Visualizing the Future

Demand for 3D Graphics and
Real-time 3D Across the Economy

May 2019
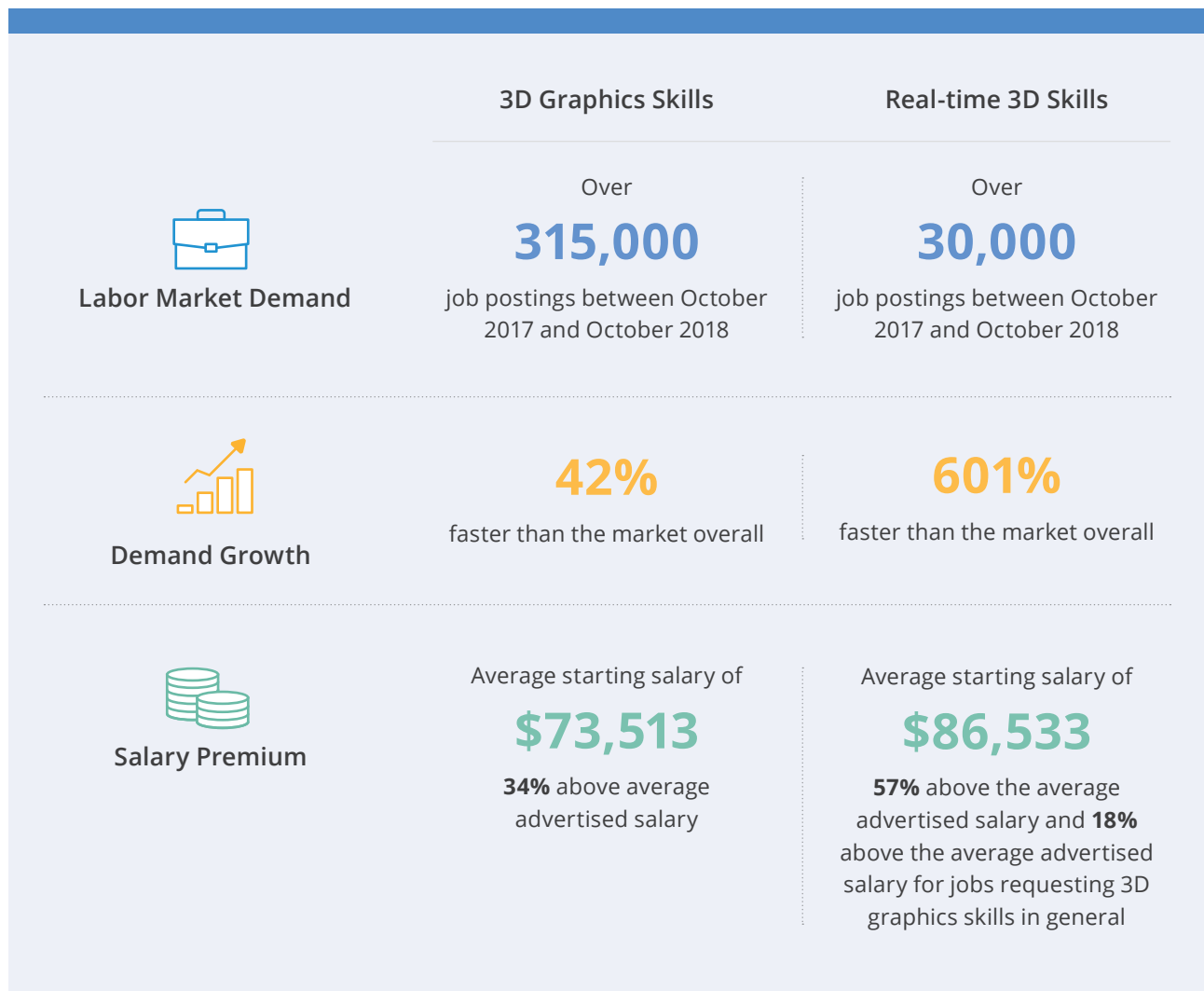
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Executive Summary

Advanced 3D technology has demonstrated the potential of the virtual world—real-time 3D is expanding the horizon. Labor market demand for workers proficient in these fields is robust and growing.

Advanced 3D technology has demonstrated the potential of the virtual world. 3D graphics have become essential to understanding designs and concepts in industries as diverse as architecture, manufacturing, health care, and film. Due to the constraints of prior technology, much of this visualization has historically been focused on static images or limited animations. In the last few years, however, the explosion of virtual reality technology has shifted the paradigm from observation to experience. Earlier 3D graphic technologies fell short of delivering experiences that allow for exploration and interaction, but the growing field of "real-time 3D" enables these possibilities. Real-time 3D skills and technologies have risen in importance as companies seek to achieve immersive experiences. Real-time 3D extends the horizon of 3D graphics to realize the full potential of the virtual world, to bridge the gap between being on the outside looking in and being on the inside looking around.

	3D Graphics Skills	Real-time 3D Skills
Labor Market Demand	Over **315,000** job postings between October 2017 and October 2018	Over **30,000** job postings between October 2017 and October 2018
Demand Growth	**42%** faster than the market overall	**601%** faster than the market overall
Salary Premium	Average starting salary of **$73,513** **34%** above average advertised salary	Average starting salary of **$86,533** **57%** above the average advertised salary and **18%** above the average advertised salary for jobs requesting 3D graphics skills in general

To be considered real-time, the interaction between a user and a virtual scene must register faster than a blink of an eye. This feat is achieved through real-time rendering. Actions animated at this rate are indistinguishable from the same actions taking place in real life. Many real-time 3D applications are already familiar: pilots training on flight simulators, video games, virtual reality headsets, or actors in motion capture suits using their performance to drive animated characters in a live environment.

Labor market demand for 3D graphics skills is spreading across the broader economy. Real-time 3D is a subset of 3D graphics with particularly explosive demand growth. 3D graphics and real-time 3D skills are emerging as a force for innovation in fields like engineering, IT, and design. Increasing demand for these skills in business fields such as sales and marketing demonstrates the desire to commercialize the associated products. As consumer appetite for immersive experiences increases, demand for real-time 3D will continue to spread across the workforce, creating hybrid roles that mix skills usually found in distinct occupations.

As real-time and 3D graphics skills become more integral to many occupations across the economy, it will be necessary to prepare a workforce able to leverage these skills. Epic Games partnered with Burning Glass Technologies to quantify demand for these skills and to investigate factors impacting the use and adoption of 3D graphics and real-time 3D skills in the workforce. The analysis yielded the following key conclusions:

- **Demand for 3D graphics is robust, and demand for real-time 3D skills is growing quickly.** Between October 2017 and October 2018, more than 315,000 job postings requested 3D graphics skills. The demand for 3D graphics skills during this time was over 55,000 openings greater than the demand for data science-related skills. Demand for 3D graphics skills has grown 42% faster than the market overall. Demand for real-time 3D skills, which are at the technological frontier of 3D graphics, has grown 601% faster than the market overall and now accounts for 10% of all openings calling for 3D graphics, up from 4% in 2013. In total there were 31,339 openings calling for real-time 3D skills between October 2017 and October 2018.

- **Real-time 3D is creating "hybrid jobs."** Previous Burning Glass research has

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found that many of the fastest-growing jobs in the economy are hybrids, merging skill sets that aren't usually found together.[1] Hybridization occurs when a skill previously found in one group of occupations spreads to a different set of occupations. Real-time 3D is an engine for such hybridization. In addition to expected occupations such as video game artists and programmers, occupations with the greatest demand for real-time 3D include software developers and mobile app developers, highlighting the diversity of use cases for these skills. Further, demand for these skills is present in business fields such as sales, marketing, and business management, demonstrating the push to commercialize the associated products and underscoring the need for workers in these fields to gain familiarity with real-time 3D. As demand for real-time 3D skills spreads across the workforce, workers in hybridizing occupations will be asked to mix skills in new combinations. These hybrid roles may not align with traditional training programs, making it harder to prepare workers for these jobs.

- **Proficiency with 3D graphics is a foundational skill for engineers.** Engineering accounts for 48% of the demand for 3D graphics, and 96% of these job openings request CAD skills. Currently 1 in 5 job openings in engineering requests at least one CAD skill. CAD technology is beginning to employ real-time 3D as well, with over 2,000 job postings requesting proficiency with at least one real-time CAD technique or technology.

- **3D graphics skills have different use cases in different career fields.** In engineering, 3D graphics skills are important for industrial and boutique manufacturing. In information technology and design and media, 3D graphics and real-time 3D are used to create immersive experiences. In these career areas, animation skills, proficiency with game engines, and manipulation of virtual reality are in high demand.

- **Real-time 3D skills are undersupplied, and that is unlikely to change any time soon.** Real-time 3D is associated with a large salary premium: 57% above the average advertised salary and 18% above the average advertised salary for jobs requesting 3D graphics skills in general. In the career fields where these skills are in highest demand, filling a position can often take over 40 days. Real-time 3D skills are also among the fastest-growing in the market, which carries the risk of exacerbating the gap between supply and demand.

- **Mastering 3D graphics or real-time 3D skills can lead to strong entry-level opportunities and provide a boost to early-career professionals.** Nearly a quarter (23%) of job openings for 3D graphics skills and a fifth (19%) of job openings calling for real-time 3D skills are entry-level positions. The vast majority of job openings require a bachelor's level education (77% for 3D graphics and 81% for real-time 3D). For students or new entrants to the job market, mastering 3D graphics skills can lead to a salary premium of 24% over other entry-level jobs—and mastering real-time 3D can lead to a salary premium of 45% above other entry-level jobs. Becoming proficient with these skills can also benefit early-career professionals who are already in the workforce. Most job openings calling for 3D graphics skills require 3-5 years of experience. On average, these postings advertise a salary 13% higher than other job postings requiring similar levels of experience—and 38% higher for jobs requesting real-time 3D skills.
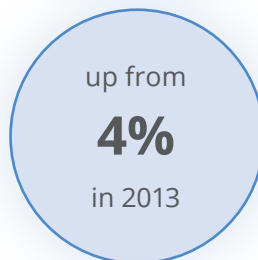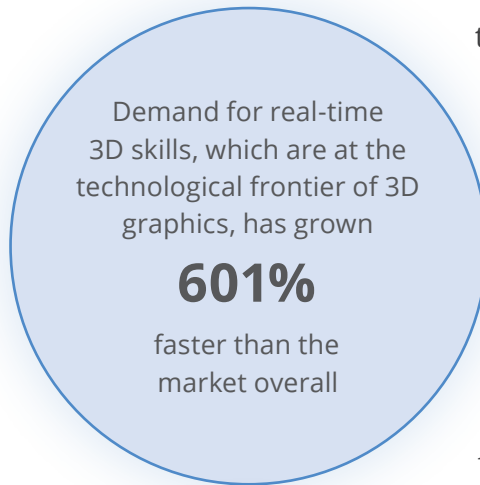
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Introduction

The difference between the real world and the virtual world is narrowing. As the generation brought up with video games, smartphones, and the internet enters the workforce and as companies explore the opportunities unlocked by advanced visual technology, the growing importance of the virtual world is also reflected in the labor market.

The initial capabilities of 3D graphics hinted at the possibilities of the virtual world. Being able to visualize 3D data brought architectural blueprints to life and brought previously impossible scenes to the silver screen. It aided prosthetists in rebuilding the human body. And it revolutionized how brands, companies, and industries present themselves and their products. Visualization using pre-rendered images alone, however, falls short of delivering the genuine experiences promised by the virtual world. Missing from such pre-rendered representations is the real-time interaction that makes an experience truly immersive. Real-time 3D, then, aims to extend the horizon of 3D graphics and realize the full potential of the virtual world.

Real-time 3D applies real-time rendering to 3D data. To be considered real-

Demand for real-time 3D skills, which are at the technological frontier of 3D graphics, has grown

601%

faster than the market overall

It now accounts for

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up from

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in 2013

In total there were

31,339

openings calling for real-time 3D skills between October 2017 and October 2018

time, the interaction between a user and a virtual scene must register much faster than the blink of an eye—films are shot at 24 frames per second, but real-time 3D technologies aim for 90 frames per second. Slower than this rate, a user will judge the experience as non-interactive. Real-time 3D also enjoys many degrees of freedom and a wide range of interaction. Instead of watching a clip of a canoe floating down a river, real-time 3D brings the viewer into the canoe, where she can not only look around but also engage with the scene—steer the canoe, rock it back and forth, or dive off of it into the water.

Real-time 3D is updating the ways in which individuals interact with designs and concepts, and its applications are already widespread. Pilots take advantage of real-time 3D when they train on flight simulators. Real-time

3D allows architects and designers to walk clients through a building that has yet to be constructed. Production facilities use real-time 3D to follow the workflow between workers and machines. Actors in motion capture suits simulating the movements of animated characters are relying on real-time 3D. Real-time 3D is an important facet of the modern economy, and its importance is only set to grow.

By extension, 3D graphics skills and real-time 3D are becoming more integral to many occupations across the economy. This shift necessitates a prepared workforce able to leverage these skills. Preparing such a workforce will require a training infrastructure to be in place to help workers develop the

real-time and 3D graphics skills necessary for jobs where these skills have value. The training infrastructure should take into consideration the challenges and opportunities associated with these skills: Where are these skills deployed? Where are they growing? Where do they add value? How does the value of these skills circle back to the worker, whether in a higher salary or greater career mobility?

To answer these questions and better understand the opportunities associated with 3D graphics and real-time 3D skills, Epic partnered with Burning Glass Technologies to quantify demand for these skills and investigate factors impacting the use and adoption of 3D graphics and real-time 3D skills in the workforce.
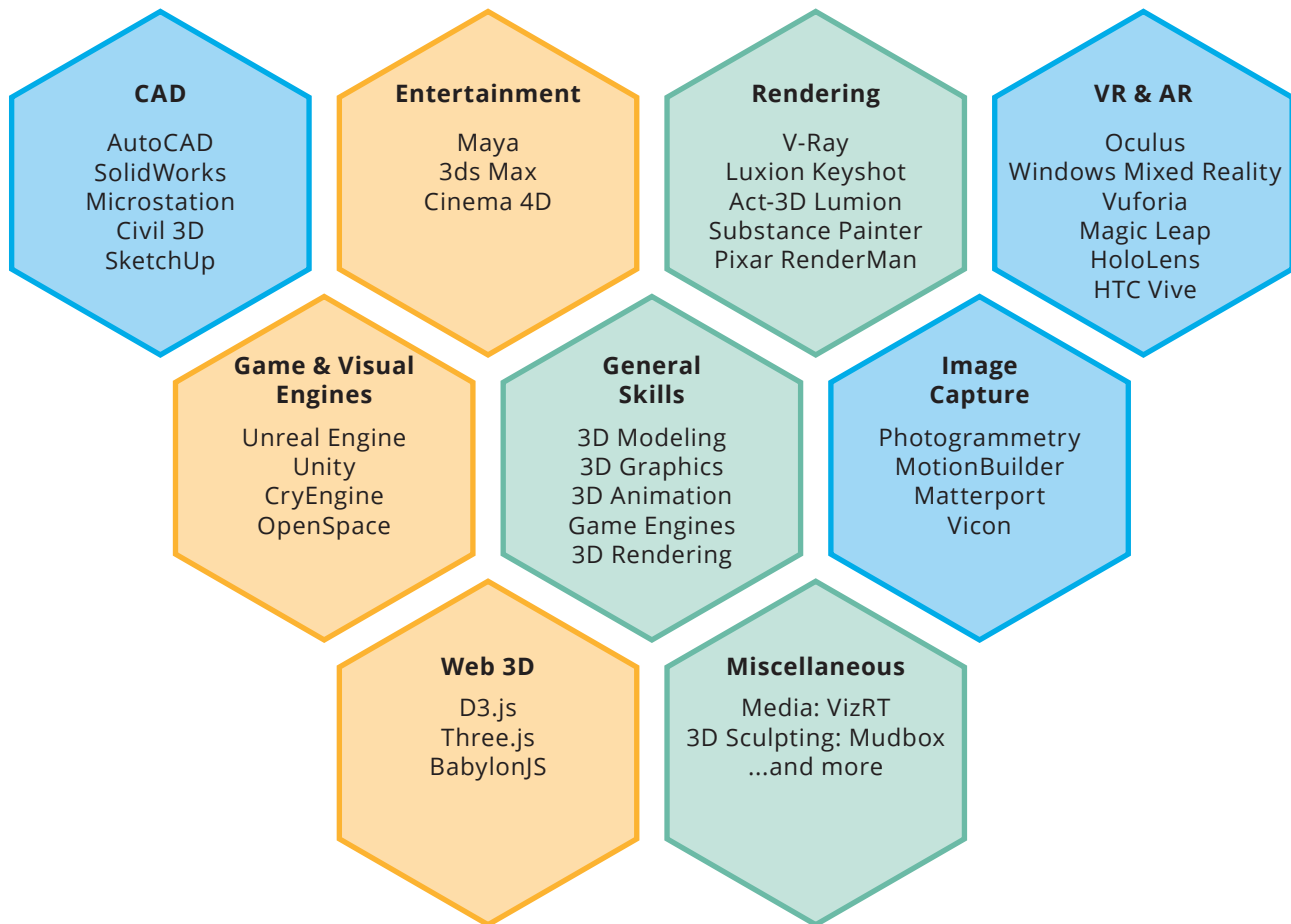
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Methodology

To analyze demand for 3D graphics skills and real-time 3D in the workforce, Epic and Burning Glass took a two-stage approach, first defining the full universe of 3D graphics skills and then identifying which of those skills leverage real-time techniques. In defining the universe of 3D graphics, Burning Glass and Epic pulled in jobs that use 3D skills from the following categories: computer-assisted design, digital content creation, rendering, virtual reality (VR), augmented reality (AR), game engines, performance capture, design visualization, 3D modeling, film and video, and a collection of general skills. Burning Glass and Epic identified 209 skills related to 3D graphics. (For a list of these skills, see the Appendix.) The second stage was to flag the 3D graphics skills that specifically utilize real-time 3D technologies and techniques. This process was informed by trade publications, product descriptions, and industry blogs, as well as through consultation with professionals with years of experience in 3D graphics. Epic and Burning Glass flagged 97 skills as relevant to real-time 3D. The basket of real-time 3D skills was then compared to the larger universe of 3D graphics skills to identify where these skills are emerging and where they are adding value.

To assess demand for 3D graphics and real-time 3D skills, Burning Glass mined its comprehensive database of nearly a billion current and historical online job postings to identify occurrences of these skills in job openings. Burning Glass builds this database by collecting job postings from close to 35,000 online job boards, newspapers, and employer sites daily. Burning Glass then de-duplicates postings for the same job, whether it is posted multiple times on the same site or across multiple sites. Finally, Burning Glass applies detailed text analytics to code the specific jobs, skills, and credentials requested by employers. Burning Glass has developed a skills taxonomy with nearly 18,000 unique skills. Many 3D graphics skills are included in this taxonomy. In the case of emerging real-time 3D skills not in the Burning Glass skills taxonomy, skills were located in job postings using keyword searches of the text of the job posting. Burning Glass's unique data assets provide a detailed view into the jobs and skills that employers demand.

Stage 1: Examples of 3D Graphics Skills by Category

CAD
AutoCAD
SolidWorks
Microstation
Civil 3D
SketchUp

Entertainment
Maya
3ds Max
Cinema 4D

Rendering
V-Ray
Luxion Keyshot
Act-3D Lumion
Substance Painter
Pixar RenderMan

VR & AR
Oculus
Windows Mixed Reality
Vuforia
Magic Leap
HoloLens
HTC Vive

Game & Visual Engines
Unreal Engine
Unity
CryEngine
OpenSpace

General Skills
3D Modeling
3D Graphics
3D Animation
Game Engines
3D Rendering

Image Capture
Photogrammetry
MotionBuilder
Matterport
Vicon

Web 3D
D3.js
Three.js
BabylonJS

Miscellaneous
Media: VizRT
3D Sculpting: Mudbox
...and more

Stage 2: Examples of Real-time 3D Skills

- Virtual Reality (VR)
- Navisworks
- Unreal Engine
- Augmented Reality
- Oculus Rift
- Mixed Reality
- Unity
- Magic Leap
- Siemens Lifecycle
- Luxion KeyShot
- HoloLens

- Flight Simulation
- Act-3D Lumion
- Three.js
- ARKit
- Dassault Systemes 3DExperience
- VizRT
- HTC Vive
- ARCore
- MotionBuilder
- ...and more

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Findings

Demand for 3D graphics is robust, and demand for real-time 3D is growing quickly

Between October 2017 and October 2018, there were 315,246 job openings requesting 3D graphics skills. The demand for 3D graphics skills is over 55,000 openings greater than demand for data science-related skills.[2] As robust as workforce demand already is for 3D graphics, it only continues to climb: since 2013, demand for 3D graphics skills has grown 42% faster than the market overall.

Of the job openings requesting 3D graphics skills, 31,339—or 10%—specifically requested real-time 3D skills. Demand for real-time 3D skills has grown 601% faster than the market overall. The demand for real-time 3D resembles demand for other advanced, fast-growing clusters of skills, such as those related to natural-language processing, digital design, or neuroscience. There were between 25,000-35,000 job postings over the same time period calling for skills from each of these clusters. Real-time 3D has emerged as a skill cluster with meaningful demand.

Percentage of 3D Graphics Jobs Requiring Real-time Skills
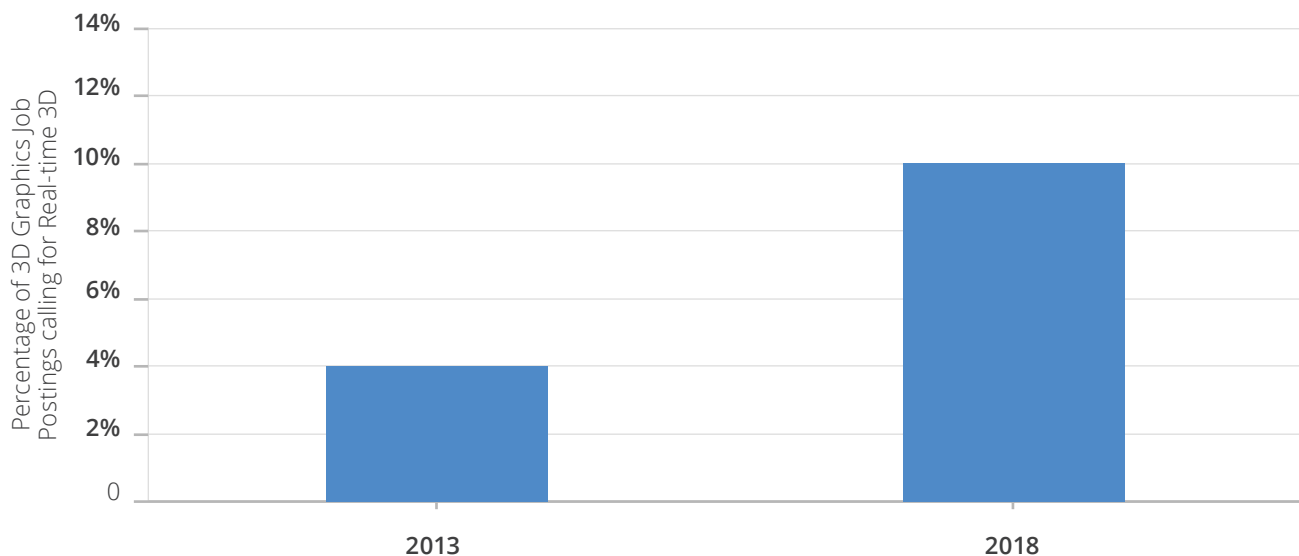
2 Specifically, data science, data mining, and machine learning.

Growth in demand for real-time 3D has outpaced the rapid growth in demand for 3D graphics skills as a whole. Demand for real-time 3D has grown nearly five times faster than demand for 3D graphics skills and over seven times faster than the market overall. Within jobs calling for 3D graphics skills, real-time 3D skills are now requested 2.4 times more often than in 2013.

3D graphics enjoys diverse use cases including industrial design for engineering and construction and extended reality (XR) for IT and design.

During the year between October 2017 and October 2018, 13 career areas had more than 1,500 openings requesting 3D graphics skills. These career areas range from

Table 1: Job Openings and Relative Growth of 3D Graphics Skills by Career Area

Career Area*	Openings Requesting Skills (2018)	Growth in Share of Career Area Requesting Skills (2013-2018)
Engineering	150,818	15%
Information Technology	38,312	36%
Construction and Architecture	20,509	34%
Design and Media	15,943	-15%
Business Management	12,686	9%
Sales	8,718	104%
Manufacturing and Production	8,690	-7%
Planning and Analysis	5,194	21%
Repair and Installation	3,822	11%
Education and Training	3,322	-35%
Health Care	3,080	9%
Marketing and Public Relations	2,947	67%
Science and Research	1,810	22%

* Career areas with at least 1,500 openings requesting 3D graphics skills in 2018

engineering and IT to sales and marketing. In a majority of these career areas, the rate at which these skills were requested increased between 2013 and 2018. That is, not only is demand for 3D graphics skills present in a wide range of professional fields, but in most of these fields, that demand is also putting down roots.

Engineering accounts for close to half (48%) of the job openings calling for 3D graphics skills, and 96% of those job openings request CAD skills.[3] Proficiency with CAD software is integral to engineering. Currently 1 in 5 job openings in engineering requests at least one CAD skill. Real-time 3D skills are also important to engineering. Over 2,000 job postings in engineering require familiarity with real-time CAD

techniques, and over 1,200 engineering postings call for real-time VR skills. Other career areas where demand for 3D graphics is synonymous with demand for CAD skills are construction (97% of demand for 3D graphics is for CAD skills), manufacturing (93%), and repair and installation (92%).

In information technology, the 3D graphics skills in greatest demand are related to creating immersive extended reality (XR) experiences. These include skills like 3D animation, rendering, and 3D modeling, as well as proficiency with game engines and VR. Together these skills account for 56% of demand for 3D graphics in information technology. The same is true for design and media, where these skills account for 58% of demand for 3D graphics.
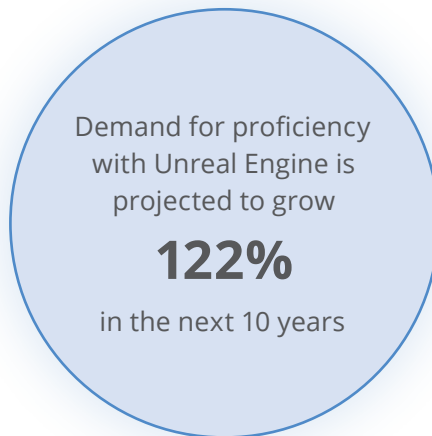
CAD in Real Time

CAD technologies are evolving to incorporate real-time technology. SketchUp, a popular CAD software, has a plethora of extensions that take advantage of real-time rendering. Autodesk software such as Navisworks and Revit is incorporating real-time rendering to create photorealistic images and to allow users to manipulate designs through different lightings and atmospherics. Given that real-time capabilities are emerging in areas that have historically embraced 3D graphics, the large number of jobs requesting CAD skills presents an opportunity for real-time 3D.

3 CAD—or computer-aided design—skills mean proficiency with the computer technologies that organize, document, and facilitate the design of a physical product.

Overall, demand for 3D graphics skills is highly concentrated in five career areas: engineering, information technology, construction and architecture, design and media, and manufacturing and production.

Most jobs within these five career areas have a strong focus on STEM (science, technology, engineering, and mathematics), and 3D graphics skills feature more prominently in STEM occupations generally. Specifically, these skills are 469% more likely to be in demand in STEM occupations than in non-STEM jobs. As emerging technologies such as the Internet of Things (IoT) and VR deepen the interplay between science, technology, analytics, and the physical world, demand for these skills in STEM roles is only likely to grow.

Real-time 3D is an engine for hybridization, as demand for these skills spreads across career areas

Labor market demand for real-time 3D skills is spreading at a faster rate than demand for 3D graphics skills as a whole. The share of 3D graphics jobs requesting real-time skills has grown 137% since 2013, from 4% to 10% of all 3D graphics openings. The share of all openings requesting real-time 3D has increased 164% since 2013. Between October 2017 and October 2018, there were more than 30,000 openings requesting real-time 3D.

The relative growth in demand for real-time 3D is greatest in the career fields responsible for commercializing the

Demand for proficiency with Unreal Engine is projected to grow **122%** in the next 10 years

Table 2: Demand Concentration for 3D Graphics Skills by Career Area

Career Area	% More Concentrated than in the Market Overall
Engineering	**+1,604%**
Construction and Architecture	**+268%**
Design and Media	**+244%**
Information Technology	**+24%**
Manufacturing and Production	**+7%**

associated products and technologies. Among career areas with at least 500 openings calling for real-time 3D, the rate of growth is greatest for marketing and PR (669%), sales (402%), and business management (363%). In each case, the share of openings in the career area calling for real-time 3D skills has increased over 300%. Professionals in these fields are responding to increased consumer appetite for immersive experiences. The proliferation of these skills across other career fields demonstrates the viability of commercializing technologies like VR and AR.

When workers in fields not traditionally associated with 3D technology need to gain proficiency in related skills, hybrid roles are generated. For these workers, proficiency with real-time 3D can lead to career advancement, a higher salary, and improved mobility. However, hybrid roles may not align with traditional training programs, making it harder to prepare workers for these jobs.

Demand for workers skilled in real-time 3D is greatest in information technology (11,441 openings between October

Table 3: Job Openings and Relative Growth of Real-time 3D Skills by Career Area

Career Area*	Openings Requesting Skills (2018)	Growth in Share of Career Area Requesting Skills (2013-2018)
Information Technology	11,441	129%
Engineering	4,053	189%
Design and Media	2,724	83%
Sales	1,722	402%
Construction and Architecture	1,192	180%
Marketing and Public Relations	1,091	669%
Business Management	1,002	363%
Education and Training	820	73%
Analysis	600	186%

* Career areas with at least 500 openings requesting real-time 3D graphics skills in 2018

Hybridization with Real-time 3D

Upskilling with real-time 3D means building on existing skills. Software developers that work on VR or game engines are still requested to know C++ in over 50% of job postings, a figure that has remained stable since 2013. However, because these software developers are programming real-time 3D into video game software, job postings for these positions increasingly request familiarity with the types of tools used by video game designers and animators. Hybridization occurs when a skill previously found in one group of occupations spreads to a different set of occupations. Tools and skills related to real-time 3D are driving hybridization for software developers, as well as for mobile app developers, engineers, and other positions in which demand for these skills is new and growing. A consequence of hybridization is that the traditional training pipelines for these jobs breaks down. For example, there is little overlap between the training pipeline for software developers and the pipeline for video game developers, so it may be difficult for software developers to gain the knowledge they need to program real-time 3D into gaming software. Employers and educators will need to develop a more flexible infrastructure to prepare workers for hybrid jobs requesting real-time 3D.

2017 and October 2018), engineering (4,053), and design and media (2,724). These professionals use real-time 3D for industrial design or to develop immersive XR experiences, and the fruits of their labor are then brought to market by those in business management, sales, and marketing. Since 2013, the greatest increase in absolute demand for real-time 3D skills was in positions related to content creation and product development, such as software developers, multimedia designers, and illustrators. Compared to 2013, in 2018 Burning Glass captured over 7,500 more openings in IT calling for these skills, over

2,500 more openings in engineering, and over 1,800 more openings in design and media.

Real-time 3D skills are among the fastest growing in the market

Although demand for real-time 3D skills is already growing considerably faster than the rest of the job market, specific skills within the field are experiencing even more rapid growth. For example, demand for proficiency with VR is projected to grow 189% over the next 10 years, while demand for knowledge of Oculus and HoloLens, two leading VR and AR

Employers Add Value with Real-time 3D

Within the world of 3D graphics, some of the fastest-growing skills are related to real-time 3D: VR, AR, visual engines. Firms employ these skills at the cutting edge of research and development. Researchers at General Motors request Unreal Engine in job postings related to their work on autonomous vehicles. Job postings for Facebook's Social VR Team request familiarity with game engines, too.

technologies, is projected to grow by 185% and 28%, respectively. Skills related to game engines are also experiencing transformative growth. Over the next ten years, demand for candidates with Unreal Engine skills is projected to grow 122%, and demand for those with Unity skills is expected to grow 72%. Technologies within the CAD skill set that embrace real-time rendering are also projected for substantial growth. Demand for proficiency in Navisworks, for example, is set to grow 110% over the next 10 years.

Just as certain real-time 3D skills are growing rapidly, certain occupations demanding these skills are also among the fastest-growing. For instance, demand for video game developers, who may use real-time 3D programs like Unreal or Unity, is projected to grow over 20% in the next 10 years, twice as fast as the overall market. The projected growth in demand is also high for GIS specialists and multiple engineering professions, among whom CAD skills are already in high demand.

Table 4: 3D Graphics Skills with the Highest Projected Growth in Demand

Skill	10-yr Projected Growth Rate in Demand
Augmented Reality	207%
Virtual Reality	189%
Oculus	185%
Unreal Engine	122%
Unity	72%
HoloLens	28%
Overall Labor Market	10%

Table 5: Fast-Growing Jobs Commonly Requiring Real-time 3D Skills

Occupation	10-yr Projected Growth Rate
Video Game Developer	21%
GIS Specialist	19%
Robotics Engineer	15%
Transportation Engineer	12%
Overall Labor Market	10%

The occupations with the greatest number of job openings for real-time 3D skills are also projected to grow, often at a faster rate than the overall labor market.

3D graphics skills command hefty salaries, and there is an even larger salary premium for mastering real-time 3D

Job openings requesting at least one 3D graphics skill have an average advertised salary of $73,513—34% above the average advertised salary of $55,000. Job openings requesting real-time 3D have an advertised salary of $86,533, a premium of 57% above the average salary and 18% above the average salary for jobs requesting 3D graphics skills.

While much of this heightened salary is due to the frequency with which these skills are requested in jobs that are already high-skilled and high-paying, there is evidence that these skills push salaries higher across career areas. For example, 3D graphics and real-time 3D skills lead to salary premiums in the two career areas with the highest absolute demand for these skills, engineering and information technology, both of which are among the highest-paying and highest-educated fields in the workforce. However, these skills also command a significant salary premium in fields traditionally open to middle-skill workers

Table 6: Occupations with the Greatest Demand for Real-time 3D Skills

Occupation	Openings Requesting Skills (2018)	10-yr Projected Growth Rate
Software Developer / Engineer	5,011	27%
Artist / Illustrator	951	-1%
Mobile Applications Developer	678	28%
Architect	665	7%
Computer Systems Engineer	626	16%
Multimedia Designer / Animator	601	-1%
CAD Designer / Drafter	590	7%
Overall Labor Market		10%

that don't require a four-year college degree, such as manufacturing and production or construction and architecture. This suggests that 3D graphics skills offer strong salaries across a broad range of careers and worker profiles.

Emerging real-time 3D skills earn the highest salary premiums

Skills that expand the boundaries of what's possible in 3D earn the highest salary premiums. These include proficiencies with game engines, which are most frequently requested in job openings for video game artists and engineers, but also appear in job openings for computer programmers and mobile app developers. In this category, Unreal Engine claims the highest salary premium, and proficiency in this skill adds

a salary premium of 51% for illustrators, 22% for computer programmers, and 5% for video game designers.

Skills related to VR also fetch large salary premiums. These skills are most commonly requested in job openings for occupations in information technology, such as software developers and mobile app developers. However, demand is also emerging for these skills in science and research. In fact, the salary premium for proficiency with Oculus technology is 77% for researchers compared to 15% for software developers.

The 3D graphics skills with the highest salary premiums are associated with new real-time technologies. Some industrial design and product lifecycle management skills also command high salary premiums. Mastering 3D graphics skills, particularly real-time 3D skills, can lead to large salary increases.

3D graphics and real-time 3D skills lead to strong career opportunities for entry-level workers and across education levels, and these skills are currently undersupplied

Real-time 3D is associated with a large salary premium:

57%

above the average advertised salary

and

18%

above the average advertised salary for jobs requesting 3D graphics skills in general

Between October 2017 and October 2018, 23% of all openings requesting 3D graphics skills were looking for entry-level candidates with no more than two years of previous work experience. By comparison, only 20% of all IT jobs were entry-level, suggesting that 3D graphics skills can open more doors for entry-level workers than many other digitally intensive skills. Further, entry-level jobs calling for these skills pay well: on average, they advertise salaries that are 24% higher than other entry-level jobs, and jobs requesting real-time 3D skills advertise salaries 45% higher than other entry-level jobs.
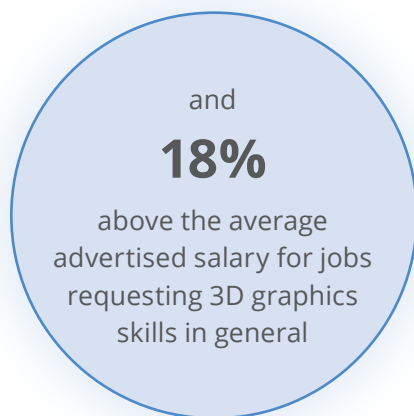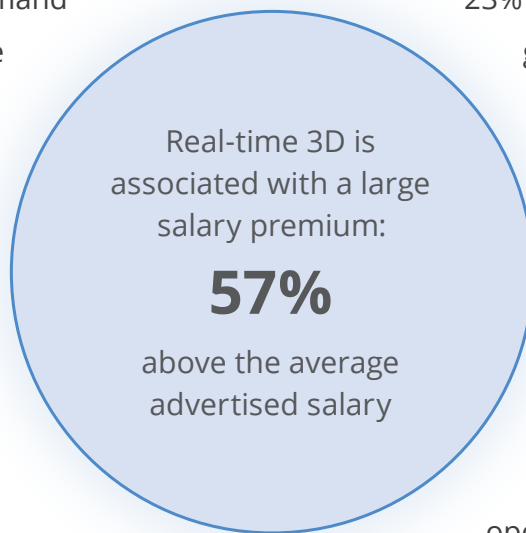
Table 7: 3D Graphics Skills with the Highest Average Salary Premiums

Skill	Average Salary Premium
Unreal Engine	$14,354
Oculus Rift	$13,137
Augmented Reality	$12,535
Unity	$12,000
ENOVIA	$10,922
Ansys	$10,353
ZBrush	$8,808
Mixed Reality	$8,158
Building Information Modeling	$7,574
Three.Js	$7,416
SideFX Houdini	$6,934
Siemens NX	$6,239
3D Rendering	$5,488
Performance Capture	$5,368

Early-career professionals can also earn a salary premium by learning 3D graphics skills. Most job openings requesting 3D graphics skills require 3-5 years of experience. On average, these postings advertise a salary of $79,296, which is 13% higher than other job postings requiring similar levels of experience. When these openings call for real-time 3D skills, the average advertised salary is $96,298, and the salary premium increases to 38%.

Graphics and real-time 3D skills are also hard to fill. Although there are strong opportunities for jobs requesting 3D graphics skills, workers and students may

not have gotten the memo. 3D graphics skills on the whole appear to be undersupplied, according to how long it takes to fill these job openings. Jobs requesting 3D graphics skills take 18% longer to fill than the average job opening. Jobs requesting real-time 3D skills in particular take 15% longer to fill than the average job posting. In certain career areas, the mismatch between supply and demand is even more striking. In construction and architecture, jobs requesting 3D graphics skills take 33% longer to fill. In design and media, jobs requesting real-time 3D take 39% longer to fill.

Tables 8: Distribution of Education and Experience for 3D Graphics Skills

	Share of Openings	
Experience Level	**Calling for 3D Graphics**	**Calling for Real-time 3D**
0-2 years	23%	19%
3-5 years	52%	58%
6-8 years	13%	12%
9+ years	12%	11%
Education Level		
Sub-BA	20%	11%
Bachelor's Degree	77%	81%
Master's Degree	3%	5%
Doctoral Degree	1%	3%

Table 9: Average Days to Fill Openings Requesting 3D Graphics and Real-time 3D Skills

Career Area	Time to fill on average	Time to fill for jobs requesting 3D graphics skills	Time to fill for jobs requesting real-time 3D skills
Construction and Architecture	33 days	33% longer	18% longer
Design and Media	31 days	23% longer	39% longer
Information Technology	34 days	15% longer	3% longer
Manufacturing and Production	32 days	6% longer	>40% longer
Engineering	37 days	8% longer	14% longer

5.

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Implications

These findings underscore that demand for 3D graphics skills is strong, yet unmet, and is only likely to continue its upward trajectory. Educators, employers, students, and workers can collectively benefit by taking steps to prepare themselves for the further integration of these skills into many occupations and career areas.

Educators

Most jobs requiring 3D skills require a college education, but many—around one-fifth—are middle-skill jobs. Educators should consider how to introduce students to these skills, particularly in vocational programs. In middle-skill career areas like construction and manufacturing, these skills lead to large salary premiums and can be a stepping stone to managerial opportunities.

At the college level, educators and faculty should look broadly at how to embed these skills within their curricula. Aligning programs with this booming demand in the labor market will make graduates more competitive. In particular, 3D graphics skills provide an edge to graduates in engineering, information technology, design, construction and architecture, and manufacturing and production. Given the fact that 3D graphics is a hybrid skill set, however, even faculty in fields like marketing, education, and health care could be impacted. Students will gain an even bigger advantage if they learn skills that are frequently requested alongside 3D graphics skills, such as project management.

Colleges and universities may also consider developing microcredential programs targeting both students interested in working

in these fields as well as workers looking to update their skills. Given that most openings requesting these skills require some prior work experience, they may be strong targets for incumbent workers looking to upskill and advance their careers.

Students and Existing Workers

Students and workers who add these skills to their portfolio reap the benefits of increased salaries and diversified career opportunities. Students and existing workers can seek out opportunities to learn these skills in the classroom, on the job, or through extracurricular activities. Incumbent workers should remain abreast of emerging 3D technologies in their career fields. Real-time 3D is a basket of such skills. Workers in engineering, information technology, construction and architecture, and design can potentially benefit by upskilling with real-time 3D skills.
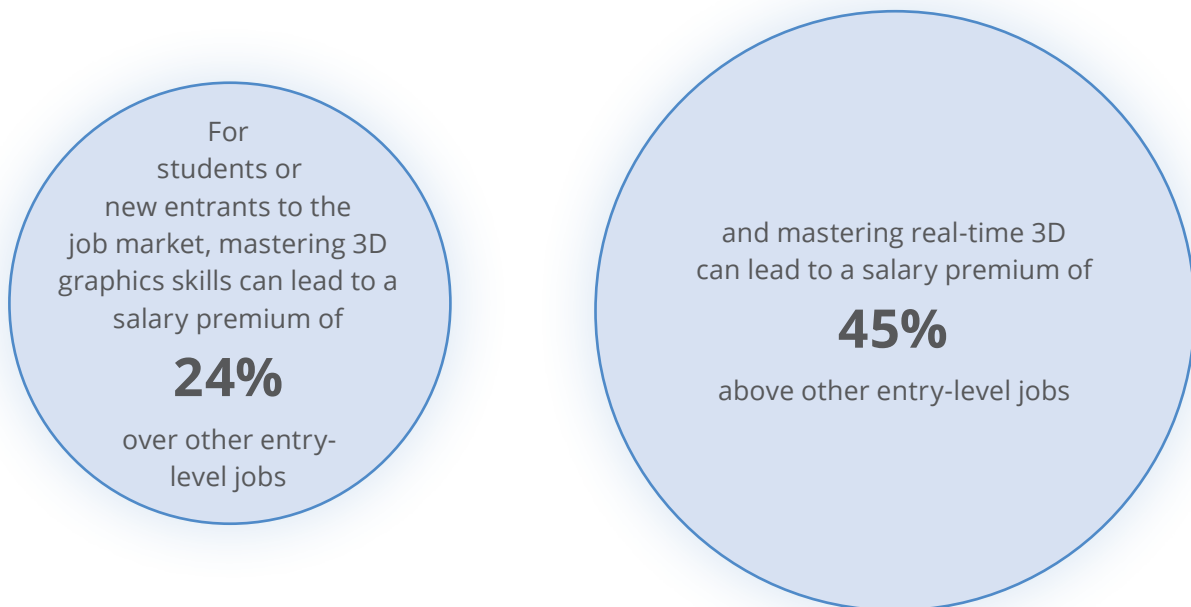
Mastering 3D graphics and real-time 3D skills offers a variety of benefits to incumbent workers or students who will eventually enter the workforce. Workers and students interested in career mobility should develop competencies in computer-aided design, since these skills are in demand in a variety of career areas. Workers and students interested in working

on the cutting edge of technology should develop the software skills applicable to fields such as VR, real-time rendering, and game engines, since demand for these skills has the highest projected growth.

Employers

Employers should develop these skills within their own talent pool. Employers can benefit from the efficiencies gained from 3D graphics technology and real-time 3D skills across a range of use cases. Increasing demand for these skills in business fields like sales, marketing, and management suggest that the underlying technologies are being commercialized successfully. But hiring for these skills is already challenging, and demand is only projected to grow. Employers hoping to leverage 3D graphics and real-time 3D can develop training programs internally or build relationships with educational institutions and workforce development organizations to train their workers in the relevant real-time and 3D graphics skills.

For students or new entrants to the job market, mastering 3D graphics skills can lead to a salary premium of

24%

over other entry-level jobs

and mastering real-time 3D can lead to a salary premium of

45%

above other entry-level jobs

Conclusion

3D graphics and real-time 3D are multifaceted and evolving skill sets. While some skills are in demand across many career areas, others are more concentrated in select fields. Changes in skill demand over time reflect the progress and innovation within 3D graphics and real-time 3D. Even as use of one 3D technology becomes widespread across the broader economy, demand for new but related technologies grows behind the standard bearer. Just as computer-assisted design brought 2D drafting into three dimensions, the emerging capabilities of real-time 3D add another dimension with which architects, engineers, designers, and artists can work, while spreading to new use cases in new occupations.

The implications of this evolving skill set are clear. Students and incumbent workers should understand the benefits accrued to those who learn these capabilities, including higher salaries, improved career mobility, and the ability to shape the way the world and technology interact. Educators should pave the way for students to learn and develop these skills. Employers should integrate these skills into their own talent pool and identify new use cases for increased productivity or improved product experiences. The opportunities associated with 3D graphics and real-time 3D are widespread—now it is up to educators, students, and employers to realize them.

Appendix:
List of Skills

List of 3D Graphics Skills (Real-time 3D in Bold)

Abvent Artlantis

Act-3D Lumion

Amazon Lumberyard

ARCore

ARKit

Augmented Reality

Autodesk MotionBuilder

Autodesk Navisworks

Autodesk VRED

BabylonJS

Bentley/e-on LumenRT

Crytek CryEngine

Cubic Motion

Daqri 4D Studio

Dassault Systemes 3DExcite

Dassault Systemes 3DExperience

Dassault Systemes 3DVia

Digital Mockup

Digital twin

Distributed Interactive Simulation

DX Studio

Enovia V5 DMU

Enscape3d

e-on VUE

Epic Unreal Engine

Flight Simulation

Game Engines

Game Programming

glTF

Godot

Google Cardboard

Google Daydream

HMD

HoloLens

HTC Vive

IC.IDO

iClone

Id Tech

Immersive Displays

Insite VR

InstaLOD

JanusVR

Light baking

Lightcraft Previzion

Lightmapping

Lightworks Slipstream

Luxion Keyshot

Magic Leap

Marmoset Toolbag

Microsoft Simplygon

Mixed Reality

Mo-sys

Ncam

NVIDIA Optix

Oculus Rift

OpenFlight

OpenSceneGraph

OpenSpace

Optitrack

Pixyz

Powerwall

Presagis Creator

Presagis FlightSim

Presagis Panorama

Presagis Vega Prime

PTC Vuforia

Quest3d

Real-time 3D

Samsung Gear VR

Siemens Lifecycle

Smart World Pro

Snap Lens Studio

SolidTrack

SpeedTree

StarVR

SteamVR

Stereographic

Synthetic Environments

Three.Js

Twinmotion

Uningine

Unity3D

Unreal Blueprint

Unreal Engine Datasmith

Unreal Studio

Valve Source Engine

Vicon

Virtual Prototype

Virtual Reality

Virtual Simulation

Visual Simulation

VizRT

Windows Mixed Reality

X3D

Xsens

Zero Density

Zerolight

3D Animation

3D Coat

3D Computer Aided Design

3D Computer Graphics

3D Conceptual Design

3D Design

3D Modeling

3D Rendering

3D Simulation

3D Texture Painting

3D Visualization

3D Web

3Delight

Adobe Dimension

Allegorithmic Substance Designer

Allegorithmic Substance Painter

Altair SolidThinking

Ansys

Artomatix

Artvps Shaderlight

AutioDesSys formZ

AutoCAD

Autodesk 3ds Max

Autodesk Alias

Autodesk Arnold

Autodesk Fusion 360

Autodesk Inventor

Autodesk Maya

Autodesk Mudbox

Autodesk Recap

Autodesk Revit

Bentley Microstation

Blender

Blender Cycles

Blender Eevee

brighter3d

Building Information Modeling

CADKEY

Cebas finalRender

CentiLeo

Chaos Group V-Ray

Character Rigging

Civil 3D

Corona Render

Dassault Systemes Catia

Dassault Systemes Solidworks

Derivative Touch Designer

Disguise.one

Editshare Lightworks

Environment Capture

Esri CityEngine

Evermotion Nox

Foundry Mari

Foundry Modo

Generative Design

Geopak

Glare Technologies indigo

Global Illumination

Graphisoft ArchiCAD

HDRI

IronCAD

Kalloc Studios Fuzor

Look Development

Lumiscaphe Lumis 3D

LuxRender

Matterport

Maxon Cinema 4D

mental ray

Motion Graphics

Motiva Colimo

Nemetschek AllPlan

Nemetschek Vectorworks

NeverCcenter Silo

NewTek Lightwave 3D

Next Limit Maxwell

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Photorealistic 3D

Physically Based Rendering

Pilgway 3D Coat

Pinksoft Fstorm

Pixar RenderMan

Pixologic ZBrush

Previsualization

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PTC Creo

Quixel Suite

RandomControl Arion

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React VR

RedShift3D

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About Burning Glass

Burning Glass Technologies delivers job market analytics that empower employers, workers, and educators to make data-driven decisions. The company's artificial intelligence technology analyzes hundreds of millions of job postings and real-life career transitions to provide insight into labor market patterns. This real-time strategic intelligence offers crucial insights, such as which jobs are most in demand, the specific skills employers need, and the career directions that offer the highest potential for workers. Find out more at burning-glass.com.

About Epic Games and Unreal Engine

Founded in 1991, Epic Games is the creator of Fortnite, Unreal, Gears of War, Shadow Complex, and the Infinity Blade series of games. Developed by Epic Games, Unreal Engine brings high-fidelity experiences to PC, console, mobile, VR, and AR platforms. Unreal Engine accelerates the creation of games, applications, visualizations and cinematic content. Download Unreal Engine for free at unrealengine.com, and follow @UnrealEngine for updates.

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