, especially in the automotive and healthcare industries. For example, PainChek is using Insights DEVELOP to "redefine pain assessments" using FER technology.[29] The SDK for Insights DEVELOP can be integrated into mobile applications or developers can access a development version of the application programming interface (API) on the cloud or on premise.[30]

23. https://www.washingtonpost.com/technology/2019/10/22/ai-hiring-face-scanning-algorithm-increasingly-decides-whether-you-deserve-job/
24. https://www.forbes.com/sites/patriciagbarnes/2020/02/03/group-asks-federal-trade-commission-to-regulate-use-of-artificial-intelligence-in-pre-employment-screenings/#3adeeaf02b54
25. https://www.brookings.edu/blog/techtank/2019/10/31/for-some-employment-algorithms-disability-discrimination-by-default/
26. https://epic.org/privacy/ftc/hirevue/
27. https://www.nviso.ai/en/sdk-licensing
28. https://www.nviso.ai/en
29. "PainChek and NVISO Are Redefining Pain Assessment." NVISO, www.nviso.ai/en/news/painchek-and-nviso-are-redefining-pain-assessment.
30. "Applications That Understand Users: Insights Develop." NVISO, www.nviso.ai/en/insights-develop.

Following are companies that provide FER as a software-as-a-service (SAAS) to allow other companies to build their own solutions:

Microsoft

Market: **FER from photos and videos**
Use Case: **Applied to a variety of use cases**

How FER is used: **Microsoft's Face API analyzes perceived emotion using FER technology, based on facial expressions depicted in photographs and videos. It also returns a bounding box around each of the detected faces in the frame. The Face API is accessed through the Microsoft Azure platform.**

Microsoft's Face API is fundamental FER technology designed for developers to implement FER in their own unique applications. It can be accessed via API or mobile app.[31] Lab 58 has explored the use of Microsoft's Face API in RTI's use cases. Microsoft bundles into its Face API three different technologies: face detection, face verification, and perceived emotion recognition.[32]

Realeyes

Markets: **Consumer Insight, Media and Creative Performance, Product Innovation**
Use Case: **Providing audience feedback and insights to marketers and innovators**

How FER is used: **Realeyes analyzes consumer emotion via FER technology (in conjunction with gesture and attention analysis) to create second-by-second reports on unbiased audience responses. These reports are mainly used to assess advertisements but can be used to gather consumer feedback on nearly any platform, product, film, and so on.**

Realeyes offers the "GO–Self Service" platform or the "API–Integrate Emotion AI." To begin with, GO–Self Service platform is designed in a way that anyone can input video data and receive an output of second-by-second audience response reports in less than 3 hours. This service costs $25k for 20 videos or $42.5k for 50 videos and it can be completed entirely via the web.[33] In addition, Realeyes offers an API, at varied costs, for developers to integrate emotion AI (including FER) into their own platforms and applications.[34]

Affectiva

Markets: **Automotive, Media, Lab Biometric**
Use Case: **Applied to a variety of use cases, within Affectiva and externally**

How FER is used: **Affectiva develops FER technology (as well as voice recognition technology) that allows other companies, such as iMotions, to use Affectiva's software as a backend for their offerings.**

Affectiva's FER "technology is used by 32 Fortune 100 companies and in 75 countries," including corporations such as Unilever, Kellogg's, Mars, and CBS.[35] Many companies use Affectiva's software because they have an impressive collection of data and a high success rate. "So far, Affectiva has amassed a data repository of 4.25 million videos from people in 75 different countries, yielding over 50 billion emotion-related data points."[35] They offer an SDK and an API, and it is important to note that academic researchers can access the SDK as a service offering through iMotions (Affectiva partner). iMotions is a platform that caters to the research community for behavioral observation. They use Affectiva's FER software as one of many multi-tools provided.

31. Davidbritch. "Perceived Emotion Recognition Using the Face API - Xamarin." Xamarin | Microsoft Docs, https://docs.microsoft.com/en-us/xamarin/xamarin-forms/data-cloud/azure-cognitive-services/emotion-recognition.
32. https://azure.microsoft.com/en-us/services/cognitive-services/face/#demo
33. "GO —Self-Service Emotion Measurement Platform." Realeyes, 17 July 2019, www.realeyesit.com/products/go/.
34. "Emotion API: Realeyes: Try Our Emotion Recognition Software." Realeyes, 28 Dec. 2019, www.realeyesit.com/products/api/.
35. Kolodny, Lora. "Affectiva Raises $14 Million to Bring Apps, Robots Emotional Intelligence." TechCrunch, TechCrunch, 25 May 2016, https://techcrunch.com/2016/05/25/affectiva-raises-14-million-to-bring-apps-robots-emotional-intelligence/.

How Companies Are Using FER in Their Business

The market is relatively new and risky, but this provides an opportunity to be on the forefront of creating applied FER technology for our clients. Although proven use cases are still minimal, the following are some key use cases in the market right now.

Observational Studies

- "Driver Sense" Driver Monitoring System, by EyeSight Technologies (2019)[36]—Driver Sense helps identify distracted driving using FER to detect drowsiness, and it also monitors other potential dangers, such as smoking and phone usage behind the wheel.

- "Google Glass" Emotion-Detecting Glasses for Autistic Children, by Google (originally designed in 2013)[37]—Google Glass provides behavioral therapy for autistic children by using augmented reality to help them identify and understand other people's emotions, which is a challenging task for many children on the autism spectrum.

Surveys and Focus Groups

- Emotion Recognition in Video Interviews, by HireVue (2018)[38]—HireVue is screening large volumes of job candidates with an automatically—generated employability score that combines FER with other factors from online video interviews.

- "Emotion-Enabled Healthcare" Pain Assessment, Medical Diagnosis, and Treatment Aide, by Affectiva[39]—Affectiva is using FER to assist in assessing pain in healthcare patients based on the level of discomfort expressed on their faces.

Product Evaluation

- Emotion Recognition to Identify the Most Engaging Commercials, by Affectiva (2019)[40]—Affectiva is a huge player in the advertising evaluation market, using FER to identify the effectiveness of a commercial and ultimately producing consumer engagement reports to assess the commercials.

- "Factorized Variational Autoencoders" Emotion Recognition of Movie Viewers, by Disney (2017) [41, 42]—Disney is observing movie viewers using FER technology (attention and facial expression) as they watch the latest Disney films to gather consumer response data, including points of excitement in the film or points of boredom and disinterest that could be improved.

RTI's FER APP
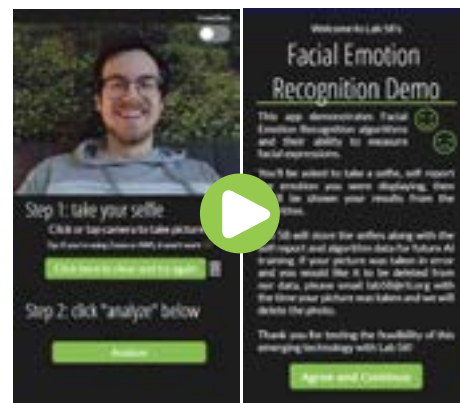
Lab 58 has created a FER app to demonstrate how quickly FER technology can be used to identify perceived emotion via facial expression. The app allows users to test an out-of-the-box FER technology to self-label their own selfies and see how they match what the technology predicts!

Working with Lab 58

Lab 58 is an applied, technology R&D lab at RTI International. We identify and develop emergency technologies internally. We also work with partners! If you would like to work with us, please contact us at Lab58@rti.org.

More Information
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36. "Emotion Detection and Recognition Market." Market Research Firm, www.marketsandmarkets.com/Market-Reports/emotion-detection-recognition-market-23376176.html.

37. Haber, Nick, et al. "Upgraded Google Glass Helps Autistic Kids 'See' Emotion." IEEE Spectrum: Technology, Engineering, and Science News, 26 Mar. 2020, https://spectrum.ieee.org/biomedical/bionics/upgraded-google-glass-helps-autistic-kids-see-emotions.

38. Zetlin, Minda. "Got a Poker Face? Employers Are Using AI to Analyze Candidates' Facial Expressions and Personalities." Inc.com, Inc., 28 Feb. 2018, www.inc.com/minda-zetlin/ai-is-now-analyzing-candidates-facial-expressions-during-video-job-interviews.html.

39. https://blog.affectiva.com/20-awesome-emotion-enabled-campaign-ideas

40. "5 Examples of How Emotion Analysis Helps to Improve an Existing Process." Softwebsolutions, 24 Sept. 2019, www.softwebsolutions.com/resources/5-examples-of-emotion-analytics.html.

41. "Emotion Detection and Recognition Market: Growth, Trends, and Forecast (2020 - 2025)." Market Research—Consulting, Reports, Advisory, Sizing, 2020, www.mordorintelligence.com/industry-reports/emotion-detection-and-recognition-edr-market.

42. "How Disney Is Using Artificial Intelligence to Figure out Exactly How Much You Enjoy Its Films | CBC News." CBCnews, CBC/Radio Canada, 4 Aug. 2017, www.cbc.ca/news/technology/disney-ai-real-time-tracking-fvae-1.4233063.

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