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Donald Knuth: Computing Pioneer

One of the greatest minds in the field of computer science today is Donald Knuth. Known as the father of the analysis of algorithms, he has made numerous contributions to theoretical computer science and the design of programming languages. Computer science was heavily influenced by him through such works as his multi-volume work *The Art of Computer Programming* and his computerized typesetting system TeX. As one of the first scholars to take computer science as a field of study seriously, Donald Knuth has become one of its leading theoretical innovators and thinkers.

Donald Ervin Knuth was born in Milwaukee, Wisconsin in 1938. His father was a teacher at a Lutheran high school and owner of a small printing business (Agarwal and Sen). Starting at an early age he was noted for his unconventional intelligence. When he was in eighth grade, Knuth won a competition by finding over 4,500 words that could be found from the phrase “Ziegler’s Giant Bar.” As a reward for his efforts his school received a television set and a candy bar for every student in the school (Agarwal and Sen). As he recalls from his childhood, Knuth had a generally pleasant experience of school. Despite his brilliance and the fact that his parents never advanced him a grade level, he was never bored while in school. He recalled never being any good at sports or penmanship, ironic for the number of publications that have since been under his name. Knuth aspired to be a teacher like his father. This remained true until he arrived at college, when he wanted to become a professor instead (Knuth 77). As a child one of Knuth’s favorite hobbies was playing music (Knuth 80). He took piano lessons as a child and became good enough to be able to effectively sight-read (Knuth 81).

From a young age Knuth loved to read books. One day his parents let him ride a street car to the local library for the day. The five year old Knuth became fascinated by the books in the children’s section and began reading, oblivious to the passing of time. As the time to go home drew near he took his books to the counter to check them out, but no one was there. Naturally, he stayed and kept reading. It was only after his concerned parents phoned the library that the staff found him surrounded by stacks of books, completely enamored by them (Knuth 83). This incident would become predictive for the rest of his life.

Knuth furthered his academic studies at the Case Institute of Technology, now known as Case Western Reserve University (Agarwal and Sen). He was noted to have a certain inferiority complex for most of his life up until that point, always striving to be the best at what he did. His confidence was enough to keep him happy, but also enough to push him academically as much as possible (Knuth 81). Upon entering college Knuth had a difficult time between choosing physics and music, ultimately choosing the later and switching to mathematics.

He first became interested with computers during his second year after he began working with the IBM 650 across the hall from his statistics lab. Knuth became so infatuated with the computer that he wrote several programs for it and even a user manual (O’Regan 169). One of said programs was used to perform analysis on the school’s basketball team. It was such a naïve approach that it was covered by Walter Kronkite in *Newsweek* on CBS. Multiple papers were published under his name as an undergraduate. One of which, published in 1957 as a freshman, was a parody on the metric system called “The Potrzebie Systems of Weights and Measure,” which was published in *MAD Magazine*. He was also one of the founding editors of a technical magazine published by the students of the university, *Engineering and Science Review*. His talents and academic achievements were so remarkable that he simultaneously received a Bachelor of Science and a Master of Science in mathematics upon graduation as a special award from the faculty (Agarwal and Sen). Along with his academic achievements Knuth managed to become a well-rounded student while at Case. He participated in enough extracurricular activities to earn the Case honor key upon graduation (Knuth 79).

Donald Knuth would continue his studies of mathematics and computers at the California Institute of Technology in 1963 to pursue a Ph.D. in mathematics. During his time there he wrote different compilers for computers. The title of his thesis was “Finite Semifields and Projective Planes.” After receiving his Ph.D. he became a member of the staff of the university until 1968, when he accepted a full time professor position at Stanford University (O’Regan 169).

One of his ground-breaking contributions to the field changed the way programs were written. In the early days of software development code was written until all bugs were found and removed from the program. It led to a vast amount of time being wasted during the inefficient development process. Knuth, with his heavy mathematical background, emphasized rigor to provide proofs that an algorithm was correct before it was implemented. It introduced a type of elegance to computer programming that made the process far more efficient (O’Regan 169).

While pursuing his Ph.D. Knuth began doing work for Burroughs Corporation. In 1962 he was approached to write a textbook on compilers, which he worked on while still a graduate student, and signed a contract to write a 12 chapter book. Upon completion of his Ph.D. he began to work on this. Knuth recognized the need for a reliable book on the state of the art information of the field of computer science, leading the book to expand quickly to over 2,000 pages. This led to the publication of the multi-volume work *The Art of Computer Programming*. The first volume was published in 1968 and the fourth and latest volume was released in 2011 (O’Reagan 170). It has had a profound effect on the development of computer science as a field and has become a common reference for programs on topics such as data structures and algorithms. On a humorous note, Donald Knuth is known to pay $2.56 for any errors found in his books and $0.32 for significant suggestions (Agarwal and Sen). If awarded, these checks have become some of the most sought after awards in the field of computer science.

Each volume of *The Art of Computer Programming* concerns itself with various topics in computer science. Volume 1 is seen as a classic and covers a wide variety of algorithms with mathematical analysis. It also includes much of the mathematical preliminaries for the field. Volume 2 is concerned with topics such as random number generators, prime factorization, algorithms for single and double precision, arithmetic calculations, and algorithms for calculating fractions. Volume 3 covers sorting and searching algorithms and how they can be improved. Volume 4a takes a look at algorithms that he considers to be important enough to be valuable topics within the next 50 years. Together they established algorithm analysis as a topic of computer science. Knuth originally wanted to change the title to *The Analysis of Algorithms*, but publishers wished to keep the original title. The books have become a focal point for the development of curricula across many universities (O’Regan 171).

Another of Donald Knuth’s major works was the development of his computerized typesetting program, TeX. Its origins can be traced to the publication of the first volumes of *The Art of Computer Programming* (Agarwal and Sen). This began in 1973 when his publisher switched from mechanical to computerized typesetting. Upon writing the book Knuth became increasingly dissatisfied with mathematical typesetting due its degradation in quality. This led to his motivation of developing a computerized typesetting program that would produce high quality documentation while being independent of the technology that it ran on. His system was announced at the American Mathematical Society Gibbs Lecture in 1978 entitled “Mathematical typography.” He developed it along with other Stanford students and colleagues. Its main components were the TeX typesetting engine, the METAFONT font design system and the Computer Modern set of type fonts. His approach was revolutionary and was made publicly available. It has since become the standard language for computer typography (O’Regan 171).

Knuth’s overall contributions to the field of computer science are staggering. Not only is he known as the father of algorithm analysis, but he has also founded the topic of computational complexity. He has also made several significant contributions to the development of compilers and computational typography. “Knuth” has become jargon for *The Art of Computer Programming*, which in term has become a synonym for the reference that answers all questions about data structures and algorithms (Arawal and Sen).

Donald Knuth has also had the honor of being bestowed upon numerous academic awards. This includes the 1974 Turing Award and the 1979 National Medal of Technology, awarded to him by President Jimmy Carter (Agarwal and Sen). The former was awarded for his contributions algorithm analysis and the design of programming languages. Knuth was the first recipient of the ACM Grace Murray Hopper Award from the Association of Computing Machinery in 1971. He also received the John von Neumann medal in 1995. Knuth has received multiple honorary doctorate degrees from universities around the world (O’Regan 170).

Donald Knuth retired from Stanford University in 1992 to commit to his books full time. He has been named professor emeritus of the Art of Computer Programming (O’Regan 170). He is a church organist who also enjoys composing organ music. He believes writing computer programs can have an aesthetic similar to that of writing poetry or composing music (Agarwal and Sen). Over his career he has authored over 26 books, 150 papers, and 5 patents. Knuth strongly opposes software patents and has made his case to patent offices in both America and Europe (O’Regan 170). Since retirement, Knuth gives free lectures across numerous universities around the world that are open to the public (Knuth 175).

Works Cited

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