The Life of Prof. Isaac Horowitz

The international control community lost a giant researcher with the death of Prof. Isaac Horowitz. His early recognition that uncertainty and quantitative design are critical in feedback system design significantly influenced control theory and its practice. Here we provide a chronological account of Prof. Horowitz's diverse academic and industrial experience as well as personal remembrances.

Isaac Horowitz was born on 15 December 1920, in Safed, Israel, one of 11 siblings. His family came to New York City when he was five years old, and shortly thereafter settled in Winnipeg, Canada.

Isaac's educational and professional career is marked by many venue changes. He worked as an accountant while attending the University of Manitoba from 1938–1944, from which he received a B.Sc. degree with honors in physics and mathematics. Isaac worked for one year as a radiosonde engineer for the Canadian Meteorological Division. In 1948, he received a B.Sc. degree in electrical engineering from MIT. He then served two years as an officer in a scientific unit of the Israel Defense Forces. During 1950–1951, he was a design engineer at Halross Instruments, Winnipeg. For the next five years (1951–1956), Issac was a full-time instructor and part-time graduate student at the Polytechnic Institute of Brooklyn. His M.E.E. thesis was titled "Push-Pull Split Feedback Magnetic Amplifier" (patented) and his D.E.E. thesis, titled "Active Network Synthesis," won a 1956 best paper award at a national electronics conference. Isaac was an assistant professor at Polytechnic Institute of Brooklyn and a senior research associate at the Microwave Research Institute from 1956–1958. He was a senior staff member at Hughes Research Labs for the next four years and, from 1964–1966, he was a senior scientist in the Guidance and Controls Division of Hughes Aircraft Co. and an adjunct professor in the Department of Electrical Engineering at the California Institute of Technology.

Issac was a professor in the Department of Electrical Engineering, City University of New York, from 1966–1967. For the next six years, he was a professor in the Department of Electrical Engineering at the University of Colorado, Boulder. Beginning in 1969, he held a joint appointment as a Cohen Chair of Applied Mathematics at the Weizmann Institute of Science, Israel, and became professor emeritus in 1985. During that time, he also consulted with Israel Aircraft Industry (IAI). From 1985–1991, he was a professor at the Department of Electrical Engineering at the University of California, Davis, and became professor emeritus in 1991. During this period (1983–1992), he held a distinguished visiting professor appointment with the Air Force Institute of Technology, Dayton, Ohio, where he was a consultant with the Flight Dynamics Lab. His last appointment was in 1993–1994, in the Department of Mechanical Engineering at the University of Witwaterstrand, Johannesburg, South Africa.

Prof. Horowitz consulted and presented invited talks internationally. He holds two patents, authored and coauthored approximately 100 journal and 40 conferences papers, and authored two books [1], [2]. At the time of his death, he was researching material for volume 2 of the Quantitative Feedback Theory (QFT) series. He is survived by two children, Matanya and Benyakir, with Mrs. Gloria August, and four children, Sharon, Ruthie, David, and Dafna, from a previous marriage to Chana Horwitz.

Prof. Horowitz was a principled, at times outspoken, person who throughout his career maintained a consistent philosophy on life, particularly when it came to control design. Early on, he advocated that any feedback design method must explicitly account for a quantitative description of plant uncertainty and desired performance, and afford the designer the ability to transparently judge design tradeoffs. His pioneering 1963 book is full of gems on uncertainty, robustness, and sensitivity reduction [1]. He strongly preached for the utilization of classical frequency response techniques over state space, mainly due to his belief that the former were better suited for practicing engineers and required little in terms of background learning to carry out a design. He felt that the emphasis on advanced mathematics in recent control theories essentially amounted to the trees hiding the forest.

In the 1980s, when many researchers turned their attention from frequency response ideas to optimal control theory, Prof. Horowitz maintained his vision and persisted with the development of QFT. Eventually, the 1990s saw more researchers embrace QFT and pursue academic careers around this method, which generated alternative descriptions and

Remembrances

The following accounts portray Isaac's life in four stages, as related by a daughter, a Ph.D. student, a key collaborator, and his second wife.

Daughter Sharon Feinberg

My father was a tremendous reader, lover of poetry and classical literature, and an avid student of Jewish history. He did not waste time and was always immersed in some sort of activity, often reading. He had an unparalleled physical stamina and energy. A perfect illustration is the following story. Four years ago, at the age of 81, he came to Los Angeles with us. Shortly after he arrived, he borrowed a bike, rolled up his pant legs, and rode off for three hours in the hilly terrain. He appreciated nature, had artistic talent, and drew quite well. He was tremendously responsive to injustice and to the plight of suffering people, in particular, his Jewish brothers and sisters. During World War II, while most of American and Canadian Jews were silent, he wrote and disseminated a paper crying out against the Holocaust. During the 1960s, when the fate of Russian Jews had not yet become of worldwide interest, my father was actively immersed in this cause, spending virtually all of his free time trying to make a difference. He had a great love of music, particularly folk music. As kids, vacations were usually a week at places like Yosemite National Park. My father was a brilliant man, always open to new ideas and new ways of looking at things. In a sense, he was childlike and very naïve, which helps explain his great love for children, who in turn always loved him.

Ph.D. Student Marcel Sidi

At the end of the 1960s, I was involved in the design of the control system for an advanced fighter for IAI, whose dynamical model, of course, included large uncertainties. One day, visiting a library, I found Prof. Horowitz's first book, published in 1963. I read with amazement his detailed description of design of uncertain feedback systems. I quickly discovered that these ideas were extremely useful in my fighter control system design challenges. Our careers crossed paths a year later, when Prof. Horowitz joined the Weizmann Institute of Sciences, Israel, and became a consultant to IAI. Soon after, I convinced my employer to let me become Prof. Horowitz's Ph.D. student. The integration of Prof. Horowitz's theoretical background with my practical engineering experience led to the development of a design technique for uncertain feedback systems, known today as quantitative feedback theory (QFT). Our first paper was published in 1972 by the *International Journal of Control* [3]. Since then, we continued to cooperate in improving this design technique.

Longtime Collaborator Dino Houpis

In the late 1970s, Prof. Horowitz made his first contact with the Air Force Flight Dynamics Laboratory (AFFDL). During that period, he applied his QFT technique to designing the flight control systems for the TYF16CCV and the X-29 aircraft. As a consequence, AFFDL felt that QFT had great potential and that the laboratory should support Isaac in not only applying the technique to the design of flight control systems but in further developing and enhancing his technique toward achieving robust multivariable control systems containing parameter uncertainty. With this in mind, in 1982 AFFDL appointed me, then at the Air Force Institute of Technology (AFIT), as a senior research associate to facilitate this interaction. During the early 1980s, Isaac taught a course on QFT at AFIT to my flight control students. In the latter part of the 1980s through 1992, Isaac devoted his time to serving as cothesis advisor to AFIT graduate students. As a consequence of this involvement, numerous technical articles have been presented at conferences and published in technical journals since 1984. The value of Isaac's contribution to the advancement of flight control system design was acknowledged by AFFDL, underwriting the first biannual QFT Symposium in 1992 at Wright-Patterson AFB, Ohio. This period of Isaac's life and his contributions solidified the foundation of QFT and provided the impetus for Prof. Horowitz's followers to carry his work in QFT to greater heights and achievements.

Wife Gloria August

Isaac and I met 25 years ago at the University of Colorado, Boulder, while I was researching Soviet Jewry. Isaac was involved in getting Jews out of the Soviet Union in the early 1970s in several ways, including hunger strikes here and in Israel. He also worked to get Jews out of Ethiopia. Isaac had a strong Zionistic predisposition early on in his life; he was part of a group who sailed from Marseilles, France, to Palestine in 1948 to assist the young state of Israel. At all times, he was a man of honor and integrity and fought the bigotry and prejudice of his country and the outside world. A month before he died, we went together to a Marine Corps recruiting agency in Colorado. Isaac was so humbled by the American people and their sacrifices. He believed that the United States afforded the Jews the best chance for freedom for Israel. As with his technical work, he was not merely a thinker but a doer. He followed, as I like to say, in the shadows of the famous French historian Marc Bloch (a victim of Nazism), who never sat in his ivory tower alone but pushed to be a part of the history of his time.

new algorithms. Since its inception, QFT has been extended and generalized to cover MIMO LTI systems, time-varying systems, and classes of uncertain nonlinear systems. Numerous impressive real-world applications of the method have been published. There have been technical sessions dedicated to QFT, and several symposia have been held on the subject.

Prof. Horowitz was an IEEE Fellow (1970), and he received the ASME Rufus Oldenburger Medal for seminal contributions in feedback control (1992). Several textbooks have appeared on QFT, and the subject is taught at the graduate and undergraduate levels at universities around the world. Software packages, including a MATLAB QFT Toolbox, appeared in the early 1990s to carry out practical designs using QFT ideas and quickly found a strong following in industry. One might say that Prof. Horowitz's QFT is a useful tool in the toolbox of the control engineer.

Prof. Isaac Horowitz made a lifetime of contributions to the practice and theory of robust control and significantly changed the course of the controls field. The control community will miss him.

Acknowledgments

In preparing this document, we consulted numerous people who knew Prof. Horowitz at different stages in his life. We attempted to convey their personal accounts in their own language; any errors or omissions are solely our oversight. Any opinions expressed otherwise are ours and may not represent the views of those we consulted. We wish to thank everyone who contributed for their generous support.

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Y. Chait was introduced to Prof. Horowitz in the early 1990s by Oded Yaniv, Chait's QFT teacher.

S. Jayasuriya came to know Prof. Horowitz in 1982 through his advisor Robert Barnard, who had worked closely with Isaac in the late 70s.

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VIII in 1303) and largest European universities, with over 100,000 students.

Prof. Ruberti was minister of Coordination of Scientific and Technological Research in the Italian Government (1987–1989) and, subsequently, minister of University and of Scientific and Technological Research (1989–1992). He promoted laws to renew the Italian system of education and training and launched innovative research programs aimed at new materials, bioelectronics, and the environment. In 1988, he instituted the Italian Space Agency and, in 1992, founded the third University of Rome.

Prof. Ruberti was the European Commissioner for Science, Research and Development, and Education (1993–1995). A European research program (4th Program Framework) for US$13 billion was launched under his leadership, along with new education and training initiatives, including the Socrates and Leonardo programs. He also undertook initiatives to promote public understanding of science through the European Forum on Science and Technology.

In 1996, Prof. Ruberti was elected to the Italian Parliament as a member of the Democratic Party of the Left. In Parliament, he chaired the Committee on European Union Policies contributing to the European integration process.

Prof. Ruberti published numerous essays and articles on the politics of research, education, and the problems of technological innovation. He edited two books, *Technology Tomorrow* and *Europe Confronted,* published in 1985 and 1990, respectively. In 1995 he published, with M. André, *Un Espace Europèen de la Science*.

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