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Richard Bellman's Biography

Introduction

There are many mathematicians who deserve to be mentioned for their great contributions to mathematics and other sciences. But it would be very difficult to try to write about all of them. Therefore, I will concentrate on one, who has left us with so much in the work of pertinent mathematical theories and discoveries. In addition to his contributions, his way of living was very interesting or even dramatic. This famous mathematician whose name was Richard Bellman had many good things to share with us. Bellman was famous for his Dynamics programming theory. I will try to reveal all the great and dramatic life events he had to go through in order to become what he is now known as: the great inventor of (Dynamic programming). Bellman left us with a very humorous autobiography telling most of his life history in a funny and entertaining way. I'll try to mention every part of his life starting from his personal and family life, to his education and carry on with his extraordinary contributions to mathematics and other sciences.

Personal Life

Richard Bellman was born in 1920, in New York City. His father John James Bellman was twenty and his mother, Pearl Saffian Bellman, was eighteen at the time he was born. His father used to run a small grocery store on Bergen Street near Prospect Park in Brooklyn. The last name of Bellman was originated in Sweden. Bellman says: “Bellman in Sweden is like Shakespeare in the United States.” This gives us an idea of how popular his last name was in Sweden.

In Bellman’s account we find a nice detail about how his parents met. He acounts that his father John James met his soon wife to be, Pearl Saffian, at the beach and only knew her first name and that she worked in a big department store in Manhattan; he fell in love with her and continually stood outside every department store at 5.00 pm every day until he found her. Bellman talks a lot about his family including his aunts and uncles who show us how close he was to them.

His father had four sisters: Pearl, Beth, Augusta and the last, Dorothy (who Bellman did not know much about). His mother had two siblings, Sylvia and Arthur. Bellman was the only son in his family but life was not that easy for him and his family as he repeatedly says "we were not suppose to be poor". He was referring to the fact that his father kept making wrong choices regarding his jobs. He took the Depression so seriously that he would decline

most jobs offers that he had; and every time he was ready to make commitments it would be too late.

Bellman confesses to us two curses he had to deal with during his childhood: bed-wetting and fear of the dark. As a young adult he talks about his experience with painful shyness. He had a fear of talking in front of class, which made him the last person to present on the last day of the term, while in high school. When he went to college, the fear was still there, but he forced himself to give as many talks as possible in order to overcome his shyness. Bellman's philosophy was "Once I get started I will do well, and that many actors and actresses have the same problem".

At 12 years of age Bellman, started to get interested in psychology, which he thinks may have helped him to deal with some of his problems he experienced during his adolescence. He was also fanatic about science fiction and literature such as the Harvard classics, among which his favorites were Mark Twain and Shakespeare. Mark Twain became the greatest influence for Bellman at this age by helping him to widen his imagination and to develop a great sense of humor. This was also the time when he started to realize that he had read enough fiction and decided to explore something real. At this point of his life for the first time, he starts getting into subjects like paleontology, archeology, philosophy, history, biography, etc. He starts reading science books by Paul de Kruif and the "Crucibles" by Jaffee. At the age of sixteen, he discovers a book on vector analysis, which caught his

interest and starts reading it. The book was not easy to understand at this time, since he did not have great ability at geometry, but the fascination he felt for the subject gave him a good experience in geometry thus he managed to grasp the concepts.

Education

Bellman completed high school at the Abraham Lincoln High School in 1937.

In his junior year in high school he participated in the inter-scholastic algebra league that involved various high schools at the time. After finishing his high school he started his college career at City College of New York (CCNY). During this time CCNY was one of the most intellectual institutions of higher education in the US. This was right before the middle class migration out of the city, and a time for new opportunities in the elite institutions for the New Yorkers. CCNY had the choice of the best of New Yorkers with a serious intellectual bent. While he was at CCNY, he worked on becoming a theoretical physicist. But he decided to major in mathematics because for him this took a little work and he could continue learning theoretical theory. Finally he concluded that theoretical theory was not field he could do, thus he stayed with mathematics, which is how he became a mathematician. Some of his studies during college years included four terms of Greek drama and language, it was then when he discovered that he had

good a memory since he was able to memorize most of the words. He did most of the mathematics by intuition and it was not until he started to write a book and teach that he felt like he needed to understand the whole theory.

Bellman was also a member of the mathematics club also in college, where he occasionally heard talks about mathematics. The talk he remembered best was the talk by Courant about the problem of inscribing a triangle of minimum perimeter in a given triangle. He stayed in college for four and a half years and upon graduating from Brooklyn College he did not get any mathematics medal since he had already won it as a sophomore. He tells us that he preferred a book rather than a medal, which is how he started to collect some good books. One of the first books he bought was "Theory of Functions" and then "Fourier Integrals". These books gave him such a good insight into mathematics that he even started to write some of his first papers at this time.

Bellman had many friends while in college but there was only one person that got his attention, her name was Betty Jo. Betty and she was his first date. This was the time when he completed his college work and when he was trying to make plans for his career. They had decided to get married after completing their Ph. D; However, this did not happened since in the same year they graduated, in November 22 of 1941, they got married "because of the uncertainties of the world situation" he says. He was twenty-one and she was eighteen "we were both too young," he said. During this

time Bellman needed to find a way of obtaining a source of income when he found out about a job position of instructor in electronics, but he did not know much about it, so when he asked to be considered for the position, he was rejected due to the level of education he had. At this point he felt like his mathematics career was over. But in 1941, he moved to Belleville where he learned electronics. At Scott Field, he had the chance to get the rudiments of radio and electronics. This was something he started to enjoy since he could relate mathematics with the equations used by Van der Pol to describe the output of circuits. After spending six months in Belleville Bellman did not want to move back to New York so he and Betty decided to move to Madison, Wisconsin.

While he was in Madison, Bellman was reading the "Duke Mathematical Journal or the Bulletin of the American Mathematical Society" where he found a paper on stability, which he struggled with to establish results since he only came up with inequalities, which did not mean much. While solving the problems in this journal, every time he got a solution the answers, although right, didn't make sense to him. So he continued to solve the problems until he was convinced that the answers made sense to him. This was later to become the most significant part of his mathematical discoveries. These new ideas and discoveries started to get him to desire to be part of Princeton, which in his inner soul, he kept thinking to be unattainable. But it was not too long after that when he received a phone call

from Lefshets, ASTP, Army Specialized Training Program, had just started and he was asked if he wanted to be an instructor in this program and come to Princeton.

Bellman entered Princeton in 1943. This was an excitement for him, since for years he always wanted to go there. As a graduate student there, Bellman became a member of an inner circle of young mathematicians led by Professor Solomon Lefschetz. His doctoral research under Lefschetz resulted in his first major work "Stability Theory of Differential Equations" (1946), subsequently published on his first book in 1953, and regarded as a classic in its field. After he taught electronics in Princeton he then worked at a sonar lab in San Diego. He spent the last two years of the war in the army, but assigned to the Manhattan project at Los Alamos. He was a social creature and it was easy for him to meet many of the talented people working on the project secretly known as “the gadget”. Typically, the physicists considered a mathematician as simply a human calculator, ideally constructed to do numerical computations but not much more. Bellman was asked to numerically solve some Partial Differential Equations at work. His mathematical pride made him refuse this task. To the great surprise of the physicists, he actually managed to integrate some of the equations, obtaining closed form solutions. Holding true to tradition, they checked his solutions, not by verifying the derivation, but by trying some very special cases. It was clear he knew what he was doing. With this Bellman’s reputation as a very

bright young mathematician was established at Los Alamos. During these years, he absorbed a great variety of scientific experiences. So much was being done due to the war demands. Richard Bellman is a towering figure among the contributors to modern control theory and systems analysis. His invention of dynamic programming marked the beginning of a new era in the analysis and optimization of large-scale systems and opened a way for the application of sophisticated computer-oriented techniques in a wide variety of problem-areas ranging from the design of guidance for space vehicles to pest control and network optimization. After staying on the faculty of the Mathematics Department at Princeton from 1946 to 1952, Bellman left to join the newly established Rand Corporation in Santa Monica, California. At Rand, he became interested in the theory of multistage decision processes, then emerging as an important problem-area in the control of both small- and large-scale systems. His invention of dynamic programming in 1953 was a major breakthrough in the theory of multistage decision processes - a breakthrough, which set the stage for the application of functional equation techniques in a wide spectrum of fields extending far beyond the problem areas, which provided the initial motivation for his ideas. In addition to his fundamental and far-ranging work on dynamic programming, Bellman has made a number of important contributions to both pure and applied mathematics. Particularly outstanding is his work on invariant imbedding, which by replacing two-point boundary problem with initial value problems

makes the calculation of the solution more direct as well as much more efficient. His work on quasi-linearization and its applications to system identification has led to many results of a practical nature in the study of nonlinear systems. In the recent years, Bellman's research activity has focused increasingly on the application of mathematics to medicine and biological sciences. He is the founder of the journal "Mathematical Biosciences," and the co-author of a forthcoming book "Mathematical Models in Medicine."

Bellman spent the summer of 1948 at RAND, where an amazing array of talent was gathered, including David Blackwell, George Dantzig, Ted Harris, Sam Karlin, Lloyd Shapley, and many others, who provided the foundations of much of 'decision and game theory'. The original intention was to do mathematics with some of the RAND talent on problems of prior interest. But Bellman turned out to be fascinated and partially seduced by the excitement in OR, and the developing role of mathematics in the social and biological sciences. Bellman's mathematical abilities were widely recognized. He was a tenured Associate Professor at Stanford at 28, after being an Associate Professor at Princeton, where all indications were that he would have had an assured future had he remained there. He began to have doubts about the payoff for himself in number theory and returned to the atmosphere at RAND often, where he eventually settled and became fully

involved in multistage decision processes, having been completely seduced, and much to our great benefit.

Here is a non-mathematical item that should be of interest. To work at RAND one needed a security clearance, even though much of the work did not involve "security." Due to an anonymous tip, Bellman lost his clearance for a while: His brother-in-law, whom Bellman had not seen since he (his brother-in-law) was about 13, was rumored to be a communist! This was an example of a serious national problem that was fed, exploited, and made into a national paranoia by unscrupulous politicians.

Bellman was a notable person, totally a man of his time and original in his interests, with a fantastic memory. Bellman was one of those who were the driving forces behind the great intellectual excitement of the times. The word programming was used by the military to mean scheduling. Dantzig's linear programming was an abbreviation of “programming with linear models”. Bellman has described the origin of the name “dynamic programming” as follows. An Assistant Secretary of the Air Force, who was believed to be strongly anti-mathematics was to visit RAND. So Bellman was concerned that his work on the mathematics of multi-stage decision process would be unappreciated. But “programming” was still OK, and the Air Force was concerned with rescheduling continuously due to uncertainties. Thus “dynamic programming” was chosen, a politically wise descriptor. On the other hand, when I asked him the same question, he replied that he was

trying to upstage Dantzig's linear programming by adding dynamic. Perhaps both motivations were true [2].

If one looks closely at scientific discoveries, ancient seeds often appear. Bellman did not quite invent dynamic programming, but many others contributed to its early development. It was used earlier in inventory control. Peter Dorato once showed him a (some what obscure) economics paper from the late thirties where something close to the principle of optimality was used. The calculus of variations had related ideas (e.g., the work of Caratheodory, the Hamilton-Jacobi equation). This led to conflicts with the calculus of variations community. But no one grasped its essence, isolated its essential features, and showed and promoted its full potential in control and operations research as well as in applications to the biological and social sciences, as did Bellman.

Bellman published many influential works. It is sometimes claimed that many of his papers are repetitive and did not develop the ideas as far as they could have been. Despite this criticism, his works were poured over word for word, with every comment and detail mined for ideas, technique, and openings into new areas. He did a great amount of work. Evidently it was the work of someone with a great background in analysis as well as a simplistic mind and sharp eye for applications. In his work there are lots of examples, with broad coverage and usually simple simple assumptions. He had a clear writing style. His ideas flow very well through the problem formulations and

analysis unlike many mathematics books that are hard to read and understand.

Who was influenced by Bellman?

According to Harold J. Kushner who worked with Bellman at the RAND Corporation Bellman was a great encouragement and influence to him in the field of Optimal and Stochastic control theory. He had received many awards in both fields. Also Mr. Kushner has written about 7 books and about 160 papers, he has contributed to the fields of stochastic control theory and optimal control theory. He also mentions how Bellman used to tell him to write his first book and he finally did. This was the result Bellman's encouragement.

"There is one more indirect connection between us. Bellman was a student of Solomon Lefschetz at Princeton, head of the Math. Dept. at the time, a very tough minded mathematician and one of the powerhouses of American mathematics, and impressed with Bellman's ability. While at Los Alamos in WW2 Bellman worked out various results on stability of ODE's. Although he initially intended to do a thesis with someone else on a number theoretic problem, Lefschetz convinced him that those stability results were the quickest way to a thesis, which was in fact true. It took only several months and was the basis of his book on stability of ODE's. I was the director of the Lefschetz Center for Dynamical Systems at Brown University for many

years, with Lefschetz our patron saint. Some of you might recall the book (not the movie) "A Beautiful Mind" about John Nash, a Nobel Laureate in Game Theory, which describes Lefschetz's key role in mathematics during Nash's time at Princeton," Harold said.

Bellman left the Rand Corporation in 1965 to join the faculty of the University of Southern California, where he holds a joint appointment as Professor of Mathematics, Electrical Engineering and Medicine. He lived in Santa Monica, wit his wife, Nina, who he spends much of his time on writing and the creation of new ideas. A prolific writer, he has authored over 620 published research papers, and forty books and seven monographs.

Bellman did a lot of traveling in America, Europe and Africa where he had done many talks and works. However, most of his recognition took place in The United States. Bellman's fundamental contributions to science and engineering had won him many honors. Famous among these are: First Norbert Wiener Prize in Applied Mathematics, awarded in 1970 jointly by the American Mathematical Society and the Society for Industrial and Applied Mathematics; First Dickson Prize, Carnegie-Mellon University, 1970; and John von Neumann Theory Award, awarded in 1976 jointly by the Institute of Management Sciences and the Operations Research Society of America. He was awarded the IEEE Medal of Honor in 1979, "For contributions to decision processes and control system theory, mainly the creation and application of dynamic programming." He was elected to Fellowship in the

American Academy of Arts and Sciences in 1975, and to Membership in the National Academy of Engineering in 1977. But what is important to mention is that Richard Bellman won more than just fame, he won the admiration and affection of all who know him for his exceptional courage and greatness as a human being. There is still so much more that we owe to him since all the contributions he made have changed the way optimization is done by mathematicians. I was able to compile this biography by summarizing Bellman's own book "Eye of the Hurricane: Auto Biography".

Some of the most important books written by Richard Bellman are:

(2003) "Stability Theory of differential Equations"

(2003) "Perturbation Techniques in Mathematics, Engineering and Physics"

(2003) "Dynamic Programming"

(1997) "Introduction to Matrix Analysis"

(1995) "Modern Elementary Differential Equations"

(1985) "Artificial Intelligence"

(1984) "Eye of the Hurricane: An Autobiography"

(1984) "Partial differential Equations"

(1983) "Quasilinearization and he Identification Problem"

(1983) "Mathematical Methods in Medicine"

(1982) "Mathematical Aspects of Scheduling and Applications"

(1972) "Dynamic Programming and Partial Differential Equations"

(1970) "Algorithms, Graphs and computers"

(1967) "Introduction to the Mathematic Theory of Control Process"

(1962) "Applied Dynamic Programming"

(1961) "Adaptive Control Process"

(1961) "An Introduction to Inequalities"

(1986) "Methods of Approximation"

(1959) "Asymptotic Behavior of Solutions of Differential Equations".

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4. Bellman, Richard, (1972) "Dynamic Programming and Partial Differential Equations," Elsevier Science & Technology Books.

5. Kushner, J. Harold at http://www.a2c2.org/awards/bellman/index.php