Machine Learning and video games

Introduction

Machine Learning and video games are both decades-old concepts, but both Machine Learning and video games have progressed vastly in only the last few decades. Machine Learning has gone from very simple experimental neural networks (see [SNARC](https://en.wikipedia.org/wiki/Stochastic_neural_analog_reinforcement_calculator)) in the ’50s to powering many of the modern day’s entertainment and financial sectors, to say the least. While Machine Learning has been rapidly developing, so have video games, by going from extremely simple games (see [NIM](https://www.archimedes-lab.org/game_nim/nim.html)) that had their machines and hardware developed specifically for them, to complex three-dimensional open-world games that can be run on multiple platforms that aren’t even dedicated to them. The progress has been staggering, to say the least.

But what has Machine Learning got to do with video games, and vice-versa? Not that much, until recently.

Machine Learning techniques in video games

Since the rapid improvement in GPU (Graphics Processing Unit) processing power in recent years, Machine Learning techniques, such as Deep Learning and Reinforcement Learning, can be utilized in video games to improve the experience in many ways. Let me present some of them to you.

Intelligent Agents

The first thing that might come to your mind is using these techniques to improve the intelligent agents in the game, or more commonly known as NPCs (Non-playable characters). You are also very correct; this is one of the biggest reasons to use Machine Learning in games. This is not some futuristic dream as these techniques are already in use (see [Black & White](https://en.wikipedia.org/wiki/Black_%26_White_(video_game)), a game that was released in 2001 and used a mix of Machine Learning and hardcoded rules). Not to mention the fact that you don’t have to be an expert in Machine Learning to use these techniques yourself. You can do it right now, as some game engine companies have released free Machine Learning packages with simple APIs for you to integrate ML techniques in your game (see [Unity ML agents](https://unity.com/products/machine-learning-agents)), using their game engines.

Traditional and still the most common way to developed AI for games has been to essentially “hardcore” the rules of the agents in code. With enough code, the agents could be made to seem like they have some intelligence. This contrasts with Machine Learning where agents are trained using pre-gathered data or using Reinforcement Learning, where agents are rewarded for correct actions, so they improve over time.

However, although Machine Learning and video games have both developed rapidly, these both in tandem are still in their infancy. To quote Tim Sweeney, the CEO of Epic Games: “[Video Game] AI is still in the dark ages”. I would expect to see some amazing things in this area in the coming years.

Graphics Rendering

Another amazing way Machine Learning has made its way into your video game experience is by making your game's graphics more dynamic and beautiful (what many call eye-candy). There is one major technique that I would like to point out: improving image quality and framerate using Deep Learning neural networks. You might already have this on your computer, as Nvidia, the company behind “RTX” GPUs has integrated a massive, general use (as in, it does not need to be trained on individually on every game) neural network that has been trained using tens of thousands of high-resolution images (see [DLSS 2.0](https://www.nvidia.com/en-us/geforce/news/nvidia-dlss-2-0-a-big-leap-in-ai-rendering/) ). Using this network, the GPU can render your games in higher resolution, while improving your framerates. While this is amazing, it requires you to buy an expensive GPU from Nvidia and the games themselves must support it in software, as it does not work for every graphical application, yet. However, many major game engines support in out of the box (or at least in theory) such as the Unreal Engine.

Other Notable Uses

I discussed using Machine Learning to improve the intelligent agents in your games, all the while improving the graphics. I chose these two topics to mention as they are both under heavy development and already in (somewhat) common use.

These are of course not the only uses of Machine Learning in video games. Video games are so complex today that they take hundreds of people years to make. Most of the systems in complex video games are still developed using traditional game development methods, aka manually programming rules of the game. Seems like an excellent case of utilizing Machine Learning if you ask me. Let us briefly discuss some other possible uses.

Machine Learning could be used in complex systems in games. Think, for example, a weather system modeled after the real world, trained from real data, instead of randomizing the weather or using simple probability (50% probability for sun, 50% probability or rain, etc). Another example could be a complex character interaction system in a game such as Red Dead Redemption 2 (which already has a very impressive interaction system). Think of the possibilities.

Machine Learning could also be used for procedural random generation in games. Procedural random generation is not a new topic in games. Minecraft (Mojang Studios), a very popular video game uses random generation. However, in Minecraft, this random generation is more based on mathematical rules such as “noise” (see [Perlin noise](https://en.wikipedia.org/wiki/Perlin_noise)), not Machine Learning. This area is exciting, but the traditional mathematical formulas are still used more here as they have been tried and tested in battle, but the research in this field is exciting and progressing (see [Deep Learning for Procedural Content Generation](https://arxiv.org/abs/2010.04548) paper).

Utilizing video games in data gathering

Real-world, usable data is incredibly valuable these days. Many services operate based on the fact that they are free while gathering data from the users which can be sold and used for monetary gain. However, for many areas, gathering real-world data can be slow, cumbersome, and costly.

You might think that by gathering data in video games we mean personal data, such as location information, names, purchase history, and so on. And yes, this is a big business, and it is done constantly by the applications and games (especially mobile games) you perhaps play. But what if I told you there was another, more interesting way to utilize games to gather data?

The answer is robotics such as self-driving cars. Neural networks, Computer Vision techniques, and even more traditional Machine Learning methods are at the center of how self-driving cars operate. These cars must be taught how to operate on the real-world conditions that roads provide, not to mention that testing, or validating operations (such as the ML models) can’t and should not always be done on real cars, as this can be expensive if something goes wrong. As you might imagine this is a very complex task. Self-driving cars must detect moving objects such as people while driving along the road and following traffic rules. Now I must add that because of the nature of the problem, and the constantly changing conditions of the real world, it is impossible to just train one neural network for this task and expect it to run forever. No, this is a task that requires constant learning. At Tesla, for example, autonomous cars operate on as many as 50 neural networks running simultaneously by utilizing data coming from various cameras and sensors. Running this many huge networks concurrently is mostly thanks to a network architecture called “HydraNet”, which allows networks to operate on much of the same data pool as other networks, but I won’t go into further details here (see [HydraNet research paper](https://openaccess.thecvf.com/content_cvpr_2018/papers/Mullapudi_HydraNets_Specialized_Dynamic_CVPR_2018_paper.pdf)).

But how do you do the initial training on these robots and cars? And what do video games have to do with any of this? Let me start with the fact that many high-budget games such as Grand Theft Auto V (Rockstar Games) are simulations of sorts, as they have cars that follow traffic rules, road signs, jaywalkers, all that stuff. But how could you tap into all that data and utilize it for Machine Learning tasks, such as training and testing autonomous cars?

Well, there are dedicated plugins for games such as Grand Theft Auto V that transform the game into its own data gathering simulation environment, by allowing you to extract data, such as frame (image), location and weather data among many other things, and thus allowing you to create huge datasets for use in self-driving car training, testing and general research (see [DeepGTAV](https://github.com/aitorzip/DeepGTAV)).

While technically not games, there are also dedicated simulation programs for self-driving cars and robotics research (see [CARLA](https://carla.org/)). These simulations allow the development, training, and validation (testing) of self-driving or autonomous cars.

Conclusion

It is clear that both video games and Machine Learning have come a long way in a short time. Video games industry is bigger than both film and music industry combined, and Machine Learning is already dominating many sectors of the real world.

These two topics combined can create both incredible experiences to enjoy from the home couch and provide valuable data for researchers, even though it might not seem obvious at first.

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