In memoriam
JACK WARGA, 1922-2011
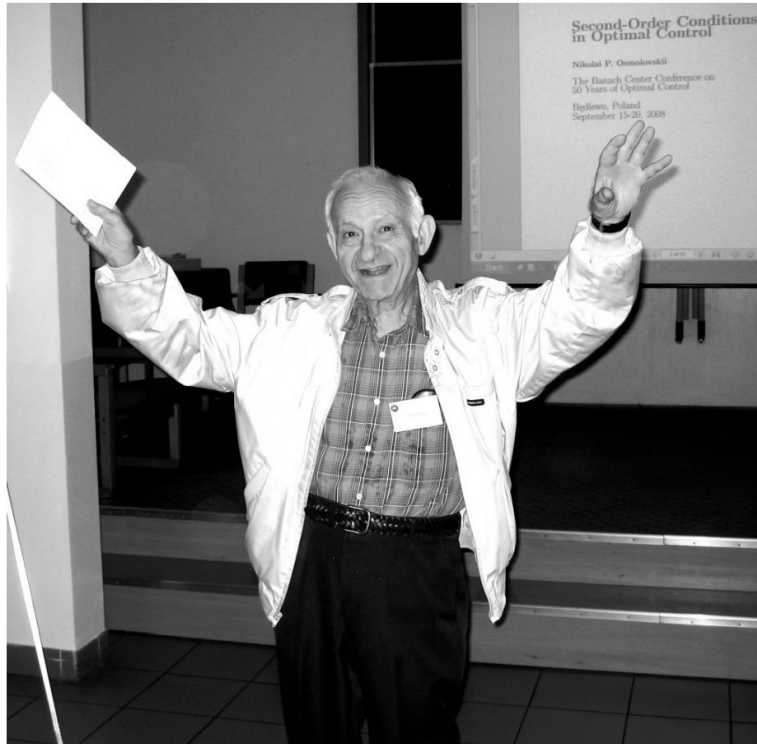
Jack Warga passed away unexpectedly on June 26, 2011, in Boynton Beach, Florida. Despite his almost 89 years of age, Jack was in a remarkable physical and mental shape, full of energy, and actively doing mathematics. He died of an accident. He was preceded in death by Faye, his wife of more than 60 years, and is survived by his son Arthur, daughter Charna, and their families.

Jack was born in Warsaw, Poland, on September 20, 1922, into a Jewish family. In 1938 he was sent by his father to Belgium for his education. This saved his life, since most of his family perished in Poland during the Nazi occupation. Jack wrote a very interesting memoir about his life, including his

years in Europe during the Second World War, when he moved from one place to another, escaping from the Nazis. He finally arrived in the United States in 1943 and participated in the war as an officer of the US Army.

He received his Ph.D. degree in mathematics from New York University in 1950. After that he worked as a mathematician and computer scientist in several R&D corporations in New York and California, before moving to Massachusetts in 1957. He worked as a mathematical analyst and then Manager of the Mathematics Department of Avco R&D Division at Wilmington, MA, from 1957 to 1966. From 1966 till his retirement in July 1993 he was Professor of Mathematics at Northeastern University, Boston, MA. Besides this, Jack held a Weizmann Memorial Fellowship at the Weizmann Institute of Science in Rehovot, Israel, during 1956 and 1957, and then spent his sabbatical year there in 1973. During 1981 he was on sabbatical at Tel Aviv University. He was an invited speaker at numerous meetings in the United States, Canada, Europe, and Israel.

During his entire research career Jack played a very active role in serving the applied mathematics community at large. In particular, for over 25 years he was on the editorial board of *SIAM Journal on Control and Optimization* (starting with 1964 when it was called *SIAM Journal on Control*), being the Co-Managing and Managing Editor of the journal from 1967 through 1978.

It is difficult to overstate Jack's seminal contributions to optimization and control theory and nonsmooth analysis; he was a pioneer and a life-long leader in these and related areas. His first two-part paper on optimal control (published in 1962 in *Journal of Mathematical Analysis and Applications*) was a breakthrough in control theory. Up to now it has been among the most fundamental achievements and sources of inspiration in control theory and variational analysis. In this paper Jack introduced the notion of relaxed controls (he coined this term), proved their automatic existence in general optimal control systems, and derived necessary optimality conditions in relaxed variational problems. Since that seminal paper by Jack, the scheme of relaxation has been applied by many researchers to various control systems governed by ordinary differential, functional differential, and partial differential equations. Jack himself greatly developed this scheme in his classical monograph "*Optimal Control of Differential and Functional Equations*" published by Academic Press in 1972 and translated into Russian in 1977.

Among other crucial contributions by Jack to optimization and control theory let us mention his results on optimal control problems with state constraints, higher-order optimality conditions, control systems with delays, controllability conditions in dynamic optimization, iterative computational techniques, minimax problems, differential games, nonsmooth control systems, etc.

Jack's study on nonsmooth control systems took him to discovering a fundamental concept of nonsmooth analysis, known now as Warga derivate containers. The first construction of this type appeared in Jack's paper of 1975, devoted to necessary optimality and controllability conditions for control systems without differentiability assumptions. Since that, Warga derivate containers, their

modifications and extensions have played a crucial role in variational analysis and generalized differentiation, being among the finest and most delicate tools of analysis and applications.

Besides being an outstanding mathematician and extremely deep researcher, Jack was very interested in and knew many things in history, philosophy, poetry, music, etc. He was a polyglot, deeply interested in the structure, etymology and new developments of the numerous languages, which he spoke fluently. These interests were also extended to the literature in those languages, in particular in Polish. Since his early years in a Polish school, Jack was enchanted by the poetry of great Polish romantic poets, Adam Mickiewicz and Juliusz Słowacki. He knew by heart long passages from their poems. His wife, Faye, who did not understand Polish, told that her husband often was reciting aloud their poems.

Jack was an exceptional human being; his kindness, helpfulness (particularly to young researchers), and personal integrity did not have any bounds. I (Boris) will never forget my first personal meeting with Jack in January 1989, just a couple of days after my immigration to the United States. He was unbelievably kind to me and my family and helped us so much. Since that time we became close friends with Jack and stayed in touch until his last days. I witnessed many times his extraordinary kindness and helpfulness to other people.

Jack did not judge people. He always had a kind word and a smile to everyone. We all will miss him terribly.

Kazimierz Malanowski
Boris Mordukhovich