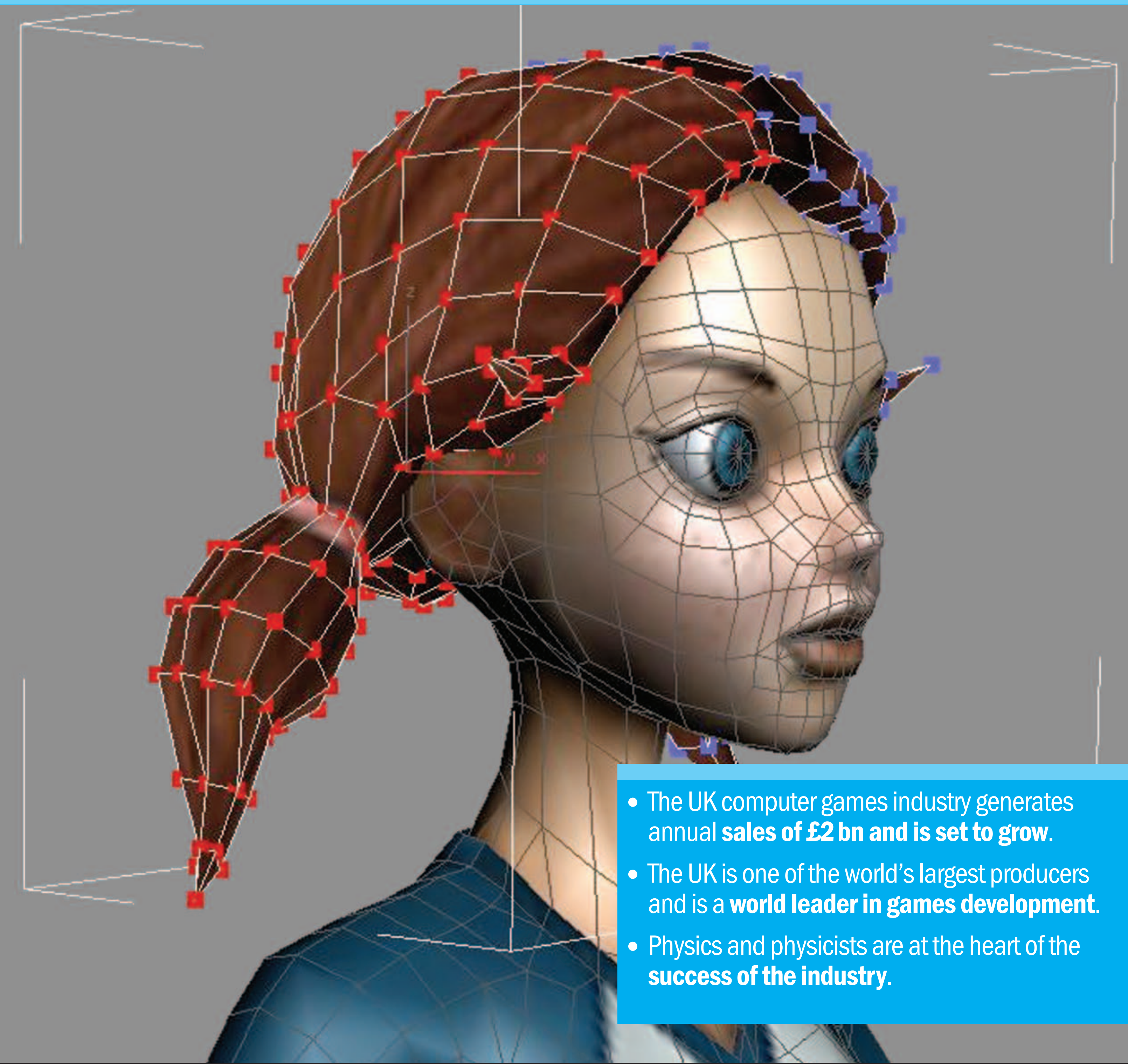
How **physics** is driving the computer games **industry**



- The UK computer games industry generates annual **sales of £2 bn and is set to grow**.
- The UK is one of the world's largest producers and is a **world leader in games development**.
- Physics and physicists are at the heart of the **success of the industry**.

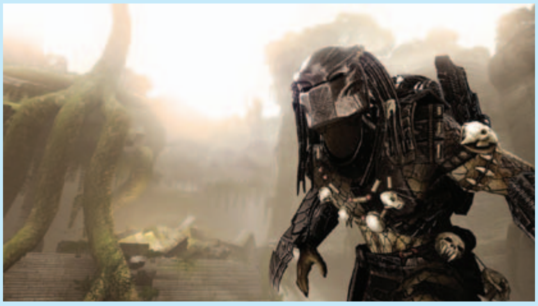
“Thanks to the increase in physics, games are more visually stunning”

Stephen Kennedy

PHYSICS GRADUATES

20%

of graduates working in the industry have a degree in maths, physics, engineering or another science



Refining the application of physics has enhanced the popular game Alien vs Predator

Computer games have come a long way since the likes of Space Invaders and Pac-Man in the early 1980s. No longer limited to two dimensions, with pixelated characters clunking around the screen, the latest in gaming technology allows players to immerse themselves in three-dimensional worlds that have close to realistic motion, sound and lighting. From killing aliens and fighting medieval baddies to driving racing cars and playing football in the World Cup final, there are vast numbers of alternative realities that players can enter.

In ensuring that these realities behave as players expect, even if gravity is different to that on Earth or the protagonist has super-human abilities, the laws of physics take centre stage. That applies to everything from making sure that a ball bounces as it should and that a speeding car corners correctly, to ensuring that a wooden hut explodes convincingly and that flowing water actually looks like it would in real life. All of which calls for expertise across a wide range of the sub-disciplines within physics, from mechanics and optics to fluid dynamics and (perhaps surprisingly) the mathematics underpinning special relativity. This is knowledge that was developed over the centuries but now finds its place at the heart of modern computer games.

As such, many of the leading games companies in the UK devote considerable resources to developing physics-based coding. Some do this themselves while others buy off-the-shelf computer code known as “physics middleware” that they can insert into their programs.

“Many developers want to incorporate elements of physics into their games because they want those games to be as realistic as possible,” says Richard Wilson, chief executive of TIGA, the trade association representing the UK computer games industry. “Indeed, players have come to expect ever-more realism, and that is not going to go away.”

Physics at the core

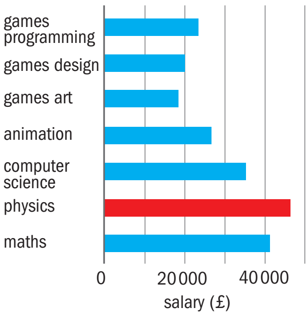
Oxford-based Rebellion is best known for its game Aliens vs Predator, which involves battles between humans and two kinds of extraterrestrial creature. As Rebellion founder and chief technical officer Chris Kingsley explains, developing the physics for the original game back in the late 1990s proved a tough challenge because at the time most games still took place in two dimensions, whereas he and his colleagues wanted their aliens to climb walls, move along ceilings and to move between the two; in other words, they had to refine their application of physics to improve the movement of the characters in the game. It took several months to make the move into the third dimension, but it was a move that Kingsley believes made the game “more realistic, engaging and enjoyable”. The challenge for computer game developers since then, he says, has been to increase the complexity of simulations by including more objects and a greater number of interactions, but ensuring that the computations are efficient enough so as not to overwhelm available processing power.

Industry leader

The UK is one of the world's largest producers of computer games, generating annual sales of around £2 bn in 2009, compared with a worldwide market of some $50 bn (£30 bn), according to a report on the media and entertainment industries published by PricewaterhouseCoopers 2010. UK developers employ around 9000 people, with those most involved in physics-based games, including Lionhead Studios in Guildford (owned by Microsoft); Criterion Games, also in Guildford (owned by Electronic Arts); Sony, which has studios in London, Cambridge and Liverpool, and which also owns the Media Molecule studio in Guildford; Ubisoft Reflections in Newcastle; Codemasters in Leamington Spa; and Blitz, also in Leamington Spa.

Rockstar Studios in Edinburgh, owned by Take-Two Interactive Software, produce the Grand Theft Auto series of games, the latest of which, Grand Theft Auto IV, broke records in 2008 when it sold 3.6 million units and earned $310 m in sales in its first 24 hours. Jagex in Cambridge, meanwhile, is the producer of the game RuneScape, which is the most popular free multiplayer online game in the world.

Salaries of respondents to video games talent survey by university degree



Source: Video games talent survey, 2010.

Stephen Kennedy is physics team leader at Havok, a Dublin-based company that provides physics middleware to computer games developers. He says that one of the key improvements to games in recent years has been the bringing to life of the environment. Previously, he explains, characters would move around while the rest of the world was static, but increasingly background objects such as vehicles also move. Havok's middleware allows developers to make their games more dynamic by handling what is known as "collision detection" and "constraint resolving" – ensuring that different objects, even when individually obeying say Newton's laws of motion, do not interact in unreal ways such as passing straight through one another. As Kennedy points out, this detection mechanism relies on a branch of mathematics pioneered by Hermann Minkowski, also famous for developing the mathematics that underpins Einstein's special theory of relativity.

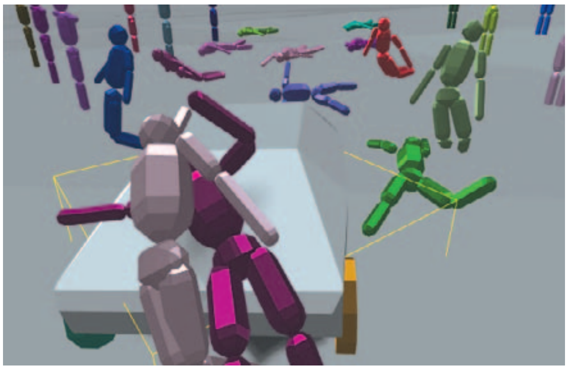
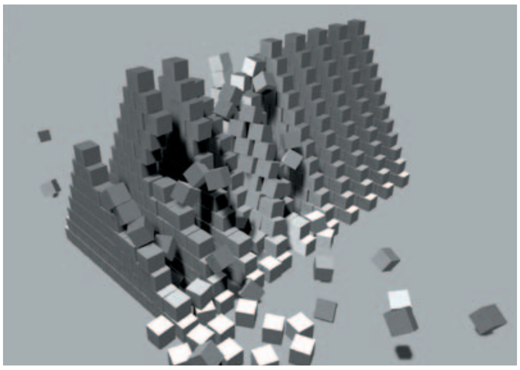
Another task that Havok's physics middleware carries out is to simulate characters as if they were rag dolls. Usually within computer simulations, humans or other beings are represented using a series of predefined animations, with these static images placed one after another in a rapid sequence in order to generate the impression of motion, as happens in cartoons on television. But the stock of images will always be finite and so will never be adequate to entirely cover all of the possible shapes that a body could take on. Instead, bodies can be approximated as a collection of rigid blocks that are connected to one another at the major body joints, such as the knee, ankle or elbow. With each block responding to the forces exerted on it, and respecting its position relative to the neighbouring blocks, a body can be made responsive to its environment.

Physics graduates, a prized asset

Much of the physics-based programming carried out at games developers is done by science graduates. In some cases these arrive straight from their degree courses and are then trained up by their employers, while others first complete a masters course such as Hull University's "games programming", which includes a number of specialist modules in physics and simulations (there are also a few who arrive after having decided on a career change). Kingsley, who himself has a chemistry degree, says that almost all of the programmers at Rebellion "have a good science degree from a good university" and that his company currently employs five physics graduates. "We find that the broad knowledge of science and mathematics is really important," he explains, "as is the scientific problem-solving methodology that these graduates have."

This importance of science graduates to the computer-games industry was highlighted in the Nesta report written for the UK government by Ian Livingstone, president of computer game publisher Eidos Interactive, and Alex Hope, managing director of the Double Negative visual effects company. According to the report, published in February 2011, about 20% of graduates working in the industry have a degree in maths, physics, engineering or another science. The report also reveals that the physics graduates on average earn about £46 000, which is more than any other type of graduate working in the industry.

"There seems little doubt that worldwide demand for physics-based programming will increase."

Demonstrations of Havok™ Physics, Courtesy of Havok Ltd.

Indeed, Livingstone believes that the relatively low number of people graduating from British universities in computer science, maths and physics, as well as in art, is a "fundamental problem for the games industry", because, he says, it is graduates with these hard skills, rather than individuals who leave university with degrees in games programming or games design, who are prized by employers.

Future growth from physics

In 2008 the UK was the third-largest computer games developer in the world in terms of sales revenue, but has since slipped to fifth place, falling behind South Korea and Canada (the US, which has annual sales of some $11 bn, and Japan occupying the top two slots). The number of people employed in the industry in the UK fell from 9900 in July 2008 to 9010 in October 2010, while those employed by the industry in Canada grew by 33% in the same period.

There seems little doubt, however, that worldwide demand for physics-based programming will increase. In its report in 2010 PricewaterhouseCoopers estimated that the global market for computer games will grow by about 10% a year over the next three years, with the market expanding to nearly $90 bn by 2014 (the UK market will also continue to grow rapidly; its entertainment and media market growing as a whole by 3.7% a year over the same period). And as Kennedy points out, "almost all big games that do well have physics in them". He says that thanks to the increasing use of physics, games are more visually stunning than they once were and that they are also less prone to "break the player's illusion" of a compelling alternative reality by preventing objects behaving as they shouldn't. "More and more games will contain physics to some extent," he says.

But Kennedy believes that there is still plenty of scope for improvement. In particular, he thinks that while inanimate objects are portrayed "pretty convincingly" human and other characters could become far more realistic if they can demonstrate an awareness of their environment. One approach, he says, is to combine animations with rag-doll physics. For example, someone walking down a staircase might have an animated body and rag-doll arm, represented by two blocks joined at the elbow, in order to make sure that they can convincingly reach out and slide their hand down the banister.

Computer scientist Jon Purdy takes a similar view. Purdy, who has a PhD in applied physics and directs the masters in games programming at Hull, maintains that while the vast majority of physics within computer games today is used to simulate the behaviour of rigid bodies, in the future far more attention will be devoted to modelling "soft bodies". These include fabrics, which, he says, will be made to move more naturally and get worn and torn, and which, he points out, have been incorporated into Media Molecule's Little Big Planet. As of a year ago this game had sold 3 million copies worldwide.

Physics looks set to become ever more central to the development of computer games. And physics graduates, as is the case in many other high-tech industries, will continue to be highly sought after.

Front cover image courtesy of Havok

Prepared by Edwin Cartlidge June 2011

Contact information
Institute of Physics
76 Portland Place
London W1B 1NT
Tel +44 (0)20 7470 4800
Fax +44(0)20 7470 4848
E-mail business@iop.org
www.iop.org

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