***Biography of a Software Engineer***

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**Introduction**

Software Engineering is the systematic approach of applying engineering concepts and processes to the manufacture and distribution of software applications and programs (Laplante, 2007). It has been a discipline of study since the mid 1960’s when the term was coined by Margaret Hamilton (among others) (NASA, 2003), who used the discipline to aid in the landing of man on the moon in 1969. Since these early days of the discipline many hundreds of thousands of software engineers have emerged using the discipline to create, perfect and distribute software applications. One of these many is a man by the name of John Cormack. Cormack is an American software engineer and designer. He co-founded the video game company “id Software” and was a lead programmer on many of their leading titles and their sequels, including but not limited to “Doom”, “Quake” and “Wolfenstein 3D”. He is well known for making many advancements in 3D computer graphics, including his most well-known algorithm “Carmack’s Reverse Algorithm” which defines shadow volumes in a 3D graphical environment. He is well known for revolutionising first-person gameplay and as a result has made a massive impact on the video game industry as a whole.

**Personal Life & Career**

Carmack was born in Shawnee Mission, Kansas and grew up in Kansas City (Orndorff, 2008), He was interested in computers at an early age and was introduced to the world of video games when playing Space Invaders at an arcade in the late 1970’s. This growing love led him to attempt to break into his local high school to steal Apple II’s from the school’s computer labs, further leading to him being sentenced to a year in a juvenile home (Kushner, 2003). He attended the University of Missouri-Kansas City for two semesters before dropping out to become a freelance programmer.

A Louisiana software company, “Softdisk”, hired Carmack to work on software for the Apple II that they were building at the time, which introduced him to John Romero, another founder of id Software, alongside other key developers that helped found id. Upon the distribution of the software they were developing, Carmack, Romero and others left Softdisk to co-find id.

At id Carmack popularised and pioneered many development techniques in Computer Graphics including “adaptive tile refresh”, a software application that allowed id’s side scrolling game *Commander Keen* bypass the lack of ability for computer hardware to enable scrolling and created a way to efficiently redraw each frame required when the player moved the character (Kushner, 2003). He also pioneered the use of “ray-casting”, a method of generating 3D models and their subsequent rendering, which is now used worldwide in both the video game and film animation industries. Furthermore, he invented “surface caching”, the method of speeding up the rendering of environments in the id game Quake, an important aspect in a high paced game that Quake was penned to be (Kushner, 2003).

**Carmack’s Reverse**

Shadow Volume is a 3D graphical technique to add shadows to a rendered scene in a 3D environment, initially proposed by Frank Crow (Crow, 1977). The technique pioneered by Carmack was that of Carmack’s Reverse Algorithm, that makes use of the stencil buffer technique, an additional buffer between the colour buffer and “Z-buffer” in computer graphics, which is now generally considered the most efficient way to develop shadows in even modern 3D graphical generations.

Carmack’s Reverse is a variation of a shadow volume algorithm that was popularised by id’s game Quake 3 it improves on Tim Heidmann’s algorithm in which the entire environment is put in shadow and light sources are calculated by drawing rays from the source of light to where in the environment they will cover. This came with problems however as shadow volumes fill a large amount of the space and as a result takes a lot of the fill-time for the environment, putting a lot of pressure on the system hardware, and can lead to errors where the computer’s “eye” can show shadows that block the vision of the player, creating a difficulty to create shadows for all camera angles.

Carmack’s Reverse Algorithm helped fix these issues by, instead of covering the whole environment in shadow initially, counting shadow surfaces behind the object casting the shadow rather than in front of it. This took the same amount of time and allowed Heidmann’s algorithm be used for all camera angles and prevented shadows being cast in front of the “eye” as all shadows were being created behind the objects rather than in front of them. John Carmack discovered this algorithm in 2000 during the id development of Quake 3 (Kilgard, 2009).

**Fast Inverse Square Root**

Carmack has also been attributed, among others, to the creation of the Fast Inverse Square Root Function that allows for the accurate computation of the reciprocal of the square root of a number to an extremely accurate degree of 0.17%. This is done by shifting the bits of a floating-point number right by 1, and then subtracting that value from a so-called “magic number” of 0x5F3759DF. (Sommefeldt, 2006). This alone gives a result with an error of approximately 3.4%, however when the result of subtraction is run through an iteration of Newton’s Method, an efficient and accurate calculator of the square root of a number, this error reduces to that of 0.17%.

These simple ten lines of code in the Quake3 source files revolutionised 3D computer graphics in computer games as it allowed for the ease of the normalisation of motion vectors a player moves their cursor, i.e., their vision around the screen. Before the use of this, as stated in the source code, “*evil floating point bit level hacking”* (Romero, 1999)*,* the use of lookup tables was prominent in most of the software where the inverse square root was required. However, this code runs at a pace four times greater than that, which was revolutionary for its time allowing the game to have a faster paced feel to it compared to other games at the time.

Although it is outdated now, the code optimised video game graphic generation and graphical output pace and was used for many years after its formulation.

**Conclusion**

John Carmack has played an essential role in the development of 3D generated computer graphics and the video game industry, enabling for the growth of the industry to a behemoth worth over $90 billion in 2020 (Dobrilova, 2021). The leading franchises of this industry being majority First Person Shooter type games, which Carmack aided in pioneering with id Software’s many beloved and still played franchises. Many of the popular video game franchises around the world such as; *Call of Duty, Half-life* and *Battlefield*, still contain the basics of his many development engines at the heart of their code and shows how Carmack’s work is still in use and effect even to this day. So I can go without saying that John Carmack has had a massive effect on both Video Game Development and Software Engineering as a whole.

***Appendices***

A person wearing glasses

Description automatically generated with medium confidence

*Figure 1:*

John Carmack in 2017

A picture containing indoor

Description automatically generated

*Figure 2:*

An example of Carmack’s Reverse Algorithm

at work in Doom 3.

A screenshot of a video game

Description automatically generated

*Figure 3:*

An example of Heidmann’s Algorithm for Shadow Volumes at Work



*Figure 4:*

Carmack et al’s Fast Inverse Square Root algorithm from Quake 3 Arena’s source code

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