Innovation Guide for Generative AI in Computer Vision

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Initiatives: Artificial Intelligence

The transformative power of computer vision for commercial applications is fueled by advancements in generative AI. Technology leaders can use this high-level guide to ground themselves in the vendor landscape for GenAI in computer vision.

Overview

Key Findings

- Generative AI (GenAI) has emerged as a catalyst for innovation in the computer vision space that will impact a multitude of use cases across industries. GenAI empowers computer vision systems to not only observe but also create, synthesize and augment visual content.
- GenAI models, methods and applications are rapidly emerging. This creates a dynamic market but also raises pressing concerns and risks surrounding legal implications, enterprise security and privacy.
- The integration of computer vision techniques with foundation models facilitates natural language contextual search of unstructured image data and correlation of data on video streams at scale. This unlocks rich multimodal analytics and experiences.

Recommendations

- Develop no more than five pilot projects by exploring industry-relevant use cases aligned with your business goals to leverage GenAI in computer vision. Document and evaluate the ethical implications, legal risks and evolving regulatory landscape when navigating the integration of GenAI into computer vision. Involve relevant teams in evaluating vendor practices to make informed decisions and mitigate potential risks.
- Assess the current business value opportunities of integrating GenAI with computer vision. Evaluate their scalability, maintenance and adaptability to future industry trends.

Contribute to Beta Research

The following research is a work in progress that does not represent our final position. We invite you to provide constructive feedback to help shape the research as it evolves. All relevant updates and feedback will be incorporated into the final research.

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Market Definition

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Computer vision with GenAI powered improvements, significantly increasing its transformative potential. Computer vision involves capturing, processing and analyzing real-world images and videos to allow machines to extract meaningful and contextual information from the physical world. Image generation models require massive training datasets (such as LAION-5B, ImageNet, CIFAR-100) to learn creatively, but when applied properly, can improve operational efficiencies and strengthen the results of computer vision use cases.

The GenAI market in computer vision is composed of the following segments, with vendors often present in multiple segments:

- **GenAI platforms** — GenAI platforms aid computer vision in many areas, including text generation tasks such as image capturing, processing and analyzing real-world images and videos to extract meaningful, contextual information from the physical world. When embedded in the experience, GenAI offers richer contextualization for singular tasks such as generating and editing images or digital avatars.
- **Model providers** — This layer of vendors offers access to commercial or open-source foundation models such as large language models (LLMs) and other types of generative algorithms (such as GANs, genetic/evolutionary algorithms or simulations) to generate digital images from natural language descriptions called "prompts."

The text-to-image generative models rely on the user to create their own queries (prompts). Because they are generic, they will require more effort in prompt creation to retrieve useful, accurate and safer outputs. The advantages can be outweighed by the effort needed to manage interaction and the risks associated with what is entered and retrieved (e.g., intellectual property [IP]).

Various kinds of techniques that can help improve the model responses include:

- **Reinforcement learning** — Reinforcement learning has become a trending research field and has stretched the limits of GenAI in both model design and application. Generation tasks in computer vision can use reinforcement learning algorithms in many subareas, including text generation tasks such as image captioning, visual question answering, visual dialogue and visual entity generation such as images, 3D objects and scenes generation. Vendors are also exploring how to combine reinforcement learning with diffusion models by improving image characteristics that are hard to describe by prompts.

- **Prompt engineering** — Prompts are a phrase or set of keywords used as input for GenAI. A vendor's prompt engineering reflects their craft at designing and optimizing user requests to an LLM to get the most effective responses.
- **Fine-tuning** — The process of fine-tuning involves taking an LLM pretrained on large-scale datasets and further training it on smaller, task-specific datasets relevant to the domain of interest. For example, fine-tuning a text-to-image model to mimic itself but with editing guided by using text prompts.

GenAI has the opportunity to enhance existing technology usage patterns and also introduce new ones. Text-to-image generative models can produce photorealistic images for an extremely broad range of concepts, and their usage has proliferated widely among the general public. On the flip side, these models have numerous drawbacks, including their potential to generate images featuring obscene content, mirror artistic styles without permission or even hallucinate (or deepfake) the likenesses of celebrities.

Therefore, technology buyers must both understand their choices for technology and map them to their use cases, learning curves, costs and risks of adoption. AI-based creation using computer vision will also require upskilling existing teams on new technology and will still require reviews and approvals as this application of GenAI expands.

Market Map Visual

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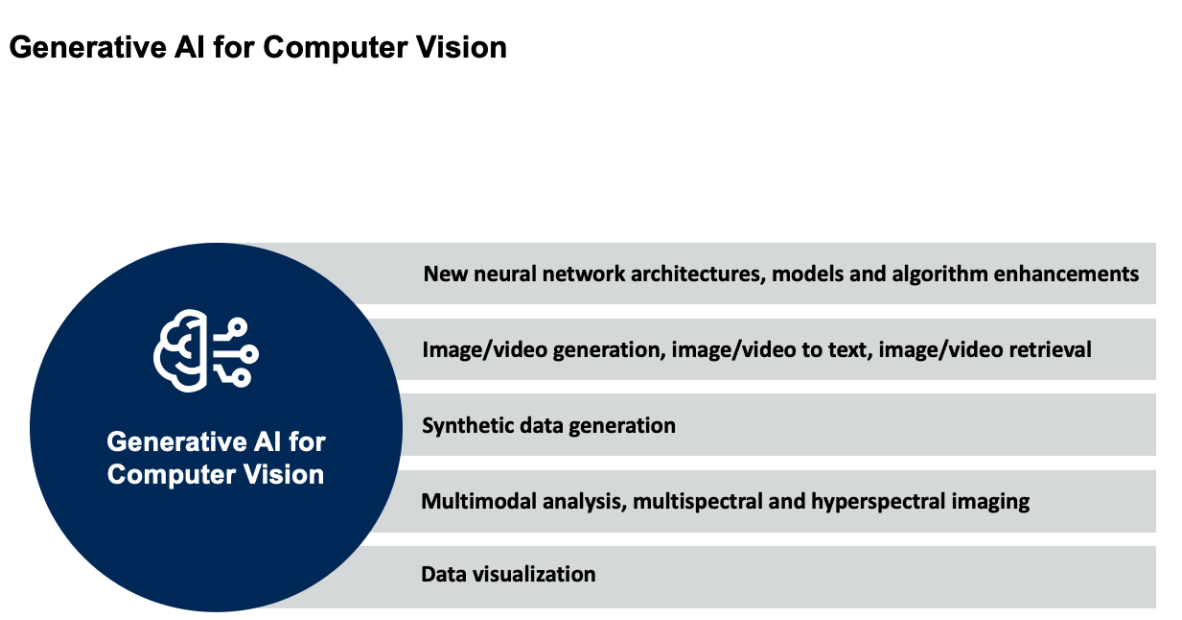
Computer vision is a rapidly innovating market. Leaders need to be proactive in identifying and developing capabilities that will differentiate their offerings. GenAI can improve operational efficiencies and strengthen the results of computer vision. Figure 1 shows key capabilities of applying generative techniques to computer vision.

Figure 1: Generative AI for Computer Vision



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Market Evolution

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The emergence of LLMs has changed the paradigm of several industries regarding how to develop the next generation of machine learning systems to further bridge the gap toward general AI. These models have demonstrated remarkable successes in language and vision tasks across various domains. The models are trained on a vast amount of data from multiple domains and modalities. Once trained, they can accomplish versatile tasks with just minor fine-tuning and minimal task-specific labeled data.

With publicly available Stable Diffusion models, the text-to-image generation models have made significant advances. In particular, they possess expressive power to generate detailed images and vast conceptual knowledge learned from the internet. Furthermore, these advancements have reached a wider audience than other AI fields, due to the simple interface that allows users to generate desired images with just a text prompt and view their results immediately.

A fundamental element for these models' continuous improvement is the use of massive training datasets from which complex models can be trained. For example, image generation models currently rely on datasets such as LAION5B, which has more than five billion captioned images, or ImageNet, which has 1 million color images of 1,000 classes. The availability of a large amount of high-quality training data is one of the major challenges in training accurate machine learning models. For text and images, the data is in many cases extracted from the internet with crawlers that automatically collect billions of images and texts.

As AI-generated data becomes more prevalent, future datasets may be largely composed of AI-generated content. Using AI-generated data for training AI models has both benefits and risks. The benefits include the ability to train AI models with less real-world data, but the risks include the potential for AI models to inherit the flaws and biases of AI-generated data. While it could make training data more accessible, it could also introduce bias and inaccuracies.

The use of AI-generated data in training could create a feedback loop where future AI models are trained on data generated by previous AI models. This raises important questions about the quality and reliability of future AI systems. A feedback loop may also lead to instability. To tackle the AI feedback loop, we could avoid using AI-generated data in training newer models. However, detecting AI-generated content is challenging due to the constant emergence of new tools and models, making it a never-ending cat-and-mouse game — that is, wait and see what will happen first. Additionally, AI-generated content can be edited or combined, making detection even harder. Hence, AI-generated content will likely persist in future training datasets.

This feedback loop's issues are evident when early AI image generators created errors, such as distorted hands. If used to train newer models, these errors might persist, even if the newer models can draw realistic hands. It raises questions about whether biases or limitations of previous AI models will burden newer ones. Also, can GenAI models fully capture dataset diversity, or will they produce a subset, creating less diverse content? Will this issue accumulate or stabilize over time? Conversely, as AI models evolve, will their generated content stay faithful to the original dataset, or will it gradually diverge? These are some of the crucial open questions about the potential implications of the feedback loop created by using training datasets taken from the internet.

Business Benefits (Use Cases)

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GenAI has emerged as a transformative technology in the computer vision space that will impact a multitude of use cases across different industries. The convergence of GenAI models, such as GANs, have unlocked new abilities to generate highly realistic and contextually relevant visual content. GenAI empowers computer vision systems to not only observe but also create, synthesize and augment visual content. See Table 1 for a nonexhaustive list of use cases.

Table 1: Generative AI Use Cases for Computer Vision

(Enlarged table in Appendix)

Use Case	Business Driver	Use Cases
Data Augmentation	GenAI improves computer vision through data augmentation by generating synthetic data and creating diverse variations. This enhances model generalization, reduces overfitting and boosts performance, which benefits computer vision tasks by increasing dataset diversity, improving model robustness and facilitating better performance in real-world scenarios.	▪ Faster creation of datasets ▪ Cheaper creation of datasets ▪ Supplements dataset by generating missing data ▪ Increased dataset diversity ▪ Improved model generalization ▪ Enhanced robustness to real-world variations ▪ Better performance in low-data scenarios ▪ Privacy-preserving synthetic data generation ▪ Addressing class imbalance in datasets
Visual Generation (Images and Videos)	GenAI can enhance computer vision with visual generation by creating high-quality, diverse and realistic visual content. This content can be used for various purposes, such as data augmentation, content creation and assisting in computer vision model training.	▪ Content creation ▪ Graphic design ▪ Video game assets ▪ Virtual worlds ▪ Animation ▪ Educational materials ▪ Marketing materials ▪ Web design ▪ Product design ▪ Increased personalization ▪ Content adaptation
Improved Search	Integrating GenAI and computer vision will make visual content retrieval faster, more precise and more tailored to individual preferences. It will enhance content organization, tagging and recommendation systems.	▪ Visual content understanding ▪ Video and image search ▪ Image captioning ▪ Content recommendation ▪ Enhanced content retrieval ▪ Content moderation ▪ Cross-model search
Data Correlation	Combining LLMs with computer vision improves data correlation. LLMs can correlate visual findings analyzed by computer vision to extensive datasets and historical information. This integration facilitates comprehensive diagnostics, including root cause analysis, by connecting visual cues with contextual information. The results streamlined analytical processes, enhanced accuracy and reduced the impact of human biases, offering advantages in fields that rely on data correlation for critical insights.	▪ Improved security systems ▪ Advanced diagnostics and patient care in healthcare ▪ Improved quality control in manufacturing ▪ Supply chain visibility ▪ Logistics efficiency
Resolution Enhancement	GANs and other generative models can enhance image resolution, turning low-resolution images into high-resolution ones. It can also help denoise images or videos.	▪ Forensic analysis ▪ Medical imaging ▪ Satellite imaging ▪ Archival footage restoration ▪ Facial recognition ▪ Intelligent document scanning (IDP) ▪ Microscopy ▪ Virtual reality (VR) and augmented reality (AR)
Data Completion and Inpainting	Generative models can fill in missing parts of images or reconstruct corrupted or incomplete images. GenAI can supplement data where it might be missing due to sensor errors or occlusions.	▪ Image inpainting ▪ Video inpainting ▪ Object removal ▪ Document restoration ▪ Semantic image completion
Image-to-Image Translation	Generative models can convert images from one domain to another while preserving relevant details.	▪ Document digitization ▪ Converting satellite images to maps ▪ Turning sketches into realistic images ▪ Style transfer ▪ Colorization ▪ Virtual try-on
Image Captioning	Generative models can generate natural language descriptions for images. GenAI in image captioning contributes to more intelligent and versatile computer vision applications, enabling deeper image understanding and improved human-computer interaction.	▪ Automated annotations ▪ Content accessibility ▪ Multimodal AI ▪ Semantic retrieval ▪ Data labeling ▪ Cross-modal learning ▪ Educational aids
Improved Simulation	GenAI can create realistic synthetic environments, objects and characters for training purposes.	▪ Safer testing of self-driving cars ▪ Training of robotic systems ▪ Resource efficiency ▪ Cost reduction ▪ Adversarial testing
3D Reconstruction	LLMs can aid in 3D object reconstruction from 2D images, enabling applications such as 3D modeling, augmented reality and virtual reality.	▪ Architectural and industrial design ▪ Medical imaging ▪ VR and gaming ▪ Data augmentation

Source: Gartner (September 2023)

Piloting and Evaluating Vendors

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Enterprises are approaching the adoption curve for GenAI at different paces and entry points, and exploration and piloting are a crucial step. The comprehensive research on exploration and piloting efforts for enterprises, How to Pilot Generative AI, provides details on how to run a pilot. Focus on no more than five pilot use cases to determine which warrant further investment. Reduce ROI risk and implementation complexity by selecting vendors with existing contracts or great-fit new vendors that offer easy trials and freemium products before committing to enterprise software purchases.

Technology leaders can use Table 2 when selecting computer vision technologies.

Table 2: Key Considerations When Evaluating GenAI-Augmented Computer Vision Technologies

(Enlarged table in Appendix)

Consideration	Analysis
Data and model quality	Assess the quality and diversity of the training data used for GenAI models. High-quality and diverse training data lead to better performance and generalization. Evaluate the accuracy and consistency of the GenAI's output. Ensure it consistently produces reliable results across different inputs.
Privacy and security	Ensure privacy and security concerns are addressed, especially when working with sensitive or personal data, and when generating synthetic data that may inadvertently reveal sensitive information. Make sure your IP and data are not used to train models and prompt content is not retained. See the Managing Risks section for more details.
Legal implications	Ensure the use of GenAI complies with relevant laws and regulations, such as data protection and intellectual property rights. Understand the concept of "fair use" in copyright law, which allows limited use of copyrighted material. Evaluate whether your use of AI-generated content falls within the boundaries of fair use or constitutes a transformative work. If you are using a third-party GenAI service or platform, carefully review its user agreements and terms of service to understand liability provisions related to copyright infringement. If your AI projects have a global reach, be aware of and comply with international copyright laws and treaties, as copyright regulations can vary across jurisdictions.
Practical implementation	Evaluate the user interface and experience of the computer vision technology, ensuring it is user-friendly and aligns with user needs. Determine the level of human oversight required when using GenAI. In some cases, human intervention may be necessary to validate or refine the AI-generated outputs.
GenAI commitment	Determine how committed the vendor is to GenAI. Get the vendor to detail the GenAI limitations and mitigations they have in place upfront and explain why they're using GenAI instead of any other form of AI. Vendors with a stack of LLMs (or LLM partnerships) will often test, experiment and reduce LLM costs. The more they use, the more competent their GenAI technology likely is.
ROI of GenAI technologies	Seek to understand from the reference customer what performance metrics were used and how those are translated into the ROI number. Perform a cost-benefit analysis to determine whether the benefits of using GenAI outweigh the costs, including data acquisition, possible model training and computational resources. Consider the long-term viability of the GenAI technology. Will it continue to meet your needs and adapt to evolving requirements?

Source: Gartner (September 2023)

Managing Risks

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Minimize the risk of making suboptimal or dangerous decisions about GenAI in computer vision by ensuring your organization is aware of the following risks:

- **Inaccuracies and bias** — Despite improvements, GenAI occasionally "hallucinates" facts and makes reasoning errors. It has also generated output that represents social biases and world views derived from its training data.

- **Misuse and adversarial prompting** — Adversarial prompts could lead to harmful content generation. There is a significant risk of misuse, with bad actors creating higher-quality misinformation, phishing emails, malware, fraud and spam.
- **Privacy and information security** — Privacy assurances vary from product to product. Always read the terms of service for GenAI applications to evaluate the privacy risk for your specific use cases.
- **IP protection and creator rights** — Expect scrutiny from governments and regulatory bodies around IP ownership when your team produces output with hybrid generative and human involvement or uses protected IP to generate new IP.
- **Lack of AI governance leading to eroded buyer trust** — Improper or unskilled use of GenAI can lead to undesirable (trust) consequences, such as spamming buyers with a high volume of AI-generated messages.
- **GenAI failing to reduce operating costs** — The domain of GenAI is growing rapidly and will become part of many commercial off-the-shelf technologies, such as Microsoft 365 Copilot or Google Bard. It's not clear yet exactly how the technology will affect operating costs.
- **IP leaking into public LLMs** — Company, product, pricing or customer information requires additional security; companies should not let it leak into public models.
- **Feedback loop** — The use of AI-generated data in training could create a feedback loop where future AI models are trained on data generated by previous AI models. This raises important questions about the quality, reliability and stability of the future AI systems.

Buyers should manage these risks when evaluating vendors and application usage by ensuring vendors have robust commercial agreements directly with LLM vendors that control what prompt content, and data used to augment the prompt, is used to train the LLM(s) being used. Commercially sensitive and personal information must be blocked from use in training or fine-tuning the LLM. Some LLM vendors "retain" prompt content for short periods as part of monitoring for abusive or contentious content; it is possible to negotiate nonretention terms to derisk against rogue activity. Seek to establish vendors' inbuilt functionality to weed out hallucinations, false outputs and sources' provenance.

The quality of fine-tuning, prompt engineering and augmentation will impact the accuracy and relevance of outputs. Through piloting periods, take steps to test and monitor GenAI application outputs to track for accuracy, bias and plagiarism.

Ensure clarity of pricing models to prevent escalating usage costs. Pilot periods will assist in understanding expected usage and controlled assimilation of practices to conserve allowance usage.

For more details on risk mitigation, see Microsoft Azure OpenAI vs. OpenAI: Comparing GenAI Trust, Risk and Security and Applying AI — Governance and Risk Management.

Representative Vendors

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The following list of vendors and their associated use cases in Table 3 is intended to provide a broad overview of available solutions in the market. It is not exhaustive, and other vendors may offer similar services or cover multiple use cases that are not included here.

Additionally, some vendors on this list may offer services that span multiple use cases. The categorization provided is a general guideline and may not fully encompass each vendor's diverse range of capabilities and offerings.

We recommend conducting thorough research and due diligence when selecting a vendor to ensure it aligns with your specific requirements and objectives. This list serves as a starting point and should not be considered a comprehensive directory of all available options in the industry.

The technology landscape is constantly evolving. This list will be updated as new vendors may emerge with innovative solutions that fit these categories.

Table 3: Vendors Using Both Computer Vision and Generative AI Functionality

(Enlarged table in Appendix)

Computer Vision Platform	Chooch, Clarifai, CrowdAI, Matroid, SceneCraft, TensorGo
Marketing/Comms/Sales/Content	Bria, Madgicx, Masterful AI, RethX, Synthesis AI,
Image Generation Models and Tools	**Models:** DALL-E, Imagen, Muse, Stable Diffusion **Tools:** Adobe Firefly, Artbreeder, Bing Image Creator, Canva's AI, Craiyon, DALL-E, DeepAI, DreamStudio, Dream by WOMBO, Jasper Art, Midjourney, NightCafe, Starry AI, Synthesys X
Video Generation	Colossyan, DeepBrain AI, DeepReel, Designs.ai, Elai, HeyGen, InVideo, Pictory, Runway, Synthesia, Synthesys, VEED, Wave.video
Software Development and Testing	Datagen, Matroid, Outerbounds, SliceX AI, Uizard
Data Labeling and Synthetic Data	Mindtech Global, Scale AI, Synativ, V7Labs
Research and Engineering	Datagen, Mirage, Xanadu
Task Mining	KYP.ai, Skan, UiPath
Business Productivity Software	Bifrost, Imbue, Kognic, LeewayHertz, Memorable, Pryon, Twelve Labs
Multimedia, Visual Editing and Design Software	Bria, DREAM.3D, Facet, Kamua, Loci, MAD, Move AI

Source: Gartner (September 2023)

Evidence

[1] Innovation Insight for Generative AI

Note 1: Prompt Engineering Methods With LLMs and GenAI

- **Zero-shot prompt:** The LLM is given a task with no further guidance as to how to perform that task.
- **Few-shot learning:** AI framework that teaches a model how to deal with data and scenarios not encountered during training with only a few examples.
- **Retrieval-augmented generation:** Incorporates private and proprietary enterprise information into GenAI applications without requiring the underlying model to be modified in any way.

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Video Generation	Colossyan, DeepBrain AI, DeepReel, Designs.ai, Elai, HeyGen, InVideo, Pictory, Runway, Synthesia, Synthesys, VEED, Wave.video
Software Development and Testing	Datagen, Matroid, Outerbounds, SliceX AI, Uizard
Data Labeling and Synthetic Data	Mindtech Global, Scale AI, Synativ, V7Labs
Research and Engineering	Datagen, Mirage, Xanadu
Task Mining	KYP.ai, Skan, UiPath
Business Productivity Software	Bifrost, Imbue, Kognic, LeewayHertz, Memorable, Pryon, Twelve Labs
Multimedia, Visual Editing and Design Software	Bria, DREAM.3D, Facet, Kamua, Loci, MAD, Move AI

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