NVIDIA Omniverse: the Future of Industrial Digitalization

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***Abstract*—This article compiles information about Omniverse, a platform created by the American company NVIDIA with the goal of providing developers with tools for industrial digitalization. The objective of this summary is to provide a brief introduction to the various applications of Omniverse, such as 3D modeling, AI training, and drone simulation, the technologies with which the platform can be integrated, and even a glimpse into the future of this technology so that those interested in delving into Omniverse can get a first glimpse into the scope of this platform, all its sustainable competitive advantages, and also the challenges that may arise.**

***Index Terms*—NVIDIA, Omniverse, OmniDrones, Simulation, Isaac Sim, Artificial Intelligence.**

I. Introduction

HAVE you heard of the Turing test? Basically, aims to evaluate a robot's ability to act like a human. In the classic version, the robot is said to pass the test if a real human cannot distinguish whether they are conversing with a machine or another person.

Now, the physical Turing test seeks to evaluate robots' actions and their behavior in the physical world. This involves manipulating objects and navigating complex environments. The question becomes: Can a robot act in a way that is indistinguishable from a human?

This is the idea behind Ominverse, is an important tool because it enables the transition from having AI that understands the world to AI that can act in it. This is possible because it allows the creation, simulation, and testing of virtual worlds with a high level of realism, such that everything learned in simulation can be transferred to the real world.

II. What is Omniverse

To understand what an omniverse is, we must first understand the concept of a metaverse. A metaverse is a 3D virtual space that seeks to replicate aspects of the physical world in a virtual reality. On the other hand, an omniverse could be seen as the interconnection of multiple virtual realities into a single "ecosystem," allowing each of these metaverses to share resources [2].

Based on this, we can consider Omniverse as a collaborative platform specifically designed to connect people, tools, and systems in a unified, shared digital environment. Its purpose is to enable the creation and simulation of complex virtual worlds that not only replicate but also interact with realistic physics and behaviors. We can describe Omniverse as a type of metaverse for engineers and robots.

Speaking more technically, NVIDIA Omniverse is a platform of APIs, services, and software development kits (SDKs) that allow developers to build generative AI-enabled tools, applications, and services for industrial digitalization [3].

A. Current Capabilities of Omniverse

NVIDIA Omniverse offers a robust set of features that position it as a comprehensive platform for industrial simulation, real-time collaboration, and physical artificial intelligence. Its capabilities are not only relevant to the fields of engineering and robotics, but also to the entertainment and animation industries. Some of the potential uses of Omniverse include:

- Avatar Creation: Omniverse Audio2Face uses generative AI to generate realistic facial expressions in 3D avatars. Additionally, using Omniverse USD Composer, you can assemble large 3D models by combining multiple components from different sources.
- Industrial Digital Twins: Allows you to design and optimize entire virtual factories with accurate 3D modeling, process simulation—such as assembly lines—and collaboration between geographically dispersed teams, reducing errors and implementation times.
- Synthetic Data Generation for AI: Integrates tools such as Omniverse Replicator and Cosmos to produce large volumes of simulated visual data, useful for training computer vision and machine learning models with high accuracy.
- Robot and Autonomous Vehicle Simulation: Facilitates the training and validation of physical robots and autonomous vehicles in high-fidelity simulated environments, perfecting controllers and perceptions before real-world deployment.
- 3D Interoperability with OpenUSD: Based on the OpenUSD (Universal Scene Description) format as an interoperable core across multiple 3D tools, advanced RTX rendering, and collaboration across applications such as Autodesk, Adobe, and Siemens.
- Real-Time Collaboration: With Omniverse Nucleus, it enables teams to work simultaneously on the same 3D assets, visualizing changes in real time to accelerate iterations and coordination.
- Cloud Integration and Advanced Services: Offers Platform-as-a-Service (PaaS) deployment via Omniverse Cloud—in collaboration with Microsoft Azure—including application streaming, synthetic data generation, distributed rendering (Omniverse Farm), and robotic simulation (Isaac Sim).

III. Integration of Technologies with Omniverse

The strength of NVIDIA Omniverse lies not only in its native capabilities but also in its ability to seamlessly integrate with a broad ecosystem of technologies and applications. Thanks to open frameworks like OpenUSD, robotics middleware like ROS2, and a robust set of APIs and SDKs, Omniverse becomes a hub where digital content creation tools, simulation engines, and industrial workflows converge. This interoperability allows applications like Blender, Unity, GitHub repositories, etc. to connect directly to the platform, enabling collaborative, real-time, and physically accurate simulations across diverse industries.

A. Key Integrated Technologies

Omniverse is built on a set of core technologies that ensure interoperability, scalability, and accuracy in digital simulation. These technologies allow multiple disciplines to work within a single shared environment.

- OpenUSD (Universal Scene Description Format). OpenUSD acts as the backbone for 3D data interoperability, allowing disciplines such as CAD, simulation, and animation to coexist in a common format, maintaining hierarchies, non-destructive composition, and seamless collaboration. Additionally, the OpenUSD Exchange SDK facilitates the creation of custom, reliable importers and exporters, accelerating workflows within the Omniverse ecosystem.
- URDF and other robotic simulation formats. Omniverse offers specific connectors such as URDF Importer (Universal Robot Description Format), allowing robot configurations to be imported directly for simulation and integration into USD.
- APIs and SDKs (Omniverse Kit, Connectors). The platform includes extensions and development kits that allow the creation of custom applications on top of USD and Omniverse, such as the development of specific tools, automated workflows, or integrations with external services.
- Connectors for CAD systems and data conversion. Omniverse Connect provides a comprehensive collection of tools for importing, exporting, and converting data from various platforms (CAD Converter, Asset Importer, SimScale Converter, etc.) into USD-compatible formats.

B. Supported applications and environments

The true power of Omniverse lies in its ability to integrate with a broad ecosystem of established design, animation, and simulation applications. This integration fosters collaboration between professionals from different fields, enabling a more streamlined workflow and the creation of rich, physically realistic virtual environments.

- Blender. Blender includes native support for USD and has collaborated with NVIDIA to improve the flow with Omniverse through the alpha USD branch, which allows full exchange of MDL materials and preservation of scene information when exporting/importing USD. Additionally, there are official add-ons on GitHub that enable utility panels, scene optimization, integrated animations, and direct compatibility with Omniverse.
- Unity. Integration is achieved through the Omniverse Unity Connector, which allows scenes to be exported/imported to USD from Unity, including materials (OmniPBR or UsdPreviewSurface), physics, animations, lights, cameras, and real-time LiveSync synchronization from Unity to Omniverse.
- Other DCC environments compatible with USD. Omniverse is interoperable with multiple applications that support USD, such as Autodesk Maya, 3ds Max, Alias, Adobe Substance 3D Painter, Unreal Engine, Rhino, iClone, Houdini, SketchUp, and more.
- GitHub and Community Development. NVIDIA's active GitHub presence showcases various tools and templates, including the Omniverse Kit App Template, synthetic data examples, web viewers, PhysX integration, and USD educational examples. [5]

IV. Code examples

NVIDIA provides several code examples that serve as a foundation for developers to help them program in Omniverse. In this section, we'll look at some code examples for the technologies that can be integrated with Omniverse, as discussed in the previous section.

A. USD in Python

Omniverse offers examples of using USD from Python, using both Kit's own APIs and the original USD API. The following example shows a code snippet to create an MDL material [7].

```
from pxr import Sdf, UsdShade

mtl_path =
 ↪  Sdf.Path("/World/Looks/OmniPBR")
mtl = UsdShade.Material.Define(stage,
 ↪  mtl_path)
shader = UsdShade.Shader.Define(stage,
 ↪  mtl_path.AppendPath("Shader"))
shader.CreateImplementationSourceAttr(Usd⌋
 ↪  Shade.Tokens.sourceAsset)
# MDL shaders should use "mdl" sourceType
shader.SetSourceAsset("OmniPBR.mdl",
 ↪  "mdl")
shader.SetSourceAssetSubIdentifier("OmniP⌋
 ↪  BR",
 ↪  "mdl")
# MDL materials should use "mdl"
 ↪  renderContext
mtl.CreateSurfaceOutput("mdl").ConnectToS⌋
 ↪  ource(shader.ConnectableAPI(),
 ↪  "out")
mtl.CreateDisplacementOutput("mdl").Conne⌋
 ↪  ctToSource(shader.ConnectableAPI(),
 ↪  "out")
mtl.CreateVolumeOutput("mdl").ConnectToSo⌋
 ↪  urce(shader.ConnectableAPI(),
 ↪  "out")
```

B. Creating RTX materials

With the Connect SDK, you can easily define RTX-compatible materials. The following example shows how to create a UsdShade.Material optimized for RTX rendering [8].

```
from omni.connect.core import
↪ defineOmniPbrMaterial
from pxr import Usd

stage = Usd.Stage.CreateNew("material_sce
↪ ne.usd")
material = defineOmniPbrMaterial(stage,
↪ "/World/Material", color=(0.8, 0.2,
↪ 0.1), opacity=1.0, roughness=0.5,
↪ metallic=0.0)
```

C. ROS2 Integration

This ROS2 sample demonstrates the creation of a ROS2 node in Omniverse Isaac Sim integrated with the ROS2 Nav2 stack to perform simultaneous navigation of multiple robots [9].

```
    navigation_goal_node = Node(
    name="set_navigation_goal",
    package="isaac_ros_navigation_goal",
    executable="SetNavigationGoal",
    namespace="carter1",
    parameters=[
        {
            "map_yaml_path":
            ↪ map_yaml_file,
            "iteration_count": 3,
            "goal_generator_type":
            ↪ "RandomGoalGenerator",
            "action_server_name":
            ↪ "navigate_to_pose",
            "obstacle_search_distance_in_
            ↪ meters":
            ↪ 0.2,
            "goal_text_file_path":
            ↪ goal_text_file,
            "initial_pose": [0.0, 0.0,
            ↪ 0.0, 0.0, 0.0, 1.0, 0.0],
        }
    ],
    output="screen",
)
```

V. Omniverse for drone simulation

Drone simulation is a key field of research in robotics, logistics, and advanced air mobility. Virtual environments allow for the evaluation of navigation, flight control, and perception algorithms without the need for expensive physical prototypes or potentially risky real-world environments. In this regard, NVIDIA Omniverse offers a unique platform for realistic drone simulation, integrating cutting-edge physics engines, artificial intelligence, and open standards like OpenUSD that ensure interoperability between models and environments. Two drone simulation tools stand out: Isaac Sim and OmniDrones.

A. Isaac Sim

NVIDIA Isaac Sim is a robotics simulator built on Omniverse that uses realistic physics, advanced rendering, and synthetic data generation to train and deploy autonomous robots [10] Its design allows for modeling drones in urban, rural, or industrial settings, evaluating their performance in tasks such as path planning, vision perception, flight control, and multi-agent collaboration.

Isaac Sim also integrates with ROS2 (Robot Operating System 2), allowing developers to run the same control nodes they would use on a physical drone, ensuring a seamless transition between simulation and real-world deployment. This compatibility allows developers to test everything from SLAM (Simultaneous Localization and Mapping) algorithms to distributed control systems.

In the context of drones, Isaac Sim's advantage lies in the ability to generate large volumes of synthetic data with high variability, training perception systems that are more robust than those obtained with real data alone. This is especially useful for extreme or infrequent scenarios, such as flights in adverse weather conditions, dynamic obstacle detection, or coordination between multiple aerial vehicles.

B. OmniDrones

OmniDrones is an efficient and flexible platform tailored for reinforcement learning in drone control, built on Nvidia's Omniverse Isaac Sim [11]. In more detail, OmniDrones is an open source platform whose purpose is to focus on drone learning. For this, it is equipped with an extensive suite of tools, including 4 drone models, 5 sensor modalities, 4 control modes, over 10 benchmarks and a wide selection of RL baselines.

Drone Models.

- Crazyflie. It is a small X-configuration quadrotor widely used for education.
- Hummingbird. It is a medium-sized quadrotor.
- Firefly. It is a medium-sized hexacopter.
- Omav. It is an omnidirectional drone with tiltable rotors.

Sensor modalities. Such as IMUs, RGB-D cameras, segmentation sensors, force sensors, and contact sensors addressing specific requirements for state estimation and perception.

Control modes.

- Rotor. The policy directly commands the target throttle for individual rotors.
- Velocity. Where the policy outputs the target velocity and yaw angle.
- Rate. Where the policy outputs the target body rates and collective thrust.
- Attitude. Where the policy outputs the target attitude and collective thrust.

Benchmarking Tasks.

- Payload & InvPendulum. A single drone is connected to a weight through a rigid link. The attached weight will alter and destabilize the drone's dynamics. The arrangement with the payload at the bottom is called Payload, while the arrangement with the payload on top is called InvPendulum.

- Over-actuated Platform. An over-actuated platform consists of multiple drones connected through rigid connections and 2-DoF passive gimbal joints. Each drone functions as a tiltable thrust generator. By coordinating the movements of the drones, it becomes possible to control their positions and attitudes independently, allowing for more complex platform maneuvers.
- Transport. A transportation system comprises multiple drones connected by rigid links. This setup allows them to transport loads that exceed the capacity of a single drone. Drones need to engage in coordinated control and collaboration for stable and efficient transportation.
- Dragon. A multi-link transformable drone. Each link has a dual-rotor gimbal module. The links are connected via 2-DoF joint units sequentially. The ability to transform enables highly agile maneuvers and poses a challenging control problem.
- Hover. The drone(s) need to drive the system to reach and maintain a target state.
- Track. The drone(s) are required to track a reference trajectory of states. The ability to predict how the trajectory would evolve and plan for a longer horizon is needed for accurate tracking.
- FlyThrough. The drone(s) must fly the system through certain obstacles in a skillful manner, avoiding any critical collision. The obstacles are placed such that a long sequence of coherent actions is needed.
- Formation. A group of drones needs to fly in a specific spatial pattern. This task examines the ability to deal with coordination and credit assignment issues.

RL Baselines

- Single-agent algorithms. DQN, PPO, SAC, TD3, etc.
- Multi-agent algorithms. MAPPO, HAPPO, MADDPG, QMIX, etc.

Despite having predefined drone models that are commonly used, OmniDrones is a flexible platform that seeks to expand the number of existing models, import new models, and add custom dynamics so that each creator can meet their research needs. By combining PyTorch-based multi-rotor dynamics and Nvidia Isaac Sim, OmniDrones can achieve remarkably more than 10^5 steps per second in terms of data collection, thus ensuring the efficiency of the platform.

C. Possible complications

Despite all the tools that Omniverse provides, certain problems can arise when modeling drones, some of the possible difficulties are:

1) High computing requirements: One of the main challenges when using Omniverse for drone simulation is the high demand for computational resources. While it's possible to start with minimal configurations such as an NVIDIA RTX 3060 GPU and 16 GB of RAM, professional and large-scale scenarios typically require workstations with high-end GPUs (RTX 4080/4090 or A6000), 16-core or higher processors, and up to 128 GB of DDR5 memory. Storage can also scale from a few hundred gigabytes for simple projects to several terabytes of NVMe storage in collaborative environments.

Another key challenge is network infrastructure, as real-time collaboration and cloud execution depend on low-latency connections. The location of Nucleus servers relative to clients directly impacts performance, and poor configuration can increase latency and costs. This requires organizations to invest not only in high-performance hardware, but also in optimized and secure networks to support multi-user and distributed workflows.

2) Costs: One of the main obstacles to adopting Omniverse for drone simulation is the cost associated with the entire ecosystem. Beyond the investment in high-performance hardware, there are additional costs for licensing, cloud infrastructure, and maintenance. For small organizations, such as startups or research groups, these expenses can be prohibitive, especially if they require training complex models or running simulations in parallel. Added to this is the high power consumption of high-end GPUs, which not only increases operating costs but also raises long-term sustainability concerns.

3) Unique drone models: Another problem arises when the specific drone model doesn't exist within the native resources of OmniDrones or Isaac Sim. Although the platform provides preconfigured templates and environments, customizing a unique drone requires considerable effort in 3D modeling, physics setup, and custom controller programming. This process involves mastering external tools like Blender for model creation, as well as using OpenUSD and ROS2 to integrate it into the simulation. Consequently, the lack of direct support for certain drones can delay projects and require specialized technical profiles.

4) Validation with the real world: Finally, even with high-fidelity simulations, the challenge of the "sim-to-real gap" persists: the difference between the drone's behavior in virtual environments and in real-life physical scenarios. Factors such as wind, turbulence, electromagnetic interference, or mechanical wear cannot always be accurately represented in Omniverse. This means that control, navigation, or computer vision algorithms trained in simulation may not translate perfectly to the real world. Field experimental validation remains essential, which increases overall development time and cost. Closing this gap requires constant iterative adjustments between simulation and physical testing.

VI. The future of Omniverse

Nvidia Omniverse is emerging as the most comprehensive platform for integrating 3D and physics simulation workflows across various cloud services, applications, and rendering engines. In the short term, Nvidia plans to strengthen the connection of these workflows with its ecosystem of hardware and artificial intelligence tools.

The company also actively collaborates with open standards organizations and communities, such as OpenXR for XR experiences and spatial computing, GLTF for 3D content sharing in consumer applications, and USD to expand its reach into advanced engineering and simulation. All of these enhancements will be progressively incorporated into the platform.

Another key pillar is the Omniverse marketplace, which makes it easier for suppliers and experts to monetize spe-

cialized services and resources. This benefits companies by enabling the flexible combination of design, development, testing, and monitoring capabilities across a variety of tools. Nvidia maintains strategic alliances with leaders in PLM, GIS, CAD, computer-aided engineering, simulation, and game engines, with the goal of continuing to optimize and unify workflows across the ecosystem [12]

A. Sustainable Competitive Advantage

The concept of sustainable competitive advantage (SCA) was first introduced in 1984 by George Day, defining that there are certain strategies that help a company "sustain the competitive advantage". In 1991, it was established that an organization has a sustainable competitive advantage when it implements a value creation strategy that is not being implemented by any current or potential competitor and when competitors cannot copy the process. [13]

With the concept in mind, Omniverse has multiple SCAs that help it position itself in the competitive landscape. On the one hand, it has established global adoption, boasting a solid base of more than 300,000 downloads and more than 250 user companies, with a strong presence in developed markets led by the US, Germany, and the UK. Its adoption by iconic companies in Japan and India strengthens its international reach and positions the platform as the de facto standard in physical AI for industry.

The platform is used in sectors as diverse as automotive, electronics, and consumer goods, powering everything from digital twin factories (BMW, Mercedes-Benz) to industrial process optimization and marketing (Foxconn, Pegatron, PepsiCo, Unilever), meaning it has great multi-sector versatility.

While there are various platforms like Unity, which excels in video game development due to its high-fidelity graphics, the competitive landscape places Omniverse in a unique position due to the elements that make Omniverse different from other platforms, such as its Universal Scene Description foundation, which allows for true interpolation between more than 50 3D formats, integration of physics-based AI across platforms like Isaac and Cosmos, and real-time RTX rendering with AI-powered features.

It also offers enterprise-grade collaboration and a wide variety of connectors with more than 80 third-party applications. Through these software integrations, an ecosystem of partnerships is created that creates significant SCAs. Omniverse is a core part of NVIDIA's growth strategy, bringing value to key segments such as data centers and automotive, which are expected to generate record revenue by 2025. While specific figures for Omniverse aren't disclosed, its role as the "operating system for physical AI" positions it to capture an estimated $50 billion opportunity in industrial digitalization, strengthening the company's leadership and competitive advantage. [14]

VII. Conclusion

NVIDIA Omniverse represents a paradigm shift in the way industries design, simulate, and deploy intelligent systems. By combining real-time collaboration, advanced physics simulation, and interoperability through standards like OpenUSD, the platform enables the creation of digital twins, the training of AI models with synthetic data, and the safe testing of robots and autonomous vehicles before real-world deployment.

Its integration with tools like Isaac Sim and OmniDrones demonstrates Omniverse's versatility, extending its impact to fields ranging from robotics and manufacturing to entertainment and design. However, the platform also faces challenges, such as high computational requirements, costs, and the persistent gap between simulation and reality, which require continued innovation and investment.

Despite these obstacles, Omniverse maintains a sustainable competitive advantage thanks to its global adoption, its partner ecosystem, and its unique combination of AI, physics, and 3D interoperability. In this sense, Omniverse is not just a simulation platform, but a fundamental technology that is shaping the future of industrial digitalization, accelerating the transition to more efficient, collaborative, and intelligent workflows.

References

[1] Sequoia Capital. (2025, 12 may). *Google's Jeff Dean on the Coming Transformations in AI* [Video]. YouTube. https://www.youtube.com/watch?v=dq8MhTFCs80

[2] Enrique, A. L. (2025, 2 abril). *El omniverso: qué es y en qué se diferencia del metaverso.* Nubiral. https://nubiral.com/el-omniverso-que-es-y-en-que-se-diferencia-del-metaverso/

[3] *NVIDIA Omniverse - NVIDIA Docs.* (s.f.). NVIDIA Docs. https://docs.nvidia.com/omniverse/index.html

[4] NVIDIA Studio Latinoamérica. (2024, March 1). *¿Qué es NVIDIA Omniverse?* [Video]. YouTube. https://www.youtube.com/watch?v=da-Ehd76QpE

[5] *NVIDIA Omniverse.* (n.d.). GitHub. https://github.com/NVIDIA-Omniverse

[6] *Code Samples — Omniverse Developer Guide.* (n.d.). https://docs.omniverse.nvidia.com/dev-guide/latest/programmer_ref.html

[7] *Create an MDL material — Omniverse Developer Guide.* (n.d.). https://docs.omniverse.nvidia.com/dev-guide/latest/programmer_ref/usd/materials/create-mdl-material.html

[8] *Connect SDK Python API — Omniverse Connect SDK 1.0.0 documentation.* (n.d.). https://docs.omniverse.nvidia.com/kit/docs/connect-sdk/1.0.0/docs/python.html

[9] *Multiple Robot ROS2 Navigation — Isaac SIM Documentation.* (n.d.). https://docs.isaacsim.omniverse.nvidia.com/4.2.0/ros2_tutorials/tutorial_ros2_multi_navigation.html

[10] *NVIDIA Developer.* (n.d.). NVIDIA Isaac Sim. https://developer.nvidia.com/isaac/sim

[11] Xu, B., Gao, F., Yu, C., Zhang, R., Wu, Y., & Wang, Y. (2024). OmniDrones: An Efficient and Flexible Platform for Reinforcement Learning in Drone Control. *IEEE Robotics and Automation Letters, Robotics and Automation Letters, IEEE, IEEE Robot. Autom. Lett, 9(3), 2838–2844.* https://doi.org/10.1109/LRA.2024.3356168

[12] Lawton, G. (2024, March 5). *Nvidia omniverse.* Search CIO. https://www.techtarget.com/searchcio/definition/Nvidia-Omniverse

[13] Gould, M. (2021). Sustainable Competitive Advantage. *Salem Press Encyclopedia.*

[14] Crosley, B. (2025b, August 11). *NVIDIA Omniverse: the $50T physical AI operating system — InTROL.* Introl. https://es.introl.com/blog/nvidia-omniverse-the-operating-system-for-physical-ai-and-industrial-digitalization