



McGill

C e n t r e f o r

Intelligent Machines

Special Issue

Newsletter

A Fond Farewell

To the faculty, students and staff of the Centre for Intelligent Machines, the loss of Professor George Zames in August was akin to that of losing a beloved family member. Indeed, as the personal tributes contained in this newsletter will attest, George Zames touched many lives in a truly profound manner – he was a mentor, colleague and valued friend.

I first met Professor Zames in October 1996. The meeting was at my request, primarily to introduce myself as the new manager of CIM and to attempt to familiarize myself with his area of research. I liked him immediately. His gentle, dignified manner and genuine approachability put me completely at ease. In the all too brief time that I knew him, I came to view him as the paternal presence in the Centre. He was a quiet leader who displayed a surprising depth of commitment to CIM's future and became a calming influence – the voice of reason – in these times of uncertainty.

I once read that there is no greater testament to a man's character than the humanity that he passes on to his children. If this is so, then Professor Zames was truly an exceptional man, for his two sons, Ethan and Jonathan, obviously possess

many of his fine qualities. Their display of remarkable courage, eloquence and dignity while facing immeasurable personal loss shall remain an inspiration to me for years to come.



IN MEMORIAM
GEORGE ZAMES
1934 – 1997

This special edition of the CIM newsletter is dedicated to the memory of Professor George Zames. The contributions made here, submitted by various members of the CIM community both past and present, are written with genuine respect and fondness for a man who continues to share a place in our hearts.

Submitted by Marlene Gray

A Tribute to George Zames

It is so hard to believe that George has gone, but this special issue of the CIM Newsletter presents an opportunity for some random reflections and reminiscences on my old friend and colleague.

George was a great system theorist; he was genuinely one of the seminal thinkers of systems and control theory. George formulated fundamental notions in the subject, and posed and solved important and beautiful questions which generated

an enormous research subculture. His outlook and his results will certainly propagate through system theory for a long time, and, indeed, will form a part of the foundations and the definition of the subject itself.

George was almost entirely motivated by the problems of inexact knowledge and information in control systems, and the way that feedback increased the accuracy and performance of systems in the face of such uncertainty. It was these considerations which motivated his early work on nonlinear systems, his later investigations of information measures for families of systems, and then, ultimately, his widely acclaimed work on H infinity control.

George was invariably interested in the fundamental, underlying, issues of any problem area. In harmony with this, he always valued quality over quantity; he would often quote the recommendation of Moishie Zakai of the Technion that when a faculty member had exceeded about two publications in any year the onus lay with the author to show that the others really needed writing. He practiced this economy himself; a review of his CV shows he was only concerned with writing papers which were potential classics. On one occasion, I was surprised and impressed when I heard him remark that he had defined enough problems to occupy him for the rest of his life.

No one could accuse George of being modest, I recall that I once suggested that we organize, Princeton style, a course or seminar called something like Great Theorems in System Theory and he impishly remarked that 60% of them would be his. But George very rarely denigrated the efforts of others, which is itself something rare in a world of comparative evaluations, he simply concentrated on looking for the genuinely valuable contributions in the field.

Some of the most hilarious incidents involving George occurred under the auspices of the Artificial Intelligence and Robotics Program of the Canadian Institute for Advanced Research, the latter remarkable institution being piloted by Fraser Mustard. his meeting of minds was supposed, in principle, to bring together systems and control researchers and artificial intelligence researchers for fruitful interdisciplinary interaction. Although

that may well have eventually taken place, in particular under the energetic influence of Steve Zucker, at the beginning there was open academic warfare, with one view being promulgated by George. While some of us thought the interdisciplinary effort would be a good thing and potentially fun, George was not going to take any nonsense from a group of computer scientists who thought they could control anything, and Fraser - who later often referred to George's 747 example - thought the first program of his Institute was just not going to fly. I believe one of the most amusing vignettes from that time was watching George musing over Fraser's invitation to devise our own criteria for measuring the worthiness of our program for continuation.

Finally, George loved to argue and we had some terrific discussions on everything from system theory, to politics and economics, to the future of China, where he spent his early adolescent years. With George's robust appearance and his love of life, and especially of his family, I really thought we were going to be debating a world of ideas for another twenty years. During my visits with him, Eva, Jonathan and Ethan, over the last two months of his life, we had many fragmentary conversations in which he never lost his sense of humour and his genial scepticism. With George's untimely death the systems community is now lacking one of its seminal thinkers and researchers, his past and present research students will miss a valued mentor, and I have lost a remarkable friend and colleague.

Submitted by Professor Peter Caines

In Memory of George Zames

George Zames walked the corridors of McGill, abstracted but engaged, providing everyone with a wonderful model of what a Professor should be: someone interested in the deep questions, and totally absorbed in solving them. Many will write to his technical and many academic skills, but I will speak to the George Zames that I knew as a friend, as a colleague, and as a mentor.

George was an antidote to the fast, technology-saturated world in which we often find ourselves.

Although uncertainty lay at the heart of his theorizing about systems, there was no uncertainty in how he saw the academic world. He had the clearist vision I have ever encountered about what was important: for George, this was his family, his research, and his community.

For George, newer was a concept to be pondered; newer rarely meant better. I recall his love for an old Pontiac, which he kept repairing well beyond its normal lifetime. He took endless pride in the amount of additional metal he had welded onto this car, and often described it in terms of military vehicles. Whenever a new spot of rust appeared, he simply had a new piece of metal welded onto it. As his reputation grew around McGill, the then Principal, David Johnston, became aware of this distinguished and internationally-known Professor. Imagine the look on George's face when he emerged from under this Pontiac, with grease on his hands from an 'on the spot repair', only to come face-to-face with David.

This pre-occupation with a mechanical device may seem odd for George, who viewed himself as much as a mathematician as an engineer. Nevertheless, he claimed on many occasions that it was a few laboratory experiences as an undergraduate at McGill that shaped his views about the importance of feedback.

When personal computers became widespread, George allowed one to be placed in his office, but years went by before it was actually turned on. In fact, he expended significant energy *restricting* the flow of information into his world, because he held the view that most of this was a distraction rather than a help. We are bombarded with papers, he claimed; the trick is to cut oneself off from the flow and to concentrate on one's work. If there were important results, he assured me, I would hear about them. I often think about these old discussions when the subject of individual web pages comes up.

George loved to argue, and I often found myself wonderfully trapped in them with him. Although my research was in areas quite different from George's, he taught me a great deal about hierarchy, organization, and complexity, and I am

certain that some of these ideas have found their way into my thinking.

George often argued in public, and many situations arose around the Canadian Institute for Advanced Research, of which he was elected a Fellow, that illustrate how he enjoyed it. A perfect example occurred at an all programs meeting of the CIAR when, following the presentation by the Cosmology Program, it suddenly seemed as if our Program in Artificial Intelligence and Robotics was small and, at least with respect to the questions they were studying about the origin of the universe, trivial. George then asked the cosmologists if they were in fact studying the origin of the universe, or just studying the solutions of a system of partial differential equations from different initial conditions and hoping that these equations bore some resemblance to the early Universe. Suddenly they were working on an arbitrary mathematical abstraction, and we were trying to understand the brain. The positions were instantly reversed.

But the person with whom George argued most carefully – and most respectfully – was his wife. Eva presented a formidable intellectual challenge to George, and the energy between them was amazing. I recall one occasion when Eva read a Newsweek piece on fuzzy systems and how well they worked in Japanese washing machines. The challenge was for George to defend H infinity-theory and why he wasn't working on fuzzy mathematics; this resulted in an entire seminar course.

While the anecdotes give you a feeling for the man, there was a depth to George that only personal encounters could reveal. The sense of joy in his family, the pride in his achievements, and the power of his intellect always came through. The last time I saw George, in the hospital, Eva and Ethan and Jonathan were by his side. We discussed science and politics, and the interface between vision and control. His conversation was broken, but his intellect clear. His untimely death has left the field without one of its most seminal thinkers. I shall miss this special friend.

Submitted by Professor Steven Zucker

In memory of my mentor

Lately, since hearing the shocking news of the illness and death of Professor George Zames, I've thought a lot about the times we spent together.

If there is one person who has influenced my life as much as my parents, it was definitely George Zames. In the past 10 years, first as his student then as a colleague and friend, I have learned tremendously from him.

In 1987, I came to McGill to pursue a Ph.D. degree under his supervision, with the recommendation of Professor Wu of Tsinghua University, who had hosted Professor Zames' first visit to Communist China in '82. Having heard of his work on H -infinity before meeting him, I prepared for my first interview with him by reading some of his publications. At that time, they seemed to have been written in a language from another planet. To my surprise, he did not even mention H -infinity during that first meeting; instead, he asked me to define compact sets. On hearing my answer, he sent me to study analysis for two years in the department of mathematics. Later, I learned that this was the norm for all his students.

After two years of training in mathematics, I was ready and determined to solve all the problems in control. The first task I got from him was to investigate the flexible beam control problem on which I worked fervently. Half a year later when I found the minimum sensitivity of a flexible beam control system, I enthusiastically wrote it up for publication. After glancing through my report, he said it was "A good exercise." Then he started talking about what we should do next. I remember coming out of that meeting quite depressed. But now on looking back, I agree with him: it was *only* a good exercise. It was this high standard on research and publication that made him one of the greatest researchers in the control community.

In all the years that I worked with him, nothing impressed me more than his deep understanding of the control and system theory. The summer of 88 was an example of this. In order to bring his two new students, James Owen and me, into his research program, he organized a study group on operator theory. He asked James and I to study one chapter

per week from the two classic books, "Linear Operators on a Hilbert Space" and "Lectures on Invariant Subspaces". The group, consisting of senior graduate students, visiting professors, and postdocs, met once a week. James and I would make presentations about what we had learned. Most participants thought it as an opportunity of learning mathematics and were satisfied as long as they could follow the proofs. But George would always interrupt our presentation and explain the concepts with examples in control. He could find a system or control interpretation to almost every concept and theorem in operator theory. At that time, I couldn't quite appreciate his zeal in such interpretations. It was only four years later, that I realized that it was his capability to map back and forth between mathematics and control that allowed him to understand many control problems at a higher level. This capability of abstract thinking formed the basis of his deep and special understanding of the system and control theory.

Even after I obtained my degree, I often turned to him for advice when I had problems at work and he was always there to help. I regarded him as my mentor. Last December, after the CDC in Japan, Professor Wu from Tsinghua University invited George and I and our wives to visit China, the country he had left 50 years previously.

He had spent eight years in Shanghai during World War II and always had strong feelings about that city. He'd often talked to me about his desire to see the changes that had happened in China over the last decade. In Shanghai, he took me to the apartment where he had lived, his old school, the park where he played, and the restaurant where he had spent his 15th birthday party. It was kind of hilarious to see a foreigner pointing here and there, giving a guided tour to Chinese people on the streets in Shanghai. A few days later, I reciprocated by showing him around when we arrived in my hometown of Beijing. We had a lot of fun and made many new friends among our Chinese colleagues.

With the memory of our trip to China still fresh, it is hard for me to believe that he has left us. Sometimes when I have a problem I still feel like calling him for his advice. It is painful to lose a great mentor like him.

Submitted by Dr. Lin Lin

The Gadfly

On a peaceful day this past summer, a quiet and inconspicuous man passed away without much fanfare. But this was none other than Dr. George Zames of McGill University. In his passing, the control systems, engineering and mathematics communities lost one of its most formidable researchers and profound thinkers.

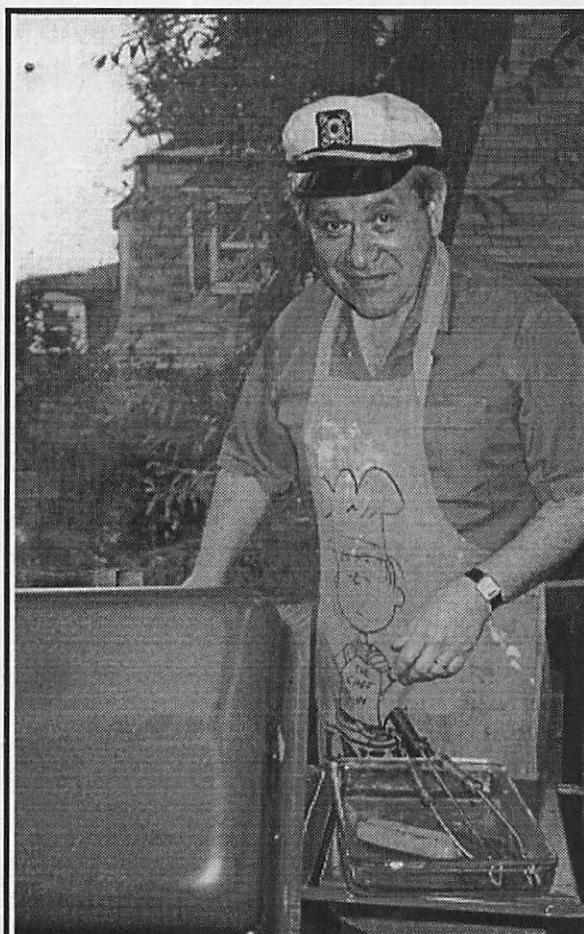
As his faculty chair excused him from most of his teaching duties, the only conspicuous presence he had on campus was when he was holed up in the engineering cafeteria reading his stack of newspapers and eating his salad. Dr. Zames used to drench his salad with dressing and scoff it back post-haste. Indeed, if one was to ask an intricate math question just as he was digging in, you were sure to see little bits of salad launched onto your notes in his zeal to eat and speak at the same time.

The engineering tradition has it that if one is lucky enough to come across an idea, one should become an entrepreneur and market it. Dr. Zames' ideas were entirely innovative but he consistently saw himself as an academic and left development to others. In fact, Dr. Zames almost never used a computer. While in the company of some very practical engineers he used to astonish them with comments like "I bought myself one of the Hewlett-Packard calculators that can plot graphs. I was trying to plot $\sin(x)/x$ the other day and I realized that you get garbage unless you get the parentheses exactly correct."

Dr. Zames techniques were entirely eclectic. Upon meeting one of his new Ph.D. students for the first time, he escorted him to his office and said, quite simply, "So, you must have some questions." Perhaps he thought Zen was appropriate for mentoring colleagues. Finished theories came packaged with incredibly convincing oral arguments but atrocious journal papers. As soon as he had convinced others of the merit of a line of research, he saw it as old-hat.

Dr. Zames used to like to call himself a gadfly, i.e. an intentionally annoying person who provokes others by persistently irritating (read: just) criticism.

Accusing engineers of being unscientific and intellectually lazy surely didn't endear himself with his more comfortable colleagues. But he proved his point twice, and surely would more if for not his untimely passing, and will be remembered as a pioneer in the fertile ground between mathematics and engineering.
Submitted by Michael Glaum, Ph.D. Candidate



George Zames: friend, colleague, and mentor

George Zames: In Memoriam

George Zames passed away this past summer after a brief illness. George has left a powerful legacy to the field of systems and control. A piece is now being organized by Sanjoy Mitter for the *Transactions of Automatic Control* with contributions by George's friends, students, and

colleagues on his remarkable technical achievements, and so I will only very briefly sketch some of his ideas here.

One of the central themes of George's work is that the main function of feedback control is to deal with

uncertainty. This fundamental idea underlies his monumental contributions in the subject. These include his input/output approach to nonlinear system stability, circle theorem, positive operator theorem, small gain theorem, feedback complexity and hierarchies, metric uncertainty, adaptation and learning, and H infinity theory. Zames posed the critical question of what types of uncertainty of the open-loop correspond to small induced-norm errors of the stabilized closed-loop? Accordingly, he introduced a topology for robustness questions which provided a unifying framework within which all other approaches to robustness could be considered. George was fond of pointing out that all of the "new" robust stability tests that he came across, structured and unstructured, quadratic and otherwise, were "all small gain." And of course he was right! The vision of Zames has come to dominate the field of control, and the most powerful testament to his legacy is that his once revolutionary ideas have become the standard now in the subject.

All of us who knew George Zames, knew of his love for his family:

his two sons Ethan and Jonathan, and of course his wife Eva. Eva Zames was truly George's best friend and intellectual partner who shared and delighted in their mutual life's adventure together. George was fond of saying that he lived a charmed life, and the foundation of that life was his family. Those of us who visited George during his last days in the hospital, could only be deeply moved by the love and support shown to him by his family. George himself did not show any fear of death. Indeed, when he learned about his condition, his main concern was that Eva and his two sons be well provided for. About himself, he said that he had lived a full life, and could ask for nothing more.

Our dear friend and mentor, George Zames, *Zichrono Levracha* (of Blessed Memory), will be sorely missed.

Submitted by Professor Allan Tannenbaum

Thanks, George

I first met George Zames 20 years ago this September. It was my final year in Electrical Engineering and I was itching to get out and join the "real" world. I don't know why I took George's course; it didn't have much to do with my technical interests at the time, but for some reason it seemed a good idea. You know, one of those courses that one uses to round out their electives in their final year. I had my career planned - back to the company that had employed me for the past 3 summers, good-bye McGill.

We had heard of this guy Zames, but no one in my immediate circle of friends could remember having him in any of our courses. About 30 of us showed up on the first day of class - George was a bit surprised (presumably by the size of the class); he looked a bit lost. Who was this guy?! And then he started to lecture and write on the board, first a 15 minute review of all the linear algebra that we were supposed to have at our fingertips, and the rest of the hour all the linear systems theory that we ever did as undergraduates. Quick, pull out those old textbooks and brush up; off to the library to get up to speed on "modern" control theory. After a few weeks of this our number dwindled (slightly) and that hour of lecturing seemed to go by in 15 minutes (can you say "time dilation").

About 6 weeks into the course George started talking about stuff that we couldn't find in the library any more. Where was he getting this stuff from?! A few of us managed to find an unused room on the 7th floor with lots of tabletop space to spread out our notes on and a large blackboard. We'd go to class and then head on upstairs to spend a couple of hours deciphering the notes that we'd hastily scribbled down earlier. Among the four of us, we managed to make sense of things. But by the end of the term, however, virtually all of our free time was spent trying to keep up. Boy was I glad when that course was over!

Or so I thought, Stockholm syndrome? Here was a whole other world that I had somehow missed. What had I learned in the past three years anyway - I didn't know anything! I went back to work that summer, but things weren't the same. Here I was at the center of the technological universe, on the

leading edge. But for some reason I felt like I was in a backwater. The excitement was back there in that dusty classroom where that rumped fellow, covered in chalk dust, was holding court.

At the end of the Summer I announced that I wouldn't be staying on at the company and enrolled in the Masters program for January. Hell - it was only 18 months more. I tried leaving again (they still wanted me at my old job), but by that time I had learned from George (and a couple of folks attracted by his presence), that I really didn't know anything - something that might be remedied by another 5 years of study.

Well, it's 20 years later, and I still don't know anything, but I'm working hard to remedy that.

Thanks George!

Submitted by Professor Frank Ferrie

George Zames transcended disciplinary boundaries

While it is true that George Zames became a household name within IEEE and other circles of electrical engineers, it is also true that George's work went beyond these circles. Having graduated from McGill's now phased out Engineering Physics Program, George worked professionally as an electrical engineer in the area of telecommunications, while his most outstanding achievement, H-infinity theory, has become a landmark in the areas of control and system theory. Now, control and system theory are themselves pervasive, and so, it comes as no surprise that George's work is highly acknowledged and appreciated in other engineering circles. I am aware of one specific case: ASME, the American Society of Mechanical Engineers, awarded George this very year the Rufus Oldeburger Award "in recognition of his significant contributions and outstanding achievements in the field of automatic control" (Spring 1997 issue of Dynamic Systems & Control Division (DSCD) Newsletter; DSCD is a division of ASME.)

Submitted by Professor Jorge Angeles

George Zames: a rare researcher

George was a rare researcher, a paper-and-pencil theoretician with a strong innate sense for the real problems. He never lost track of the fundamental reason for feedback control: to counter the effects of uncertainty. This was forgotten by most of the research community in the 60's and 70's, when state-space theory was the rage. George persisted in his belief that this was not the proper setting to take into account the uncertainty of models, and was somewhat outside the mainstream during that period. Eventually, he brought the field back to his point of view with H-infinity theory. That was in fact his second breakthrough, the first one having been nonlinear stability results of the late 50's.

He was on everyone's list of the top 5 researchers in the world in Control, and at the top of many. Still, he had the quality of not taking himself, or anyone else, too seriously. He viewed the world with amused detachment most of the time, and often loved to argue a point for the pleasure of the debate rather than in defense of his point of view. He was fond of movies, and liked to discuss the latest films. He was always approachable to everyone; kind and courteous.

Submitted by Professor Pierre Belanger

More Reflections

It's recalled vividly and fondly that George Zames once recounted a story about his having (while doing a post doc at MIT) met Niels Bohr who was visiting. Bohr made a great show of hobnobbing with the grad students and postdocs at the grad students' centre and engaged them in lively conversation and answered all their questions in a friendly, patient manner and at great length.

All at once a funny little fat guy scuttled up obsequiously to the great man and seriously asked him to look briefly at some analysis written on a piece of paper. Bohr glanced briefly at the offering, looked down his nose & sneered dismissively, muttering something to the effect that he had a rather scientifically indifferent relative who dabbled in such stuff. Well, the little fat guy was Norbert Wiener, father of control theory and I guess the point George was making, concerning Bohr's moment of less than perfect human relations, was that one should be respectful and considerate even of those whom one considers to be inferior colleagues. They probably have considerable merit which has escaped first impression and one's perceptions. In this regard, Zames was greater than Bohr. What cannot be conveyed in retelling the tale are the gestures and rubber-faced imitation (George actually brought himself to resemble, at least the photos I've seen of, Bohr) that was worthy of a trained (not only mind but) mime.

Submitted by Professor Paul Zsombor-Murray

With fond memories:

I will remember Professor Zames not only as a world famous contributor to control theory but also, and more importantly, I will remember him for his wonderful personal qualities, his generosity and his capacity to relate to all of us and our problems.

Submitted by Professor Hannah Michalska

George Zames was a truly great man and he cared about the people around him. I shall always remember his warmth and gentle nature and will miss the interesting chats that we had together.

One of the most memorable experiences I can recall, was being invited to go to Ottawa to attend the Killam Prize 1995 presentation that he was presented with. I recall being so proud knowing that this recognition was so richly deserved and that I was invited to share this day with him and his family.

Submitted by Mindle Levitt, CIAR Secretary
