

EMERGING TECH RESEARCH

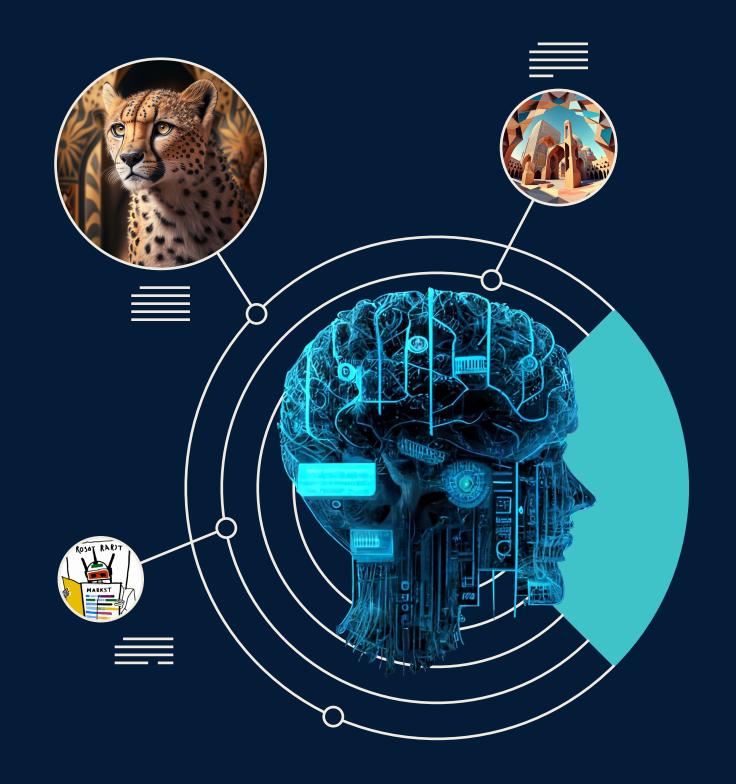
Vertical Snapshot: Generative AI

VC trends, industry overview, and market landscape

2023

REPORT PREVIEW

The full report is available through the PitchBook Platform.





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Institutional Research Group

Analysis



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Executive summary

- VC investments soar in natural language interfaces, 2D media, Al Core, and biotech startups. Between 2018 and 2022, natural language interfaces and 2D-media generation captured 29.3% and 18.8% of VC-backed deals, respectively, and 23.6% and 11.4% of total dollars invested, respectively, in the generative Al space, making them the leading applied segments of the technology. Within the natural language interfaces segment, chatbots, voicebots, and personal assistants captured \$544.9 million in 2022—or 59.6% of all dollars invested in the segment. For the 2D media segment, avatars and video generation and editing accounted for 37.7% and 40.8%, respectively, of all VC dollars invested in the segment in 2022. Al Core, which includes foundation model developers and infrastructure for model development, raised a whopping \$5 billion from VCs between 2018 and 2022. Remarkably, even biotech startups utilizing generative techniques have been hot destinations of VC capital—with \$1.6 billion invested during the same period.
- Lower training costs and advances in research propel in-house teams and startups. The declining cost of foundation model training and usage, along with advances in artificial intelligence & machine learning (AI & ML) research, is driving the industry forward, making it possible for both in-house research teams and research-oriented startups to thrive. With hardware optimization and customized software, competitive foundation models can now be trained at significantly lower costs. As more AI researchers move from academia to the private sector, companies will compete for talent, and startups that simultaneously dedicate resources to model and product development will be more competitive.
- **Hyperscalers investing heavily in startups.** Cloud providers recognize that leading innovation in generative AI algorithms comes from startups; these providers are both making significant acquisitions and striking generous partnerships to align themselves with the future of creative

- software. Microsoft's \$10.0 billion financing commitment for OpenAI and Alphabet's VC megadeals for Anthropic and Cohere stand out for their scale, yet Meta, Spotify, and Apple have made significant acquisitions in generative audio as well. These investments come after a relatively quiet period for hyperscaler acquisition activity in AI, demonstrating that tech giants now require urgency to prevent disruption.
- New business opportunities from generative foundation models will rely on user experience. Generative foundation models are still in their infancy, but this presents an exciting chance for basic innovation to produce better user experiences. We have already seen commercially successful products based on generative transformer and score-based diffusion models, so a solid precedent exists for future research and development to yield results within just 18 to 24 months. And as model capabilities continue to advance, new business models and applications will likely emerge, including exciting experiments with video, voice, scientific publications, and databases. However, it is crucial to ensure that foundation models have guardrails in place to guarantee trustworthy outcomes. For startups looking to take on industry incumbents, the keys to success will be user experience, customization, and access to proprietary data.
- The generative AI market is expected to grow, with a multitude of enterprise applications. Generative-relevant use cases already present a significant enterprise opportunity, estimated to reach \$42.6 billion in 2023, with natural language interfaces offering the largest market due to customer service and sales automation use cases. We expect the market at a 32.0% CAGR to reach \$98.1 billion by 2026, even without accounting for the potential of generative AI to expand the total addressable market of AI software to consumers and new user personas in the enterprise.



Generative AI timeline

General model research

Image / video models

Text models

Business events

December 1997

Two computer scientists, Sepp Hochreiter and Jürgen Schmidhuber, invent Long Short-Term Memory (LSTM) networks, which improves memory capacity in neural networks and thus allows for faster and more precise pattern recognition in training data.⁶

December 2013

2013

Diederik P. Kingma and Max Welling publish a paper on VAEs.⁶ VAEs deconstruct input data into code, known as the latent space, and then construct new, representative data out of the latent space.

July 2015

Google's DeepDream model for image generation is launched. ⁷

2016

June 2016

Style Transfer, a deep neural network that can transfer the style of one image to another, is released.⁷

2012

A seminal year in deep learning research that enables significant advances in computer vision, speech recognition, and natural language processing. These accomplishments are best signified by AlexNet, a convolutional neural network (CNN) trained on graphical processing units (GPUs) and developed by researcher Alex Krizhevksy. AlexNet was the first model to break 75% accuracy, identifying images from a 14-million-image manually tagged database known as ImageNet.

January 2014

Google acquires DeepMind, an Al research lab based in the UK.

March 2015

June 2014

Ian Goodfellow invents GANs.6

Researchers Jascha Sohl-Dickstein, Eric A. Weiss, Niru Maheswaranathan, and Surya Ganguli introduce diffusion models.⁶ These models apply noise to an image until it is incomprehensible, then gradually reduce the noise in the image and thus learn how to generate actual images from noise.

December 2015

OpenAI is founded as a non-profit, open-source research lab.

June 2017

Google researchers release "Attention Is All You Need" paper on transformer models, a type of neural network architecture that lends attention to context and syntax.8 This allows for immense strides in natural language processing and understanding.

<u>5: "2012: A Breakthrough Year for Deep Learning," Medium, Bryan House, July 17, 2019.</u>

6: "The Generative Al Revolution Has Begun—How Did We Get Here?," Ars Technica, Haomiao Huang, January 30, 2023.

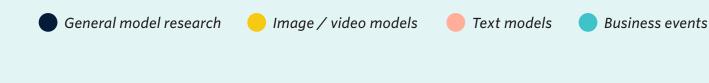
7: "Timeline of Text-To-Image Machine Learning Models," Fabian Mosele, n.d., accessed March 9, 2023.

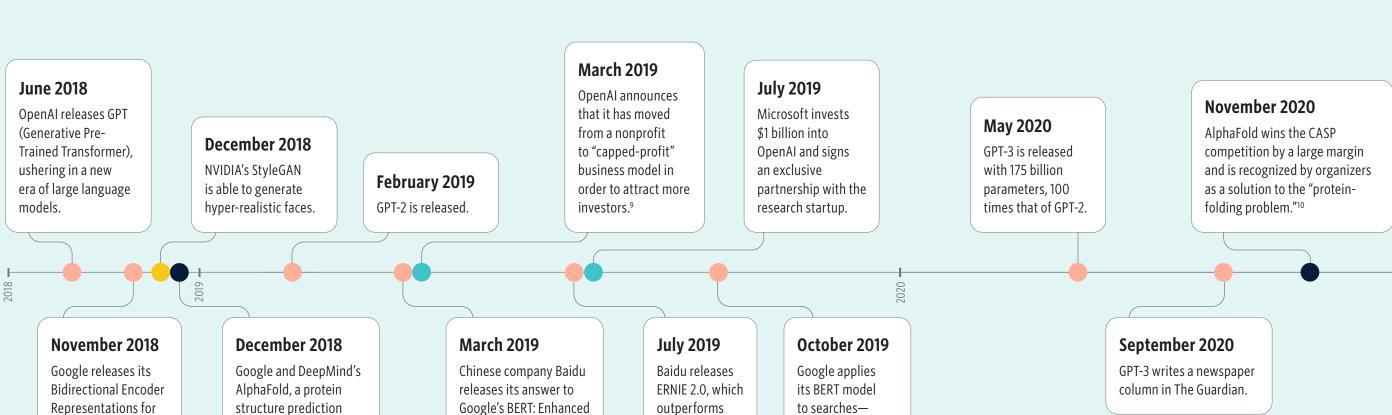
8: "Timeline of Al and Language Models," Life Architect, Alan D. Thompson, n.d., accessed March 9, 2023.

Vertical Snapshot: Generative AI



GENERATIVE AI TIMELINE





Google's BERT.

demonstrating

capabilities.

semantic search

model, places first in the

Protein Structure (CASP)

Critical Assessment of

competition.

10: "DeepMind's Protein-Folding Al Has Solved a 50-year-old Grand Challenge of Biology," MIT Technology Review, Will Douglas Heaven, November 30, 2020.

Representation Through

Knowledge Integration

(ERNIE 1.0).

Vertical Snapshot: Generative AI

Transformers (BERT).

^{9: &}quot;OpenAI Shifts From Nonprofit to 'Capped-Profit' to Attract Capital," TechCrunch, Devin Coldewey, March 11, 2019.



GENERATIVE AI TIMELINE

General model research

Image / video models

Text models

Business events

January 2021

OpenAI launches Dall-E, its text-to-image model, along with the open-source version of the model: Contrastive Language-Image Pre-Training (CLIP). This enables a flood of text-to-image models.

June 2021

GitHub, a subsidiary of Microsoft, announces its code-completion Copilot tool. GitHub Copilot is built on OpenAl's Codex, which is trained on 54 million public GitHub repositories.

April 2022

OpenAI releases Dall-E 2. Shortly thereafter, Boris Dayma releases an open-source but unaffiliated version called Dall-E Mini. Dayma's model eventually changes its name to Craiyon to avoid any legal disputes. Craiyon becomes rapidly popular due to its accessibility and through memes.

July 2022

The French National Center for Scientific Research debuts BigScience Large Open-Science Open-Access Multilingual Language Model (BLOOM) on the platform HuggingFace. With 176 billion parameters, BLOOM is larger than GPT-3 and also completely open-source. It goes beyond Meta's OPT by being freely available for research or commercial use.

September 2022

NVIDIA releases Get3D, a 3D-shape generator trained only on 2D images.

December 2021

Baidu releases ERNIE 3.0.

May 2022

Google releases its answer to Dall-E, Imagen, though not to the public.

May 2021

Google announces Language Model for Dialogue Applications (LaMDA), its transformer-based large language model.

November 2021

Microsoft announces NÜWA, a multimodal model for text-to-image and text-to-video.

March 2022

MidJourney, a text-toimage model offered through a Discord server, moves into open beta.

April 2022

Google releases its 540 billion parameter Pathways Language Model (PaLM), a multifunctional language model.

May 2022

Meta releases its Open Pretrained Transformer (OPT) model, a totally open-source LLM, to the public. Details about the model's training are also released. Access is available upon request, but the license limits usage of the model to research purposes.

July 2022

Research startup Stability.ai launches Stable Diffusion, an open-source text-toimage model.

September 2022

Meta announces Make-A-Video, its text-to-video model.

Vertical Snapshot: Generative AI



GENERATIVE AI TIMELINE

General model research Image / video models Text models Business events

> February 2023 Microsoft releases a limited beta

upgrade to its Bing search system, with new capabilities such as February 2023 summarization and chat based on ChatGPT. GPT is also integrated into other Microsoft products including Teams and its Edge browser.

Google announces BARD, its answer to ChatGPT, for limited beta testing.

October 2022

Google launches text-to-video model Imagen Video.

November 2022

Stability.ai and Amazon Web Services announce a partnership.

February 2023

AWS and Hugging Face announce partnership.

November 2022

OpenAl announces ChatGPT, a powerful chatbot tool running on the GPT-3.5 model. It soon becomes the most quickly adopted tech product in history. February 2023

January 2023

2023

Microsoft announces a "multiyear,

multibillion-dollar" investment in

OpenAI and exclusive integration

with its Azure cloud system.11

Runway, an AI research lab, announces its Gen-1 model that allows for style transfer across videos. February 2023

Google invests \$300 million into Anthropic, a research startup made up of former OpenAI employees. Anthropic calls Google its "preferred cloud provider." 12

March 2023

Google announces generative tools to be integrated into workplace.

March 2023

OpenAl releases GPT-4.

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^{11: &}quot;Microsoft Announces New Multibillion-Dollar Investment in ChatGPT-Maker OpenAI," CNBC, Ashley Capoot, January 23, 2023.

^{12: &}quot;Google Invested \$300 Million in AI Firm Founded by Former OpenAI Researchers," The Verge, James Vincent, February 3, 2023.



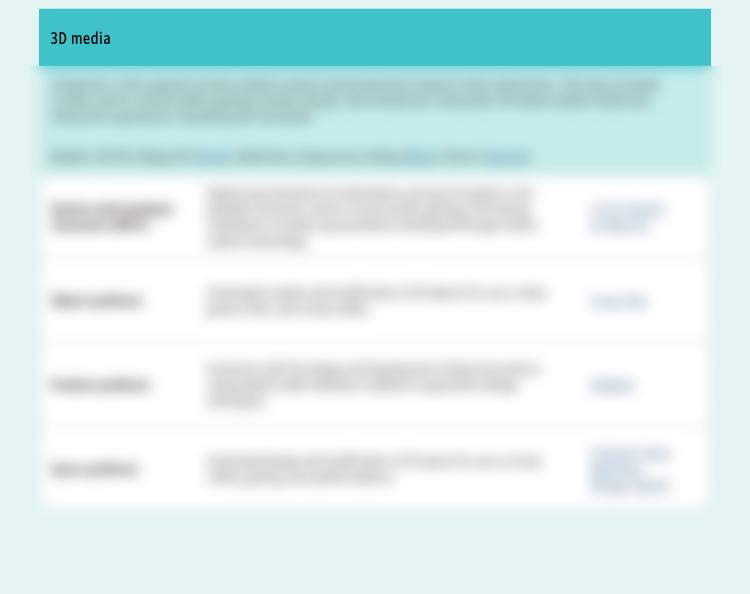
GENERATIVE AI TAXONOMY

2D media

Companies in this segment produce, manipulate, or identify flat digital content—images, videos, or other media that lack spatial depth. These tools enable use cases in marketing, design, entertainment, and e-commerce.

Models: DALL-E (<u>OpenAI</u>), <u>Midjourney</u>, Stable Diffusion (<u>Stability.AI</u>), Make-A-Video (<u>Meta</u>), Imagen Video (<u>Google</u>)

Avatars	Digital representations of individuals or groups of people used in personalized videos, virtual assistants, or e-commerce.	Soul Machines, Synthesia, DeepBrain Al
Content suite	Automated content creation and optimization of multiple forms of digital media for content marketing, advertising, and presentations.	<u>Lightricks,</u> <u>Jasper, Tome</u>
Image: Generation and editing	Creation, modification, and enhancement of digital images for graphic design, photography, and e-commerce.	lmagen, PhotoRoom
Product design	Assistance with the design and development of physical products such as clothing and furniture using generative design techniques.	ZMO.AI, CALA
Video: Generation and editing	Automated video editing, enhancement, and generation for video production, advertising, and entertainment.	Runway, VideoVerse, Waymark
Visual search	Automated identification and categorization of visual patterns in images and videos for e-commerce, content discovery, and analytics.	Air, Twelve Labs



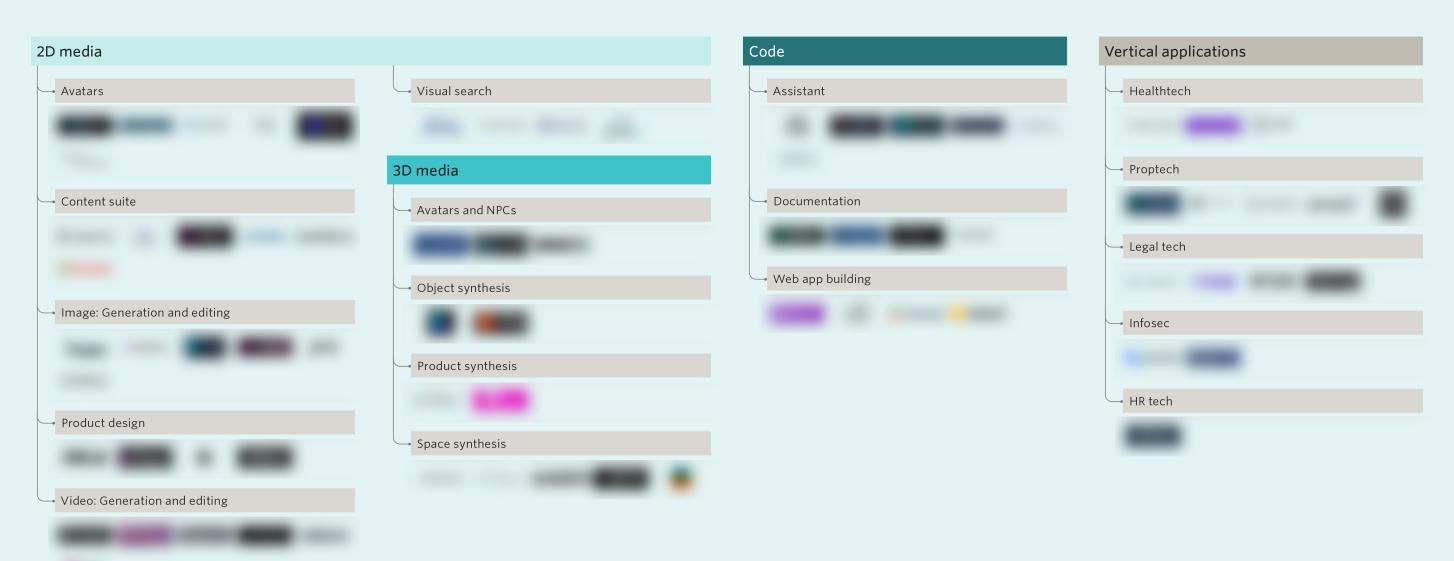
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Generative AI market map

Click to view the interactive market map on the PitchBook Platform.

Market map is a representative overview of venture-backed or growth-stage providers in each segment. Companies listed have received venture capital or other notable private investments.



Vertical Snapshot: Generative AI



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Biotechnology

About PitchBook Emerging Tech Research

Independent, objective and timely market intel

As the private markets continue to grow in complexity and competition, it's essential for investors to understand the industries, sectors and companies driving the asset class.

Our Emerging Tech Research provides detailed analysis of nascent tech sectors so you can better navigate the changing markets you operate in—and pursue new opportunities with confidence.

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