

Application of Machine Learning to Computer Graphics

A Brief Overview

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Machine learning (ML) is impacting almost all industries at a rapid pace. The article is a sampling of ongoing ML efforts in the computer graphics industry.

“Artificial intelligence is the new electricity,” asserts Andrew Ng, an adjunct Stanford professor who founded Coursera and the Google Brain Deep Learning Project. Professor Ng posits that as electricity transformed every major industry a hundred years ago, machine learning has the potential to transform every industry including computer graphics.

This article captures the current status of this wave as new techniques and technologies are being deployed inside the computer graphics industry. There are two ways that this adoption is happening: (a) incorporation of machine learning modules inside existing products and services, and (b) offering of new products and services that did not exist before.

EXISTING PRODUCTS AND SERVICES

Companies across the landscape are evaluating their pipelines and substituting machine learning components when appropriate in the tool chain. In most cases, these changes are trade secrets that companies keep private. The following is a sampling of some applications of this new capability.

In image editing tools, machine learning algorithms have been used for upscaling, denoising, hole filling, and object replacements. Certain tools like Photolemur (photolemur.com) advertise the use of machine learning, whereas a tool like Adobe Photoshop implements machine learning algorithms behind the scenes.

Among 3D rendering products, AMD’s Radeon ProRender and NVIDIA OPTIX 5.0 use machine learning for denoising (see Figure 1 for an example). In addition, NVIDIA is investigating using machine learning for facial animation, anti-aliasing and optimizing light paths for rendering.



Figure 1. NVIDIA is using machine learning for denoising rendered images. (Source: NVIDIA; used with permission.)

NOVEL APPLICATIONS

Equally important, machine learning is enabling new products and services that were not possible before.

Image Processing

Magic Pony Technologies (acquired by Twitter, 2016) optimizes transport of game, image, and video assets for web and mobile, by using machine learning techniques for image processing.

Algorithmia (algorithmia.com) is creating a marketplace for ML algorithms, where services are charged based on compute power and royalty per invocation. Algorithmia offers modules for colorizing black and white photos and enhancing the resolution of images, as well as stylization filters.

Last October, Adobe demoed Project Scribbler that colorizes black and white photos automatically as a part of Adobe Sensei. Final details on availability to the users are still forthcoming.

Image and Video Stylization

Products for image and video stylization have existed for some time, but they really took off when the seminal Leon Gatys paper¹ brought the application of deep learning to this problem into the limelight. Some of the applications in this space have had a mobile focus (e.g. Prisma), while others have primarily focused on a web presence (e.g. DeepArt). In either case, the following applications deserve mention: Prisma (prisma-ai.com), Artisto (artisto.my.com), Paintt (moonlighting.io), Style (macdaddy.io/style), and finally DeepArt (deepart.io), which is the productization of Gatys' paper. See Figure 2 for photographs that have been stylized using DeepArt.



Figure 2. DeepArt uses machine learning to stylize photographs to have the style of an artist. (Source: DeepArt.io; used with permission.)

Extensions

There are two extensions worth noting. High resolution stylized images have long been sought after in order to be displayed on large canvas. Since the algorithms are computationally expensive, the workflow usually involves picking a style at a lower resolution and then upscaling while preserving the style. This is usually not straightforward since image up-sampling is unique to the style being used for that image. For an impasto style, the desired detail is the brush marks on the canvas, whereas for watercolor style, the desired detail is the paper texture for the canvas.

Another extension is producing video from still images. Although this poses a variety of problems, the primary challenge is preserving the coherence of the style. In addition, the high cost of computation is prohibitive because the computations have to be repeated 24-60 times per second of video.

According to the author's biased eye, DeepArt does the best job with image quality, whereas Prisma has the best penetration in the marketplace. Although this field faces challenges such as giving users more control over the stylization and storytelling, machine learning has enabled results that were hitherto unachievable.

Real-time Facial Video Stylization

Another area where interesting new offerings have developed is in the field of real-time facial morphing. Lookery (lookery.en.uptodown.com/android, acquired by Snapchat) and MSQRD (msqrd.me, acquired by Facebook) both provide real-time video morphing of the imagery from the front facing camera of a mobile phone. First, the face is tracked from the camera using machine learning. Once a 3D mesh of the face is extracted, the model can be morphed or textured based on the desired effect.

CONCLUSION

In conclusion, this article captures some of the broad areas where machine learning is having an impact on computer graphics. This publication will continue to follow these exciting trends as more of Andrew Ng's predictions are realized.

REFERENCES

1. L. Gatys, A. Ecker, and M. Bethge, "A neural algorithm of artistic style," *Nature Communications*, 2015; <https://arxiv.org/abs/1508.06576>.

ABOUT THE AUTHOR

Amit Agrawal is the principal at Kleene Closure Consulting. His experience includes leading technical teams creating visual effects for Hollywood blockbusters, running a startup on non-photoreal rendering, using serious games for education, and most recently applying machine learning to the problem of identity. Agrawal received a PhD in Geometric Modeling from the Institute of Robotics and Intelligent Systems at the University of Southern California. He can be reached at amit.agrawal@me.com.