Chapter 18: Our New Life in Coto de Caza

"Times they are a'changing" was a line from a popular song in 1964 by Bob Dylan, but it seemed to be appropriate for our situation in 1987. The introduction of the personal computer had a profound effect on the world as PCs seemed to arrive and overwhelm instantaneously and ubiquitously. Many of our clients, such as Wilson Sporting Goods, Spalding or AMF, could now buy their own in-house computers and pay a license fee to use our software. This allowed them to process their own research without the concern that the information could leak to competitors.

Although we had derived great enjoyment being involved in the projects we had executed, the thrill of developing new software on newer hardware had an intoxicating appeal. Nothing could replace the Olympic athletes and their enthusiasm. There was no replacement for analyzing a violinist, or calculating forces on three-wheeled recreational vehicles, or evaluating the science of behavior of sporting equipment. But the vast majority of companies wanted to keep their secrets to themselves while, at the same time, we had discovered a vast new horizon of computer technologies ripe for exploration.

From this new, smaller computer world perspective, our own corporate needs no longer required a large dedicated computer room with special air conditioning and elaborate hardware. The women's volleyball team had left after their silver medal victory in 1984. As I mentioned before, most of our corporate clients were more interested in licensing our software for in-house use and, thus, our need for extensive space was eliminated.

Ann and I decided that now was the time and the opportunity to make a big move. We could focus on improving our software and hardware for the IBM PC and continue software enhancements for the Ariel Computerized Exercise Machine. The time seemed right to conclude our co-venture of the Coto Research Center with the Coto de Caza Development Company, settle the financial ownership, and each of us could go our own way.

Fortunately, the Coto de Caza Development Company had been successful at selling properties to new owners for a hefty profit and they had already sold most of the real estate. By 1987, as a real estate corporation, they no longer needed athletes or corporate executives to visit the research center. In the early years, the unique advantages of the research center had served them well from a business point of view. At this point, however, they cared only about selling the few remaining lots and houses. Our existence, from their point of view, had been a unique advertising and news-worthy part of selling and advertising property but was now unnecessary.

Coto de Caza when we arrived in the late 1970's
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I had fulfilled my promise to Mr. Palmieri to bring the Olympics to Coto de Caza and this had helped to sell many homes and real estate property for them. However, the current administrators of the Coto de Caza Development Company were not particularly interested in the Olympic ideals. To my continuing amazement, the owners of Coto de Caza have never used the Olympic rings symbol in their restaurants or the arrival gates. They have the right to use the rings for their marketing since Coto de Caza was an official Olympic site just as Squaw Valley has been using this designation for years since the Winter Olympics were held there. I would have assumed that they would enjoy the notoriety of this designation as well as pride it their achievement, but I guess my thinking differs from theirs. Essentially, our needs and those of the Coto de Caza Development Company had been completed and it was in the best interests of both par-

Coto de Caza today
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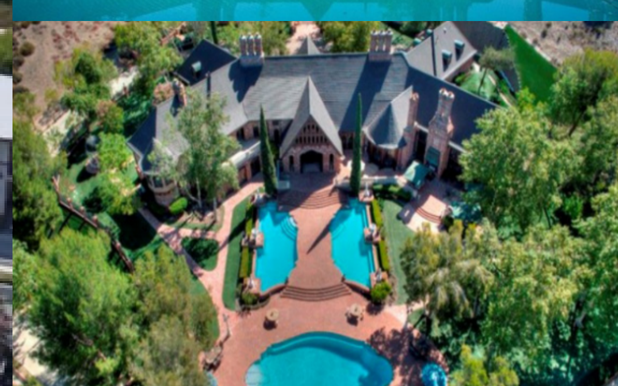


ties to conclude the joint venture. Fortunately, we were able to complete the dissolution quickly and amicably.

Now we began our search for a new, smaller, more modern facility for our corporate focus. Ann and I explored the areas around Coto de Caza and even drove as far south as northern San Diego County. We examined office spaces available in the newly expanding community of Rancho Santa Margarita which was adjacent to our beloved Coto valley. Everywhere we looked had wonderful choices but none was as perfect as Coto de Caza, so we started to search closer to home.

I had a small Honda motorcycle that I used to ride between our condo and the research center. Suddenly, I had an inspiration that sent me on a "sight-seeing" adventure around Coto to explore some of the newer housing developments. After a while, I discovered a brand-new section with four models located on a cul-de-sac. There was a real estate company sign in front of one of the model houses, so I parked my Honda in the driveway and went into the office.

I walked into the real estate office in my normal Coto attire—shorts, T-shirt, and flip-flops. There were two women sitting at desks in the reception area, both very well dressed with perfect makeup and hair styles. When they asked if they could help me, I responded that I needed to purchase two houses side-by-side. I am sure they imagined that I was either a prankster or from a gag TV show. I obviously did not look as though I was a serious home buyer nor was my request for two adjacent houses a normal one.

They politely informed me that the only two houses available that were adjacent to each other were two of the models.

"I'd like to buy those two homes immediately," I said, running my hand through my hair.

The two realtors looked at each other and then at me in my shorts and flip flops who had just parked his little Honda motorcycle in front of their office. They looked me over suspiciously. "Well," one lady said, "Would you like to see what they look like inside?"

"Not really," I answered, "I am sure they are perfect or you wouldn't have built them in Coto de Caza."

Living in our condo with Melich

"You will have to make a down payment of $50,000 on each house." the second lady told me, presumably thinking that this crackpot would be discouraged and leave.

"That is no problem" I replied. "What is the next step?"

"You will need to complete this form," the realtor said, "and we will need the down payment." At this point, I was sure they were no longer certain if I really was crazy or just extremely eccentric.

"Can I use your phone to call my girlfriend?" I asked, since this was in the days before cell phones.

Our "Living House" & "Office House"

I dialed our phone number and said "Ann, please bring a check for $100,000. We are buying two houses here, one beside the other."

"What?" was the response.

However, Ann knew my eccentricities and trusted my hunches. She drove from our condo in our 1985 Chevrolet with the checkbook. Once she arrived at the real estate office, I was relieved that the two agents had become a little friendlier and perhaps slightly less confused by my behavior. I had spent the interim telling them about my background as well as our search for a new research center.

When Ann arrived, the ladies told her that inspecting the two houses was of no interest to me. As always, I was the visionary or dreamer and Ann was the more practical. I, therefore, was not surprised when Ann assured them that she most certainly wanted to see what the buildings looked like inside. The ladies escorted us on a brief tour of each house and we agreed that they would suit our purposes. Then Ann and I conferred and decided that we would reside in the smaller one-story unit, and use the larger two-story building for our research center.

Not only was Ann the practical one, but she was also completely prepared to take the time to complete the necessary forms and write the checks for each of the houses. Then she waited for the agents to make duplicate copies of our records. I could image the wheels turning in her head as she prepared for the next steps of organizing and moving.

The two real estate agents must have thought that I was totally crazy because of the way I was dressed and the manner in which I was attempting to purchase two houses. However, my assumption was that you could not make a housing mistake in Coto de Caza. For years, our valley had been described as "Shangri-La" or the "best kept secret in Orange County" among other accolades. The real estate "heirs" of Victor Palmieri had maintained tight control over the builders whom they had selected to develop the different areas. Therefore, all of the houses were well-suited for the lot upon which they were built and their interior architecture and floor plans were well conceived. While many of these homes were most likely priced at double what a comparable house outside this gated community would have cost, the uniqueness of living in this gated community in a scenically lovely valley more than justified the price… at least to those who purchased houses here.

To get a sense of some of the residents who came to live in this community, you could watch a television series called "The Real Housewives of Orange County". This program was developed and filmed in Coto de Caza.

The creator and director of the show was Mr. Scott Dunlop who has been a friend for many years. I met Scott with his brother, Mr. Doug Dunlop, who had been the attorney for the US Olympic Committee, and Scott had worked with me from time to time. After the first few shows had aired, we happened to be having dinner with Scott and his beautiful wife, Gayle. Ann asked Scott how this television show was conceived and the answer was quite astonishing. Scott described going to a local restaurant with his wife and another couple. While they were waiting for their meal, their friend ordered a sour apple martini. When the drink arrived, she requested one of the tiny cocktail straws used to stir drinks. To the amazement of Scott and his wife, she then used the straw to sip her martini.

Scott Dunlop and the Real Housewives of Orange County
http://arielnet.com/ref/go/2738

“Why are using the straw to drink your cocktail?” was Scott’s stunned question.

“I don’t want to mess up my lipstick” was the answer.

This true event was one among many of his tales of people they experienced among their friends and acquaintances living in Coto de Caza. Some were even more bizarre but there were enough to form the core around which Scott was able to create an entire season of stories.

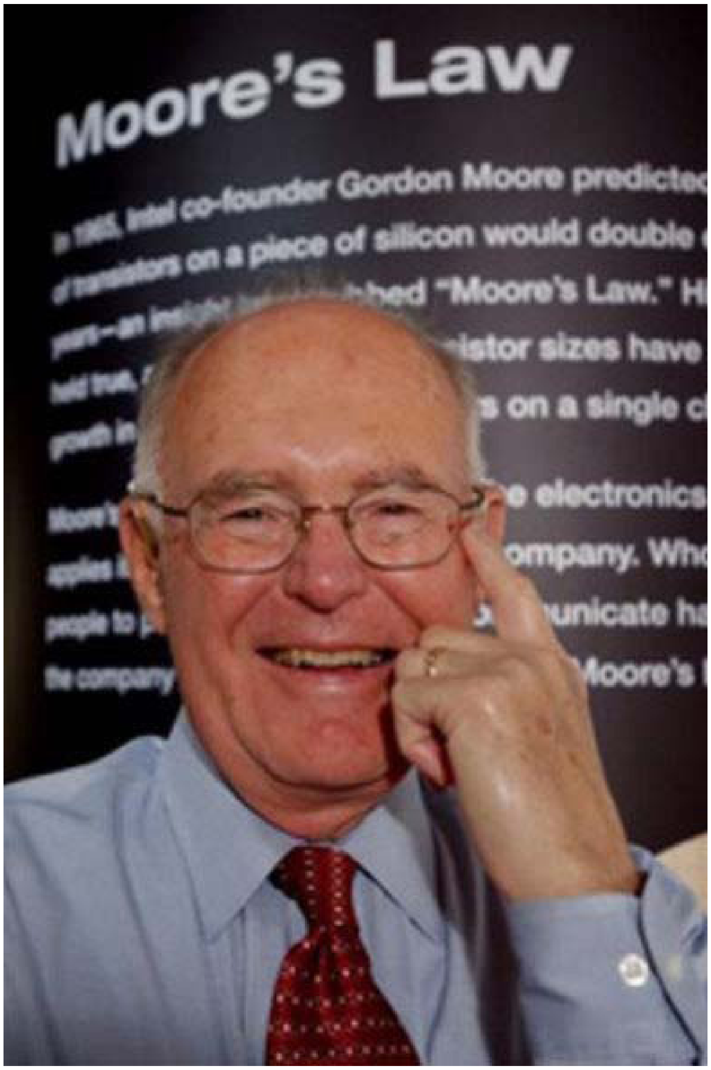
They even interviewed me, in show number 7. I was the local biomechanical expert who lived in Coto de Caza and could perform an analysis of the baseball pitching motion of the son of a baseball professional who lived in Coto. The wife and mother of this young man was one of these “housewives”. Needless to say, after I watched the first episodes of the show, I tried to get out of my segment, but could not. Since Scott was my friend, I did it for him. Ann was, and continues to be, outraged and embarrassed that people would think that she was like any one of those television portrayals. But I have assured her that they are more unique than flying sharks would be.

Now that we had purchased our new home and research facility, we were ready to move. This was more convenient than our previous journey from the East Coast to California, but it was still an arduous task.

Our new research building was located in a residential area but only a few of our personnel came during the day, so there were no problems with the neighbors. Our business had evolved into software development and was Internet-based. Thus, we only needed desks and computer connections. There would be no manufacturing on site, nor big trucks picking up and delivering merchandise. In addition, we no longer needed a large facility for athletes. In fact, most people in the community had no idea what activities went on inside of either of our houses. The company which manufactured our exercise machines was located approximately 20 miles away, so very little traffic went in and out of the office-research house.

The time came to dismantle the Coto Research Center. It was heartbreaking to watch all our inventions and equipment, which had been significant vehicles for our achievements, reaching the point of uselessness. However, we could no longer use them since they had all become obsolete. The Data General computers were big and slower than the IBM PC. The Megatek graphics workstation had been state-of-the-art when we first began using it for three-dimensional display. Now we could use a smaller, faster desktop computer to accomplish the same display techniques. The special room with its raised floor and dedicated electrical circuitry and air conditioning to maintain the Data General computers was no longer necessary. Now, for a few thousand dollars, we had as many PCs as we wanted and they could function on a desk anywhere in the building without temperature control requirements. When a computer went bad, it was cheaper to replace it with a newer model than to fix it.

This phenomenon of needing to change computers to obtain increased computing speed and storage capacity was not surprising to those involved with the computer world of that time, and was consistent with Moore’s Law. “Moore’s law” is the observation that the number of transistors in a dense integrated circuit doubles approximately every two years. The observation is named after Gordon E. Moore, the co-founder of Intel and Fairchild Semiconductor, whose



Gordon E. Moore
http://arielnet.com/ref/go/2739

1965 paper described a doubling every year in the number of components per integrated circuit and projected this rate of growth would continue for at least another decade. In 1975, looking forward to the next decade, he revised the forecast to doubling every two years.

Moore's prediction proved accurate for several decades and the law was used in the semiconductor industry to guide long-term planning and to set targets for research and development. Advancements in digital electronics are strongly linked to Moore's law: (1) quality-adjusted microprocessor prices, (2) memory capacity, (3) sensors and (4) even the number and size of pixels in digital cameras.

Digital electronics have contributed to world economic growth in the late twentieth and early twenty-first centuries. Moore's law describes a driving force of technological and social change, productivity, and economic growth. The period is often quoted as 18 months because of Intel executive, David House, who predicted that chip performance would double every 18 months (being a combination of the effect of more transistors and the transistors being faster).

"Moore's law" should be considered an observation or projection and obviously not a physical or natural law like gravity or magnetism. Although the rate held steady from 1975 until around 2012, the rate was faster during the first decade. In general, it is not logically sound to extrapolate from the historical growth rate into the indefinite future. For example, the 2010 update to the International Technology Road map for Semiconductors predicted that growth would slow around 2013. In 2015, Gordon Moore foresaw that the rate of progress would reach saturation.

However, for our needs and experiences from the 1970s through into the late 1980s, this growth and development within the computer industry had been volatile. The explosion of computer parts, software, and displays had been nothing short of awe-inspiring. We were akin to children addicted to sugar being released in a candy factory. No sooner had we developed our codes for one type of computer, another more exciting and revolutionary one was introduced. It was a fantastic new world for us and our products.

We also engineered all of the new technologies available at that time in both houses. There were no new technologies that we did not have especially with communications tools. In the early 1970's, I had realized that on-line communication, which today is the Internet, was the future and we would always have to concentrate on mastering and using it.

While we were preparing our new lab and home for the technological advancements that were currently available. Ann reminded me that during our graduate study years, I insisted that getting in a car and driving to a classroom to listen to a professor was a ridiculous, medieval educational concept. My thinking was that education should be available in your own home or office through computer connections in the same way that we were able to currently communicate via modems. In today's world, universities all over the Earth provide on-line classes, Khan Academy helps students with understanding concepts, and there is a myriad of educational opportunities available at the fingertips of anyone with a computer and an Internet connection regardless of where you are on our planet. Now my idea seems obvious, but back in the 1970s, most people thought I was describing a science fiction movie.

I am sure that the modern reader of this material wonders at these tales of ancient history in the same way that I thought King Lancelot and his knights were ridiculous. But, these "archeological" descriptions are accurate for those times. I was also convinced that television choices should be available when the consumer wanted to view the shows not just at the time that the network broadcast them. In the

1970s, for example, American family television options were limited to only 3 or 4 stations. There were the "regular" network stations of CBS, ABC, and NBC with the occasional public station or an independent channel. Those were the days when television signals were picked up with antennas usually sitting on top of the set. Many a home had "flags" of aluminum foil attached to these "rabbit ears". The stations operated with limited hours of broadcasting and had sign-off hours, usually about one in the morning followed by hours of static on the screen until the station returned around five or six in the morning with the next day's programming. That was it! None of the 100+ channels currently available. There were no cable networks or web streaming stations. Those were the pioneer days of visual broadcasting.

However, I wanted the ability to watch the evening news when I got home even if it was after midnight. I was confident that it was possible to enjoy this freedom of selected viewing if only I could find a way to tap into a broadcasting system and develop a delivery mechanism similar to how I was able to communicate with the university computers via a modem connection.

It turned out that I was not the only fellow who imagined the concept of education on demand in your own home or office. In 1953, the University of Houston had offered the first televised college credit classes via KUHT, the first public television station in the United States. The live telecasts ran from 13 to 15 hours each week. Most courses aired at night so that students who worked during the day could watch them. By the mid-1960s, with about one-third of the station's programming devoted to education, more than 100,000 semester hours had been taught on KUHT. The problem, from my perspective, was that the classes were just as time dependent as driving to the lecture. The student had to take the class when the teacher gave it. I wanted education to be as available as selecting an option presented on a computer.

Some improvement had been made by 1959 when the University of Chicago first produced "Sunrise Semester". This was a series of courses delivered via broadcast television which, from my point of view, was moving in the right direction.

However, in 1960 an even better system was developed called PLATO (Programmed Logic for Automated Teaching Operations). This was a system developed at the University of Illinois at Urbana-Champaign. One of the primary developers was Donald Bitzer. The PLATO system featured multiple roles, including (1) students, who could study assigned lessons and communicate with teachers through on-line notes; (2) instructors, who could examine student progress data, as well as communicate and take lessons themselves; and (3) authors, who could do all of the above, plus create new lessons.

Another important development in 1960 was called Project Xanadu, the first known attempt at implementing a hypertext system, founded by Ted Nelson. In 1962, the initial concept of a global information network is credited to J.C.R. Licklider in his series of memos entitled "On-Line Man Computer Communication". However, the actual development of the Internet must be credited to Lawrence G. Roberts of MIT.

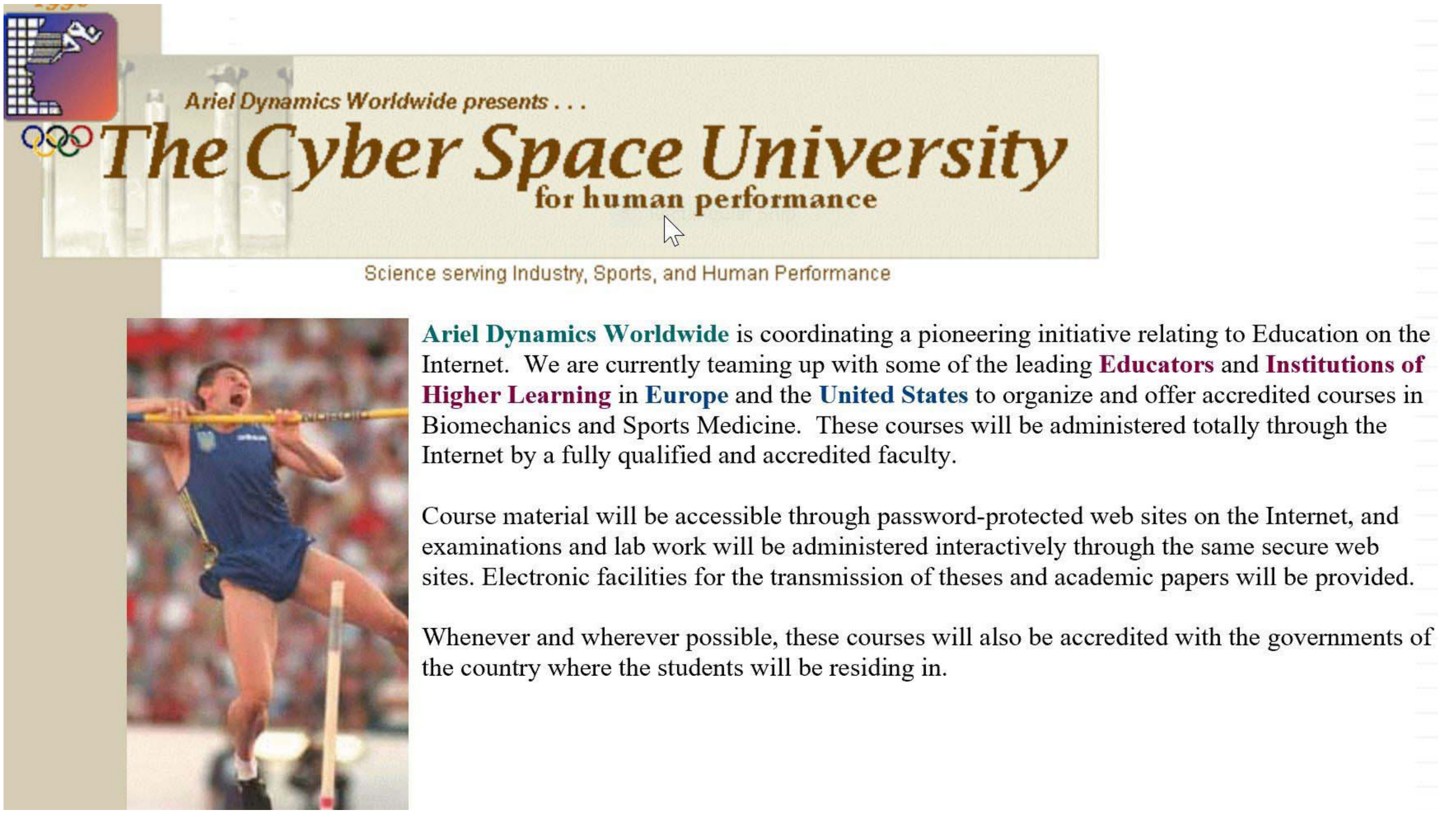
Telesecundaria, a system based on satellite TV for secondary students in rural areas, was set up by the Mexican Government. Initially, over 6,500 students were served in 304 classrooms, each one equipped with a satellite dish and a black-and-white TV set. The system is still in use, but now reaches over a million students in 16,000 rural facilities in Mexico and several Central American countries.

An IBM 1500 system was installed at the University of Alberta, where on-line courses included cardiology training for the university's medical school. This system was finally taken out of service on April 10, 1980, after twelve years of operation. Over 20,000 people had used the system in that interval and programming was available for 17 university courses. The instructional operating system of the IBM 1500 had a registration system, bookmarking, authoring, and progress reports all built-in.

By 1969, the U.S. Department of Defense commissions created ARPANET and, thus, the Internet as we know it today. At the same time, Stanford University broadcasted 12 engineering courses on two channels via the Stanford Instructional Television Network (SITN). Patrick Suppes, the professor at Stanford University, developed computer-based courses in Logic and Set Theory which were offered to Stanford undergraduates from 1972 to 1992.

The Learning Research Group was formed at Xerox PARC in Palo Alto, California. It was led by Alan Kay, who advanced the idea of a graphical user interface (GUI) by inventing icons for folders, menus, and overlapping windows. Kay and his group envisioned a computer for teaching and learning that they called the "KiddiKomputer", to be programmed using the Smalltalk language they had developed. While Kay could envision many educational uses for this computer, he had four initial projects in mind: (1) teaching thinking skills, (2) teaching modeling through the simulation of systems, (3) teaching interface skills, and (4) tracking what children would do with the computer outside school hours, when left to their own devices. Second level projects for teaching children with a computer included (1) computer evaluation and (2) iconic programming, especially for children under eight. Kay and his colleagues started teaching programming to children and adults in 1973.

These dedicated educators of the past were ahead of their time but relentless in their efforts to provide educational op-



The Cyber Space University - another one of our first in the world
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portunities to both young and old people. Another requirement for computer-at-a-distance learning was that it should be available whenever it was wanted regardless of the time of day. Although I had not personally developed an on-line educational system, I had insisted and promoted the concept for years as the only program that made sense. I was quite gratified that there were educators and universities able to create the systems that we use today.

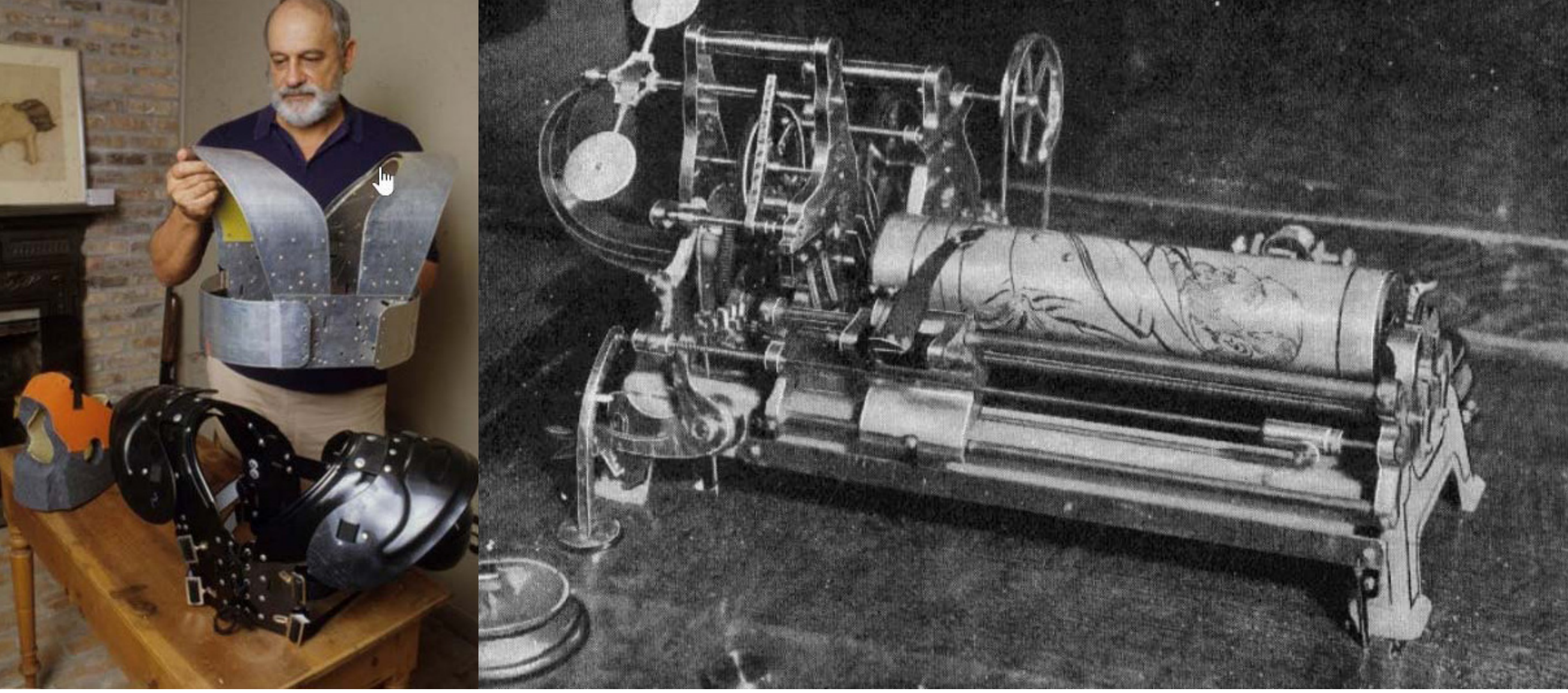
My idea about television shows available on demand nearly materialized during our Amherst, Massachusetts days in the 1970s. In our laboratory, I met Mr. Robert Block who owned a broadcast station in Milwaukee, Wisconsin. I described my ideas to him and he was extremely excited about them. We made several trips back and forth to Milwaukee to try to develop the concept for watching a television program whenever the consumer requested it. Unfortunately, the telephone lines had insufficient "bandwidth" to transmit the audio and video. Again, technology lagged behind an idea.

Another one of my ideas was to develop a way for students to learn on the computer. I realize that current students think it is quite an ordinary concept to attend a university and receive a degree "online". But in 1974, this was not only unheard of but was scorned and ridiculed as a ridiculous concept. However, I was never one to shirk from trying and my Cyberspace University concept from the early 90's can still be found on my website.

Another one of my ideas stemmed from frustration with the slowness of interacting with customers. I hated the process of printing documents, driving to the post office, standing in line to send the package, then waiting for the transit, processing, and return documentation. Patience was not one of my virtues so I chaffed at what seemed to me to be an enormous waste of time. Once again, I was convinced that connections via a phone line between two places could be harnessed to transmit documents. It was never easy for me to have what seemed to be a terrific concept with no means to make it happen.

One day, Mr. Byron Donzis visited our office about a project for air-filled football protective gear and brought with him a large tube-like machine. Not only did Mr. Donzis want us to analyze his football gear, but he wanted us to send him the results on his "fax" machine.

His fax machine was a large tube-like equipment which he plugged into the wall outlet near our phone. Then he connected the phone line to his machine, pushed a button, and the center "tube" began to rotate. With a printed document attached to the tube, the material could be conveyed over the



Byron Donzis Fax Machine Football gear

phone line to a receiving unit in his Texas office. Imagine my amazement to see that one of my ideas was available.

Byron Donzis' fax machine was very slow and took at least 20 minutes to transmit a single typed page. With long distance phone charges ranging from 70 cents to a dollar per minute, the price for one letter on Mr. Donzis' "fax" machine was fourteen to twenty dollars. Obviously, there needed to be a faster, cheaper solution. For the younger readers, not only did we only have 3 television networks with limited viewing, we also had only one telephone company, AT&T or "Ma Bell". This was unlike today, when consumers can choose their carrier, select the "plan" that fits individual needs, and are usually not charged for long distance services except to foreign countries. This luxury was non-existent at that time, so people always had to be aware of the cost and time for telephone calls.

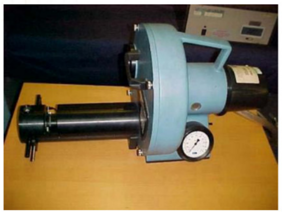
By 1987 "Moore's Law" was affecting our lives in many ways beyond televisions and telephones. The Internet revolution had brought many things closer to the consumer, not just communication and education. We installed in our new research center and adjacent home, computers, printers, and telephones in every room of each house. We installed the most modern, up-to-date technologies available.

Another of the futuristic developments that we added to both of our new buildings was the installation of solar panels. We were probably the first people in Coto de Caza to be totally independent of power delivered by the electric company. With solar panels on our roof, we were able to watch our electric meter rotate backwards since we sold our excess electricity to the electric company. We were connected to the electric company through a system called "net metering" which kept us on the electricity grid. This system allowed us to sell our excess electricity to the company during the day time and buy electricity from them during the night time hours. We enjoyed a silly little game to entertain our visitors by showing them our electricity counter rotating backwards.

Besides the fun of watching the wheel turn backwards, for our business needs, it was a logical and necessary advantage. During those years, much of California experienced frequent "blackouts" and "brownouts". We were concerned

Our solar panels the first ones in Coto de Caza

See "Table of Contents" or "Index"



Redlake 35mm
High Speed
HYTAX

rocket in flight made with synchroballistic photo c. 1990

that our business could be adversely impacted were we to lose electricity, so we decided to be independent of the grid. When all of the other houses on the street went totally dark with the loss of power, we were able to continue working. It has proven to be a valuable asset over the years and we frequently congratulate ourselves for having this foresight.

One of our initial projects in our new lab involved improving our biomechanical software. The introduction and growth of video cameras presented many opportunities for quicker and faster biomechanical processing. The new cameras provided immediate "films" without having to wait to have the films developed. They also provided the opportunity to review the activity before advancing to the next step. It eliminated the step of filming today and waiting until next week to learn if the camera was focused and the frame had not cut off the subject's head. This development was akin to our constant challenge of improving the software on newer, faster computers, but now the need was to leap forward with the visual portion of the biomechanical program. However, the advancement of video camera technology for our system was through several difficult transitional steps

The speed of the recording device was critically important for the success of our biomechanical processes. When watching a movie, we actual see a successive number of frames flipping by one after another. Our eyes work with the brain to stitch them together and create the appearance of motion. Historically, movies were filmed at 24 frames per second. This speed allowed the brain to interpret the activity as a smoothly progressing activity rather than appearing to be discrete frames with a jerky movement. For biomechanical quantification, we found 24 frames per second to be too slow. We had to film at higher frame rates, ranging from 100 frames per second to as high as 10,000 frames per second, depending on the application.

When video technology was introduced, therefore, we were presented with a problem regarding recording speeds. A video camera which, while it has a shutter, is dealing not with a single image, but with dozens upon dozens of single images strung together. The speed at which these frames are moving must be both constant and fast enough to create correct full-motion video when played back.

A significant difference between the older film and the new video technologies was the method which each system used. A film consisted of a number of individual frames captured sequentially. However, television and video technologies use a "raster scan" which is the rectangular pattern of image capture and reconstruction. Imagine the pattern of lines left by a rake when it is drawn straight across a soil garden. These lines left in the soil resembles the parallel lines of a raster. This line-by-line scanning is what creates a raster. It is a systematic process of covering the area progressively, one line at a time. Although a video scan travels a great deal faster, it is similar in the most general sense to how one's gaze travels when reading lines of text.

A video image is captured as a series of lines starting at the top of the screen and, line by line, moving down to the bottom of the screen. The horizontal scan lines of each complete frame are treated as if numbered consecutively and captured as two fields: an odd field (upper field) consisting of the odd-numbered lines and an even field (lower field) consisting of the even-numbered lines.

In the most general sense, the word "frame" refers to the smallest unit in a motion image stream which includes all of the information for a single, complete image. In other words, it contains all the color, luminance, etc., information for one image at the full resolution of the system. Ideally, it represents one temporal sample, that is, an image which is captured at one particular point in time, in a series of such images which together are used to give the illusion of motion when displayed. This last point is where the notion of a "frame" in video starts to break down, since clearly, in a raster-scanned system, the entire image is not captured at the same time. The term is still used nonetheless.

A "field," on the other hand, is a sub-part of a frame. The most common usage of this term is "interlaced video". With "interlaced video", two "fields" are produced which are supposed to correspond to or be capable of being combined into one complete frame. In interlaced video, the two fields are generally produced as such, separately, by the camera or telecine, as opposed to actually being the result of separating the odd and even lines of an original complete frame.

At a refresh rate of 30 frames per second, the human eye perceives a "flicker" as the screen is updated. To minimize this phenomenon, interlaced scanning is typically used. Here, the image frame is split into two fields, one containing odd-numbered horizontal lines and the other containing the even-numbered lines. Then the display is updated one field at a time at a rate of 60 fields per second. This update rate is not detectable by the human eye (remember that AC lighting operates at 60 Hz).

For some high-speed applications, the display needs to be updated as rapidly as possible to detect or measure movement accurately. In that case, the update of the display is made without combining the odd and even fields into each frame. The resulting image frames would each consist of one field, resulting in an image with half the height and twice the update rate as the interlaced version. This is called "non-interlaced" video, and cameras that output signals of this type are referred to as "progressive scan" cameras.

Our initial step into the world of video technology was the discovery of a Panasonic S-VHS video camera. This camera was able to record at 30 frames per second and had a variable shutter. As with our previous experience with film cameras, the video capture speed was too slow for our normal biomechanical analysis. We were able to overcome this limitation with our software processing by using both fields in each frame, producing 60 fields per second.

The variable shutter feature of the Panasonic S-VHS was critical for our use since it enabled the figure to be viewed as a sharp rather than as a blurred image. This was accomplished by adjusting the shutter speed to open and close at a rate fast enough to capture the person's motion. The video camera shutter fires very fast while the light sensing recording sensor is being bombarded by the light of the scene. As the light is first going through a lens, physical properties such as the amount of light in the scene and how fast the shutter fires apply here just as they do to a still or movie camera. Therefore, the faster the video camera shutter fires, the more light is needed to keep the scene from becoming too dark.

For example, imagine the shutter opened and the person moved 3 steps. The resulting image would be quite blurred. However, if the shutter opened and closed so that each step was captured with 100 frames individually, each image would be sharp. The shutter, thus, had to be adjusted for each activity. Hitting tennis balls by swinging a racket required a faster shutter speed than studying heel strike during a walking activity.

At last, we were ready to proceed with our biomechanical analysis using video rather than film. First, the activity was recorded on the analog tape in the video camera. The next step was to play the tape in a VCR and view this analog signal on a screen. After we filmed our subject with a video camera, we needed to digitize that image on the computer. We were able to view the recorded image on the VCR, but the problem we faced was how were we to digitize the image on the monitor. This step did not turn out to be as easy as we had initially envisioned.

Video technology was first developed for mechanical television systems which were quickly replaced by cathode ray tube (CRT) television systems. However, several new technologies for video display devices were invented. Charles Ginsburg led an Ampex research team which developed one of the first practical videotape recorder (VTR). In 1951, the first video tape recorder captured live images from television cameras by converting the camera's electrical impulses and saving the information onto magnetic video tape.

Video tape recorders were sold for $50,000 in 1956 and videotapes cost $300 per one-hour reel. However, prices gradually dropped over the years and by 1971, Sony began selling affordable videocassette recorder (VCR) decks and cassettes to the public.

VCR gained mass market traction in 1975. Six major firms were involved in the development of the VCR: RCA, JVC, AMPEX, Matsushita Electric/Panasonic, Sony, and Toshiba. Of these, the big winners were the Japanese companies Matsushita Electric/Panasonic, JVC, and Sony, which developed more technically advanced machines with more accurate electronic timers and greater tape duration.

The VCR started to become a mass market consumer product and, by 1979, there were three competing technical standards using mutually incompatible tape cassettes. The two major standards were Sony's Betamax (also known as Betacord or just Beta) and JVC's VHS (Video Home System) which competed for sales in what became known as the format war.

Betamax was first to market in November 1975. It was argued by many to be technically more sophisticated in recording quality although many users were unable to perceive

Panasonic VHS camera

VHS and Betamax

Betamax VCR and Panasonic 6300

a visual difference. The first machines required an external timer and could only record one hour or two hours with lower quality. The timer was later incorporated within the machine as a standard feature.

The rival VHS format was introduced in Japan in September 1976 and in the United States in July 1977 by RCA. This format had a longer two-hour recording time with a T-120 tape or four hours in lower-quality "long play" mode.

In those pre-digital days, TV broadcasters could not offer the wide choice available in rental stores. Rented or recorded tapes could be played as often as desired. Material available on tape with violent or sexual scenes were not available for broadcasts. Home video cameras allowed tapes to be recorded and played back.

Two hours and 4 hours recording times were considered enough for recording movies and sports. Although Sony later introduced L-500 (2 hours) and L-750 (3 hours) Betamax tapes in addition to the L-250 (1 hour) tape, the consumer market had swiftly moved toward the VHS system as a preferred choice. During the 1980s, dual-speed (long play) models of both Beta and VHS recorders were introduced allowing much longer recording times. The recording length on consumer video recorders (VHS) was 8hrs with PAL color encoding, and 5hs-46mins with NTSC color encoding. The total recording length on Professional Broadcasting (Betamax) was 3hrs 35mins on PAL color configuration and 5hrs on NTSC color configuration.

In the early 1980s, U.S. film companies fought to suppress the VCR in the consumer market citing concerns about copyright violations. In Congressional hearings the head of the Motion Picture Association of America, Jack Valenti, decried the "savagery and the ravages of this machine" and likened its effect on the film industry and the American public to the Boston strangler. However, in the case Sony Corp. of America v. Universal City Studios, Inc., the Supreme Court of the United States ruled that the device was allowable for private use. Subsequently the film companies found that making and selling video recordings of their productions became a major income source.

Panasonic's first VHS camcorder, the NV-M1, was developed in 1985 as a VHS video recorder with a built-in camera that allowed recording using a standard VHS cassette. In those days, there was an increasing demand for a video with a built-in camera that could easily be used by anyone. Adopting a new loading system, a compact head cylinder and other brand-new technologies, the video was compact and very light, weighing only 2.5 kg.

For our biomechanical system, we also needed a VCR which was more sophisticated than one merely for recording television shows. We needed a unit that we could control to "step" the image one "frame" at a time just as we had been able to do with our 16mm film camera and projector system. Unfortunately, a video signal was not separated into discrete frames, but rather was a continuous electromagnetic stream.

We found the Panasonic 6300 VCR could function in the way we needed. We could film an activity with our Panasonic S-VHS camera, remove the VCR tape, insert it into the VCR, and view the image on the computer monitor. The next step was the real challenge. Although the Panasonic 6300 VCR allowed us to advance the tape one step at a time, similar to the way we had been able to advance the movie film one frame at a time, how were we to digitize the image and record the X and Y coordinates for each joint center into the computer? Fortunately, our CBA software geniuses produced the solution.

The solution was to use a video overlay card which allowed the computer to generate a mirror image of the VCR image on the monitor. We would advance the tape one step at a time with the Panasonic 6300 and, using the mouse, place the cursor at the selected joint center and "click" to identify the X and Y coordinates. This process allowed the X and Y coordinates to be stored in a computer file. Once the activity had been digitized in this manner, the computer file of coordinates could be processed by our biomechanical software. The only change for the biomechanical system was the technique in which we were able to obtain the joint center coordinates.

This system worked perfectly for biomechanical processing, however, there was one limitation. We operated with the

VCR image residing only on the monitor. The VCR had to be stopped manually and any problems with the video system meant starting the digitizing process from the beginning. We could not compare the digitized image with the taped image since it was available only on the VCR tape not the computer. What we wanted was to have the video image stored on the hard disk in the computer so it could be examined, reexamined, digitized, or simply played from the beginning to the end without having to depend on the VCR. Another advantage to storing the image on the computer's hard disk was its permanent availability for examination.

We needed a method to convert the video signal into a digital signal which would reside on the computer's hard disk. In today's world of sophisticated computers and electronics, this is a trivial task. But in the 1990s, this was wishing on a star or hoping that the tooth fairy would leave something under our pillow at night.

This step required both hardware and software developments. Although we no longer used our large 3-D graphic system, Megatek, I was still friendly with our contact there. During a phone call to him, I briefly described the hardware that I needed and inquired if he knew of anyone with these electronic development skills. It turned out that he had worked with Mr. Alex McKay, a young man in San Diego, CA, who might be able to build what we needed.

I called Mr. McKay and arranged for him to come to Coto de Caza to meet me and my development team. When Mr. McKay arrived we demonstrated how our biomechanical system functioned and that we were now in a new developmental era. We needed to move from 16mm film cameras to the newer video technology but we were experiencing a stumbling block with the analog-to-digital conversion. We were confident that we could write the software code for a new digital file, but we would need the hardware to convert the analog signal from the camera to the digital signal for the computer.

Original video board

Alex, as he insisted on being called instead of Mr. McKay, spent several hours with Dr. Jeremy Wise, our software expert. They discussed the specifics for this conversion medium and eventually arrived at the solution. Alex would develop a video board which could be installed in one of the slots in the computer. The board would accept the analog video input from the VCR and connect through the video board in the computer and convert the analog into a digital signal. Once we had the digital signal, we would be able to see the video images on the computer monitor. Jeremy would write the software allowing us to digitize the image that appeared on the computer monitor.

Measurements from the real world are almost always analog. Imagine drawing a curved line on a sheet of paper. If a graph is superimposed on top of the drawn curve, each point on the curve can be represented by two numbers, X and Y. This is the same situation with an analog film. The analog signal had to be represented by a digital one since computers can only use digital signals.

This was our situation. We had the real world of movement which we humans see as smooth, continuous, and flowing. However, a computer can only understand two conditions: "on" and "off" or in the binary system "0" and "1". These are the digital signals that computers can "understand". Therefore, analog signals must be first transformed into digital signals or a series of digital signals. For example, a digital signal could only know if a door is open or not. An analog signal would cover the entire door movement from open to close. For our application, the entire movement had to be converted, a step at a time, from the analog to the digital representation. In other words, our tape had to be able to produce an accurate digital signal for each portion of the analog signal as it advanced. The accuracy of the figures we produced depended on this digital conversion from the analog image.

Several weeks after our first meeting, Alex sent the new analog-to-digital, or A/D, board to Jeremy and it worked perfectly with Jeremy's newly written software. We now had the capability to record any activity and transfer the data for storage on the computer. From that point, we could retrieve the file anytime we needed it to review or perform a biomechanical analysis on it. Video images could now be stored on the computer. The digitized file of X and Y coordinate for each joint center would be stored in the computer file similar to the method we had used previously.

This was the first time in history that a video image could be quantified biomechanically and create three-dimensional motion. This is the basis for all of the modern computer games and movies, such as "Avatar". It is possible with today's

	Analog	**Digital**
Signal	*Analog signal is a continuous signal which represents physical measurements.*	*Digital signals are discrete time signals generated by digital modulation.*
Waves	*Denoted by sine waves*	*Denoted by square waves*
Representation	*Uses continuous range of values to represent information*	*Uses discrete or discontinuous values to represent information*
Example	*Human voice in air, analog electronic devices.*	*Computers, CDs, DVDs, and other digital electronic devices.*
Technology	*Analog technology records waveforms as they are.*	*Samples analog waveforms into a limited set of numbers and records them.*
Data transmissions	*Subjected to deterioration by noise during transmission and write/read cycle.*	*Can be noise-immune without deterioration during transmission and write/read cycle.*
Response to noise	*More likely to get affected reducing accuracy*	*Less affected since noise response is analog in nature*
Flexibility	*Analog hardware is not flexible.*	*Digital hardware is flexible in implementation.*
Uses	*Can be used in analog devices only. Best suited for audio and video transmission.*	*Best suited for Computing and digital electronics.*
Applications	*Thermometer*	*PCs, PDAs*
Bandwidth	*Analog signal processing can be done in real time and consumes less bandwidth.*	*There is no guarantee that digital signal processing can be done in real time and consumes more bandwidth to carry out the same information.*
Memory	*Stored in the form of wave signal*	*Stored in the form of binary bit*
Power	*Analog instrument draws large power*	*Digital instrument draws only negligible power*
Cost	*Low cost and portable*	*Cost is high and not easily portable*
Impedance	*Low*	*High order of 100 megaohm*
Errors	*Analog instruments usually have a scale which is cramped at the lower end and give considerable observational errors.*	*Digital instruments are free from observational errors like parallax and approximation errors.*

Analog versus Digital comparison chart

more advanced technologies, to film a great tennis player hitting a ball, digitize the image, and, when playing it back, "dress" the player as a frog or a rabbit. Without the ability to convert the analog movement into discrete digital signals which can be stored on the computer's hard disk, these fun images and games would not be possible.

In keeping with Moore's law, an A/D board soon became commercially available. This board was called a "video capture card" and was better than what we had developed ourselves. It could capture the entire tape more quickly and with significantly higher resolution. The new board produced a digital file in what was known as the AVI-format, which was different from what we had been using for the digital input format.

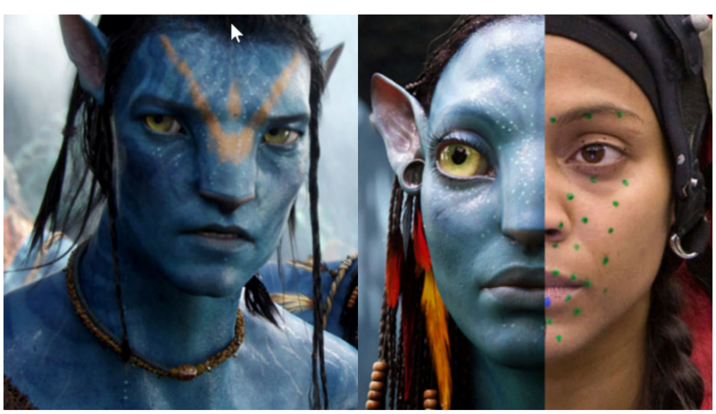
Needless to say, we wanted to immediately adapt this board for our system. However, our software engineers had to write the software to read and utilize this AVI-format. Once that was accomplished, we could operate our biomechanical programs using the new board.

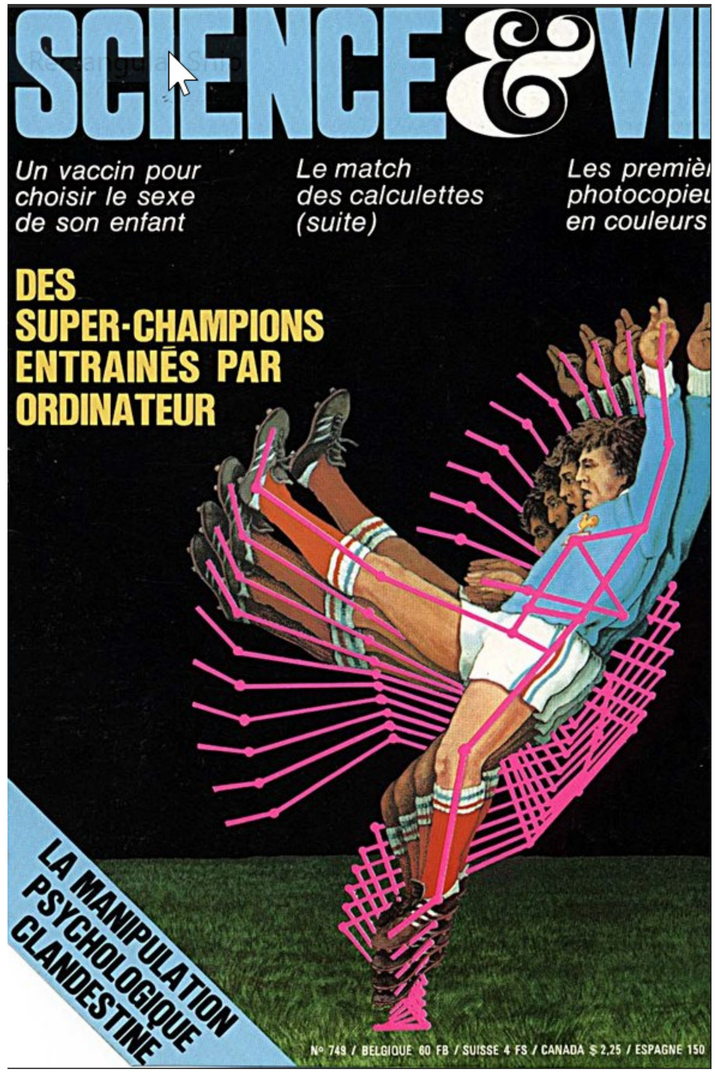
Another innovation which presented a very attractive time saver was the “FireWire”-connection directly from the analog camera to the computer. The official name for the standard is IEEE 1394 which was originally created by Apple and standardized in 1995. A FireWire connection allows data to be sent to and from high-bandwidth digital devices such as camcorders and was faster than a USB (Universal Serial Bus). This was another fantastic time saver for our biomechanical processing since we were able to record the activity and send the data directly to the computer. We had the most sophisticated software for processing the data but were continuously searching for newer and better ways to obtain and store it.

We continued to sell our biomechanical systems to customers around the world. Each new innovation, therefore, made our product more attractive to that consumer market. Our university contacts were usually technically adept and knowledgeable in the field of biomechanics. However, many of our corporate customers, who merely wanted to test a new iteration of their basic product, were primarily interested in the quickest and most efficient method of data collection. Thus, this new FireWire technology was another step in improving and speeding up our system.

My next idea was that we should make the biomechanical system operate more smoothly and quickly. We had spent years digitizing manually and, even with our newer video system, it still operated in this step-by-step manual mode. I was convinced that there had to be a better method.

Modern transformation in the AVATAR movie

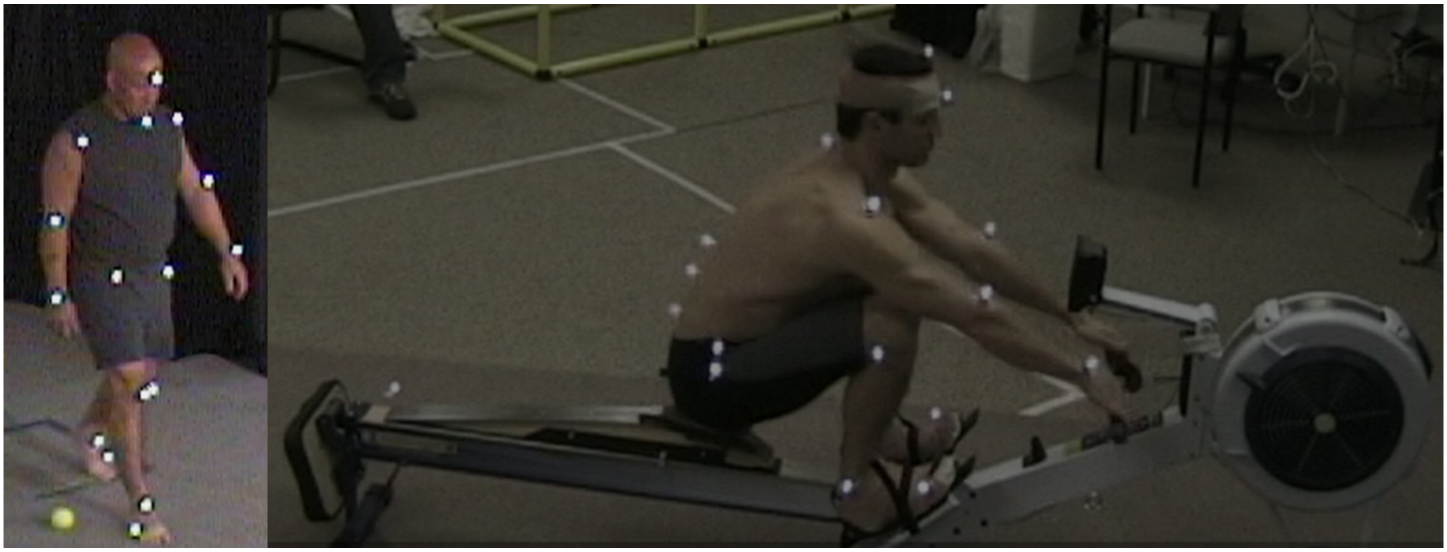




APAS in 1980 - first animation system
http://arielnet.com/ref/go/2741

In the 1980s, we had begun to pursue a method using markers on the body. The markers were small “balls” covered with reflective material. These markers were placed at the various body joints via adhesive stickers. Then the subject performed some task such as walking. When the acquired images appeared on the monitor, the markers were seen clearly. Examples of using marker sets of an individual walking and another individual rowing are shown on page 452.

The first step in the digitizing process proceeded normally with the user touching each of the markers with the cursor. After the first two or three frames, the computer cursor would automatically jump to the location that it predicted would be the location of the joint center. From that point forward, the computer could “digitize” the entire sequence with or without human intervention. Because human movements cannot exceed 6 Hz, patterns of movement can easily be predicted by the computer program.



Gait and Rowing

The marker system, while elegant in its convenience and simplicity, has several unfortunate flaws. The major drawback is that placing a "ball" on top of a body part does not accurately represent the location of the actual joint center. If you put the "ball", for example, on the top of the shoulder to represent that joint, it is nowhere near the joint center if the arm is raised over the head. The reader can try this by taping a penny onto the area that would be considered the shoulder.

Gait analysis with multiple cameras with interactive video

Then move the arm around and observe that the penny is no longer a good representation of the shoulder joint.

A further development of marker sets was the introduction of three markers placed at specific locations. This development was created to correct the previously noted flaw in joint detection. However, usage of these markers sets requires the acceptance of various assumptions about the location of the joint center which can have a distorting effect on the resulting data.

Another disadvantage of the marker system is the need for special lighting which is mounted in an elaborate array in a laboratory-like setting. Such a motion system is more expensive since a minimum of five cameras is needed to collect the data. These restricted conditions are sufficient for many types of studies particularly those that are combined with force platform and/or EMG data acquisitions. But for evaluating athletic performances, these testing models cannot accurately measure the individual's actual motion. No one can perform normally when they have wires or markers on their bodies. Most people behave differently when they are told in advance that their picture is going to be taken. A normal person will react by becoming tenser or fixing their hair or many other conscious and unconscious mannerisms. Expecting an Olympic athlete to perform normally with markers in a closed laboratory environment will not result in an accurate representation of that individual's actual performance. Imagine a world class golfer wired with EMG sensors and markers on the body standing on two force plates bathed in bright lights hitting a ball in a white room. Quite unlike the golf course to put it mildly!

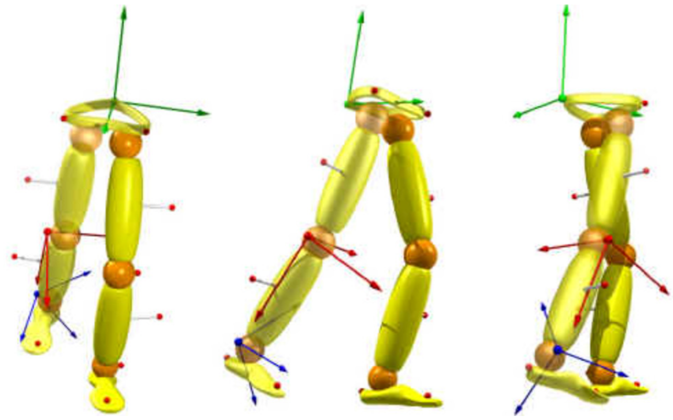
In specific applications such as "gait analysis", different models ("marker sets") were introduced for measuring human motion, such as:

1. Helen Hays Hospital marker set
2. Helen Hayes Modified marker set
3. Vaughan marker set
4. Vaughan modified marker set

We decided it would be interesting to compare the results of all four marker sets using the same subject and trial. Theoretically they should all yield the same results.

In order to analyze the results comparing the marker sets, we attached all four marker sets to the same individual so we could compare the results simultaneously. Since our APAS/Gait application was a video-based system, we were able to make these comparisons. With other marker tracking systems, it would be impossible to make this comparison since there are no video sequences in their system. With video, it is simple to activate or deactivate any marker. This allowed us to make a comparison of markers for the same individual and for the same trial.

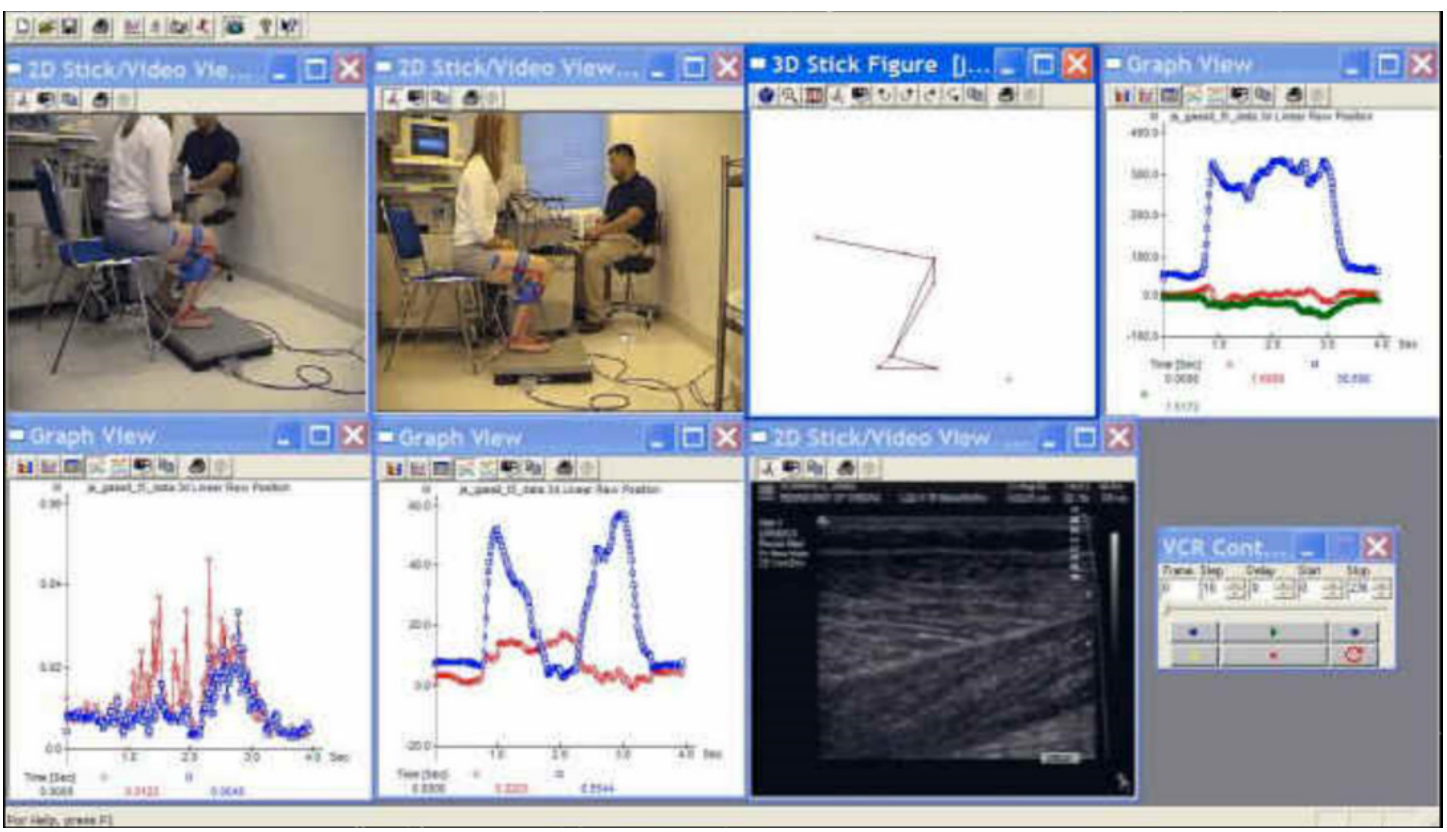
We used eight subjects and analyzed their gait. We found that the difference between marker sets was significant.

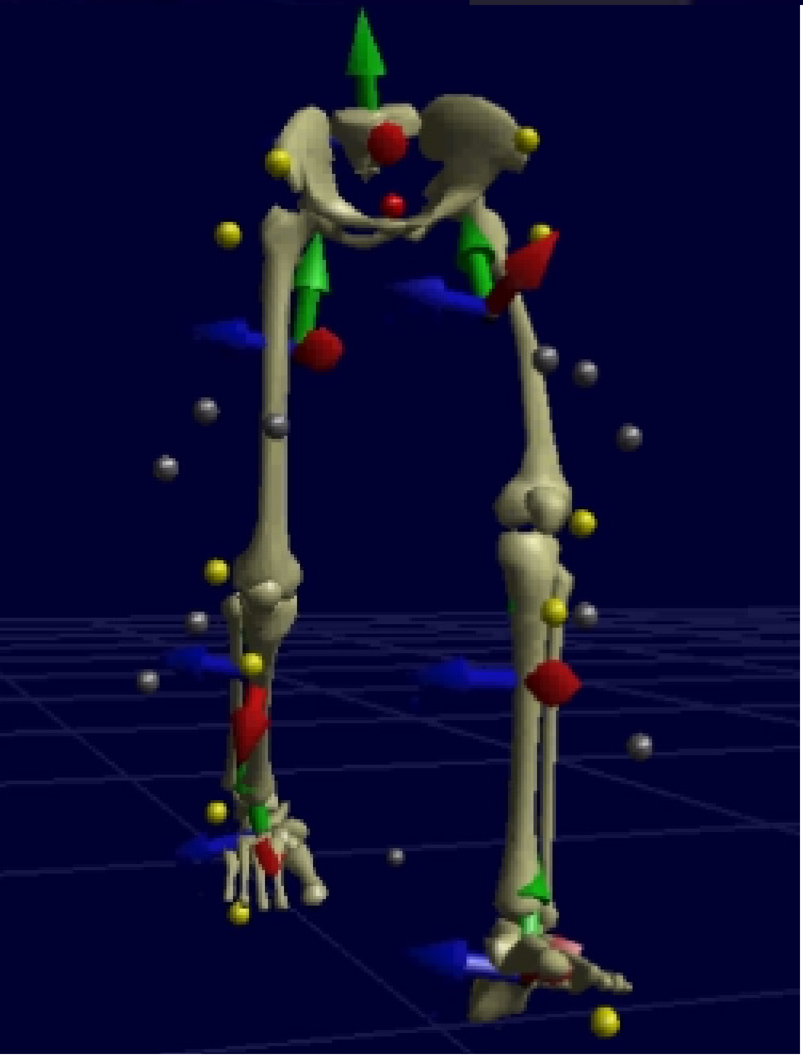


The APAS Gait System

Although we were not enamored with marker sets, we decided to make our biomechanical system flexible for every user in any environmental location regardless of whether they wanted to use markers or not. We had many customers around the world who used our system for studies examining different gait patterns. Some of these researchers focused the cameras only on the feet as the person walked across force plates. One customer used markers and EMG electrodes to

The first fully automated video based system





Comparison of markers sets in gait analysis

study muscular coordination in rowing. Our philosophy was to make our system open and compatible with any investigation that the customer wished to pursue. It was not our intention to tell other investigators what to do or how to accomplish it.

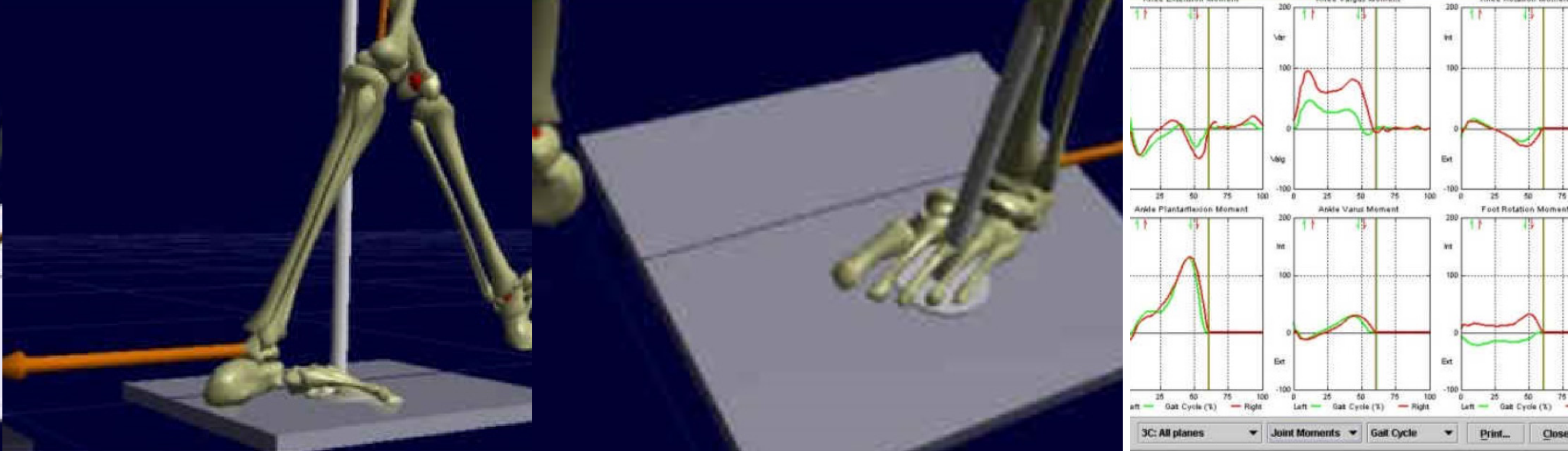
Another feature we perfected with the digitizing process was to "teach" the computer to locate the joint center with or without using markers. The location of the joint center, after digitizing the first few frames, is relatively predictable based on human capabilities. Regardless of whether the video has been captured with or without marker sets, the person digitizing must be careful that the computer makes the "correct" choice for the joint location. However, the computer-assisted digitizing is faster than the manual joint selection option. Also, sometimes the joint center is obscured from the camera view and this computer-generated prediction can be quite helpful in determining the location of the joint center.

We began using this technology for analyzing golfers on the golf course. We called it "e-Golf". Imagine a golfer standing on the green, swinging his golf club, and hitting a drive down the fairway. A video camera records this swing. The video is captured directly onto the hard disk in real time. Then a compressed sequence is transmitted automatically through a wireless connection to a processing server online. From this server the sequence can be digitized at any location in the world through the Internet. The velocity of the golf club can be determined in a few minutes and the results transmitted back to the server. The server automatically calls the cellular web phone which the golfer carries. He can then pick up the phone, click a button, and the velocity of the club head as well as other kinematics parameters are shown on the small color screen on his phone.

Suppose that the golfer wants to retrieve a particular video frame where the impact occurred. He clicks the frame number and the video frame is transmitted from the server is then superimposed on the particular stick figure.

We continued to have projects with NASA which were challenging. Our Computerized Exercise Machine had entered a new phase as well. We were developing new and improved software for several clients with unique applications. One of these clients worked with young people who hoped to improve their baseball skills. Another client worked with insurance companies and disability claimants. Each case may have been unique but each insurance company has their own protocols. The client wanted us to develop these protocols.

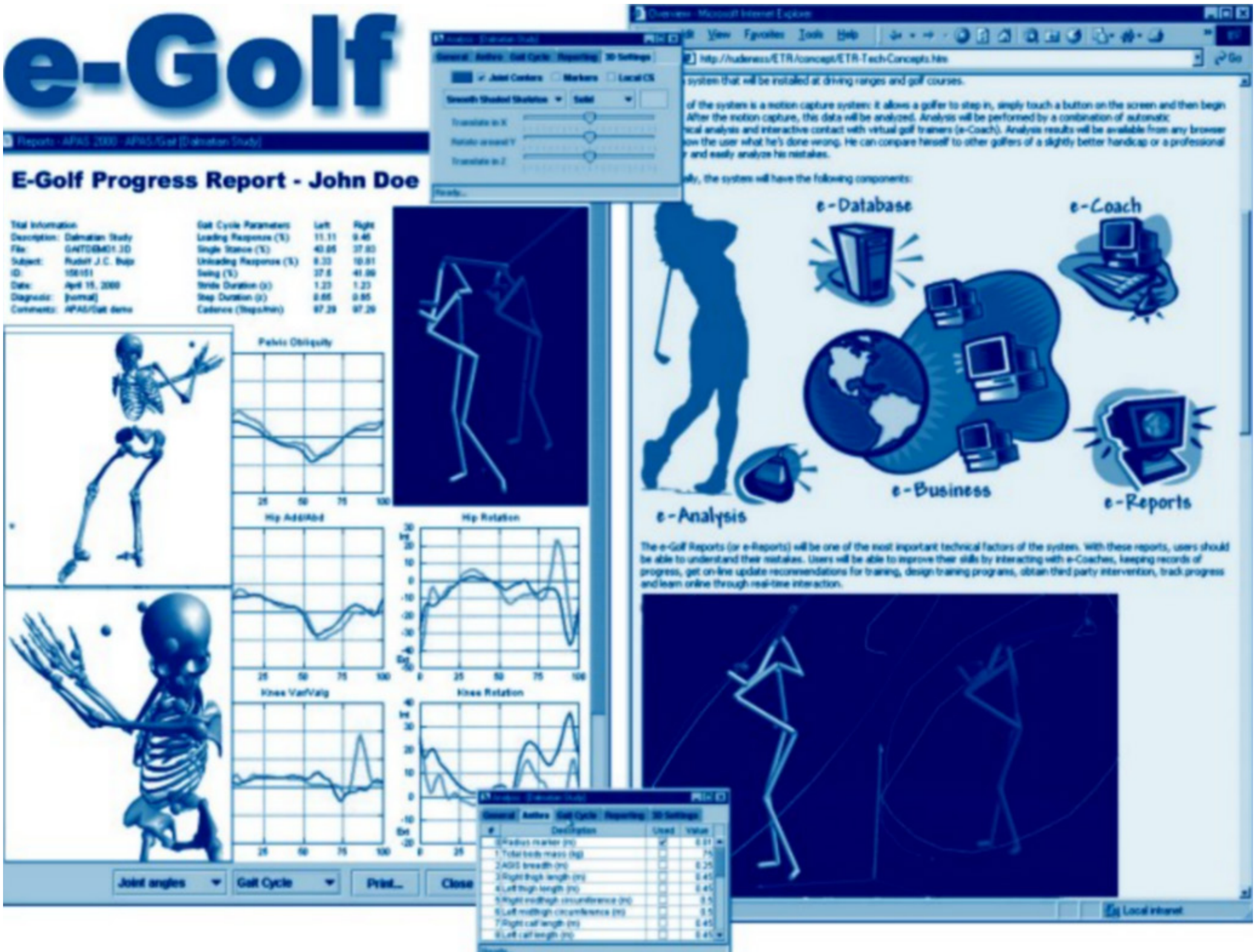
Another interesting situation occurred when I was contacted by my old friend, George Marom, who now lived in New York City. Before he moved to the United States, George



had been a great sprinter in Israel running the 100 meters. After he had moved to America, he attended Temple University where he specialized in the Physiology of Exercise.

George called and told me that he and some partners were opening the most advanced health club in the world in New York City at the corner of 2nd Avenue and 52nd Street. He wanted to incorporate my computerized exercise machines and the motion analysis system as part of the unique theme of his club. I was more than pleased to work with George and we arranged for his company to purchase several of the CES systems and the APAS as well. Nearly a year passed and finally his club was ready for the grand opening. George invited me to the open house of the club, named "Excelsior". Of

e-Golf
http://arielnet.com/ref/go/5015



See "Table of Contents" or "Index"

Lucia Tristao

course, I agreed and volunteered to demonstrate the equipment to all of the people who came to the open house.

I enlisted the aid of my friend, Bob Wainwright to help with the demonstrations at the Excelsior's open house. Bob had 12 of my machines in his own facility which were used primarily for Physical Therapy, but he was quite skilled at demonstrating the uses of the equipment. The club looked fantastic and it seemed that at least 300 people came to the open house while Bob and I were demonstrating the machines. The people continued to come to our section in a continuous non-stop flow.

Suddenly, I noticed an exquisitely beautiful lady walking up the stairs to the open house. Both Bob and I were quite mesmerized by her beauty as well as her graceful and elegant manner. As she walked over to the CES, I realized that this lovely woman was escorted by another friend of mine. My friend was Toby and he happened to be George's brother-in-law. Toby introduced me to the woman as his client, Lucia Tristao, a former prima ballerina originally from Brazil. Toby explained that Lucia had been dancing ballet from a very young age, perhaps 3 or 4 years old. By the time she was twelve, she had already begun to suffer from knee problems. In spite of the pain, she had continued to dance and had performed with many companies after leaving Brazil, including the Bolshoi, the American Ballet Theater, the Pittsburgh Dance, and others. However, she had been forced to retire at the age of 24 because of the constant, unrelenting knee pain. Toby wanted to know if I could help her resolve any of this pain.

I told Toby that I would try and felt certain that there were some things that she could do both on and off the CES that should help her with her knee pain. I demonstrated the

machine for her and had her perform several exercises on it so she could experience the exercise machine for herself.

This was a truly unique experience for me to be involved with a prima ballerina since my experiences until then had been with athletes. I was more than familiar with the stresses and strains associated with athletic performances, but this was the first occasion that I encountered the physical demands associated with ballet. Understanding the demanding work and constant pounding that the feet, legs, and joints must absorb in ballet was interesting and eye opening for me. Watching a ballet performance transports the audience into a world of grace and beauty. Dancers appear to float on air as they glide around the stage. However, I learned that this airy floating illusion that ballet presents masks the tremendously demanding physical price that dancers' bodies must pay.

While Bob and I demonstrated the machine, I asked Lucia if she had any plans for dinner. Although she did have plans, she accepted my offer since her goal was to find any means possible to help with her knee pain. Lucia joined me and Bob for an important dinner meeting in an exclusive restaurant in NYC. Our meeting was with Mr. Doug Dunlop, the attorney for the U.S. Olympic Committee, and Mr. Ryan, a famous New York corporate attorney. I introduced Lucia as my administrative assistance. As we enjoyed our dinner and discussed business Mr. Ryan suddenly asked me: "how long have you and Ms. Tristao been working together?" I answered "2 hours", and the entire table burst into laughter.

In fact, Lucia helped me in various shows to sell the machines. During the ensuing years, she learned how to demonstrate the machines and assisted me at many conference meetings. She was quite adept at operating the equipment and was an exceptionally charming person. I am certain that her talent accounted for many equipment sales. In addition, she has been a dear friend of mine for many years and I cherish that friendship.

I spent most of my time in California although we had as many trade shows as we could handle. One day, Ann and I drove to Los Angeles to meet our intellectual properties attorney, Mr. Norman Zafman. While we were there, a discussion ensued about the manufacturing and sales of our Computerized Exercise Machine with its continuously developing and evolving software. Mr. Zafman asked if we would be receptive to meeting a businessman with whom he had worked on several occasions. Mr. Zafman thought that this gentleman, Mr. Herbert Lightstone, might have some contacts who could help us expand our business. Because we trusted Mr. Zafman with all of our legal matters in this area and since he had always demonstrated the desire "to make a deal", not "kill a deal", we thought the idea sounded intriguing.

Mr. Zafman made the contact and we arranged to meet Mr. Lightstone at our office so that we could demonstrate the Computerized Exercise Machine. We had experienced a similar situation in Amherst when we met Larry Graham.

Lucia on the Ariel Computerized Exercise System

Norman Zafman

However, this time, we had progressed beyond just two graduate students working in the kitchen.

The day Mr. Lightstone arrived, we gave a full demonstration of the Computerized Exercise Machine and, just to impress him, we also gave him a brief presentation of the Ariel Performance Analysis System. Needless to say, he was very impressed with the technology. After a lengthy discussion about how we were currently manufacturing the hardware, shipping the equipment, and managing sales, he said he wanted to think about the situation more thoroughly. He had several ideas and would call us soon.

About two weeks later, Mr. Lightstone called to arrange a second visit. He asked if he could bring a friend who had partnered with him previously in a business they had operated in La Jolla, CA. That former partner was Dr. Don Brucker who had been an optometrist and one of the inventors of the hard contact lens. I was impressed with the opportunity to meet a fellow inventor despite being in different fields of interest.

Before Mr. Lightstone brought his friend to Coto de Caza, I researched his background and discovered that he was an interesting person. Donald Brucker was born in 1932 and brought up in Los Angeles and became an optometrist because his brother-in-law was a professor of optometry at the University of California at Berkley. He graduated from UC Berkley in 1956. His interest in the then rather primitive contact lenses began in the late 1950s. Brucker thought he could make better lenses for himself and friends and set up his own laboratory where he developed a continuous curve hard lens with a gradually flattening periphery. The design had a fairly smooth posterior surface and its success prompted him to start Continuous Curve Contact Lenses in 1960.

Before Bausch & Lomb gained FDA approval, Dr. Brucker developed his own lens design in a material devised by Maurice Seiderman. Brucker started clinical work on the new material in 1971 and gained a New Drug Application in April 1974. Hydrocurve, using Hefilcon A, was only the second hydrogel in the USA to achieve FDA approval. The cost for the approval was $1.5 million. Later the lens was made from Bufilcon material and the first "ultra-thin" lenses to improve oxygen transmissibility and reduced hypoxia were introduced in the USA in 1977.

Other companies followed suit. The following year, Hydrocurve gained FDA approval for the first soft toric contact lenses available in the USA. In 1982, Continuous Curve

Don Brucker

Contact Lenses was sold to Revlon which also owned Barnes Hind. Brucker continued to run both companies.

In the mid-1970s, by virtue of Hydrocurve lenses, Continuous Curve was the second largest contact lens company in the world after Bausch & Lomb, and in the early 1980s they were the fastest growing company on NASDAQ. Brucker also made gas permeable hard lenses and claimed to have had the first such lenses on the market. He was an early soft lens investigator for Bausch & Lomb and also developed cold contact lens disinfecting solutions which were made by Burton-Parsons.

My conclusion was that here must be another "crazy" scientist-inventor like me. Mr. Lightstone told me that Dr. Brucker had just sold his patent for 120 million dollars and, therefore, had a lot of money, time, and motivation to invest in a new venture. Dr. Brucker was not the type of individual that could sit around with nothing to do, so the Computerized Exercise Machine could be an interesting and provocative challenge for him.

The day arrived for the presentation of our system to Dr. Brucker and Mr. Lightstone. I demonstrated how the equipment worked and then had Dr. Brucker experience the exercise equipment himself. As usual, the system sold itself and Dr. Brucker was extremely impressed. He spoke enthusiastically about what he would propose to do. He wanted the opportunity to manufacture the equipment and market it. He had experience in both areas although with different products. However, he felt sure that he could repeat his previous success with our product.

We concluded the long afternoon meeting with both parties responsible for developing detailed plans for a new future together. The details, about where to execute the various tasks, who would be in charge, and where and how much money would be needed, were just a few of the considerations that would have to be identified. The day ended and we agreed to be in touch.

During the next several weeks, documents bounced between us, our lawyer, Mr. Lightstone, Dr. Brucker, and their lawyers. Eventually we agreed that Dr. Brucker would create a company, Ariel Life Systems (ALS), which would manufacture and sell our Computerized Exercise System on an exclusive basis. In addition, if the customer of the CES also wanted the biomechanical motion analysis system, ALS could sell the APAS on a non-exclusive basis. Since our company owned all of the patents and copyrights, we would receive a royalty for each CES and APAS sold by Dr. Brucker's new marketing company. It seemed like a perfect solution for us since we had been searching for the right company to take over the manufacturing headaches. We loved to sell the CES, but manufacturing took our attention from our greater strengths which were software and technological advancements. Now we could spend more time on improving our software without the aggravation of having to manufacture it.

Our attorney, Mr. Norman Zafman, wrote a strong contract, licensing our product to ALS and protecting us from any imaginable negative consequences that might occur down the road. He told us it was better to prepare for a clean, easy, and straightforward termination but hope that the protection was never needed. Our participation was simple: (1) we licensed ALS to manufacture and sell the CES; (2) ALS could sell, on a non-exclusive basis, the APAS; (3) we would receive a royalty for each system sold; (4) ALS would pay our company for the CES control boards and the hydraulic pack.

All of the participants and the respective attorneys met in Coto de Caza to sign the documents. There were smiles all around the table after the many documents had finally been signed. Everyone was excited to begin this new adventure.

Dr. Brucker resided in La Jolla, California and, upon signing the contract in 1990, he threw himself into the business. He created an amazing office, fully staffed, in one of the most expensive buildings in La Jolla. As it turned out, he owned the building and also operated a French restaurant on the second floor. His wife owned and managed a day fitness, spa, and beauty treatment business on the first floor. Ariel Life Systems occupied the top 3 floors. Dr. Brucker hired approximately 50 people, including professional engineers with manufacturing experience and highly paid secretaries. In addition to the prestigiously located office complex, Dr. Brucker also rented a 10,000 square foot facility for the manufacturing, assembly, and testing of the computerized exercise machines. The entire organization from purchasing the first piece of metal through to the sale and delivery of the CES was under Dr. Brucker's control. He told me that the monthly overhead exceeded three hundred thousand dollars.

Dr. Brucker hired several experienced sales and marketing people who launched into their jobs enthusiastically. They created new brochures as well as participated in conventions and shows which catered to any professional organization related to exercise or health diagnostic needs. These marketing efforts generated sales almost immediately. They sold at least 20 machines each month for an average price of $45,000 each, and at least 10 APAS systems averaging $35,000 each. Profits were high and everyone was happy.

During ALS meetings with local residents and at trade shows, the technologies were presented as described in our brochure:

> *The Ariel Computerized Exercise System (CES) represents the state-of-the-art in technology for medical diagnostics, physical therapy and rehabilitation, sports medicine evaluation and treatment, fitness training and research. The CES employs true, interactive bio-*

Meeting with sales staff

feedback control of both effort and movement during exercise, which allows the machine to dynamically adapt to the activity being performed, rather than using the traditional approach of modifying the activity to conform to the limitations of the machine.

The CES training/rehabilitation units utilize a passive hydraulic resistance mechanism under the direction of the system's fully programmable computer. Originally there were two models of the CES, the Arm/Leg Machine designed for single joint movements and the Multi-Function Machine designed for multi-joint movements. Many centers use both machines, which can be run off a single computer. Recently the newly-developed CES Back Machine has also been made available.

The Ariel Performance Analysis System (APAS) is the latest enhancement to the proprietary biomechanical analysis systems, developed through more than two decades of research by Dr. Ariel. This movement analysis system measures speed, acceleration and energy transfer by use of video cameras in combination with a computer. It is the most advanced and flexible system of its kind, yet is still user-friendly.

Besides assisting athletes in their self-analysis, several seminars for the APAS system have been held for those involved with the Americans with Disability Act (ADA) of 1990, to explain how Ariel technology will allow the industry to conform to the sweeping changes in employment screening, hiring and job task analysis that this Act requires.

Internationally, in addition to a distributor in Japan who was "inherited" from Gideon Ariel, the Company has added distributors in France, Belgium, Germany, Scandinavia and Australia.

Dr. Brucker believed that the ALS target markets included: (1) the aging population; (2) baby boomers determined on staying young and who were frequently experiencing spiraling health care costs; and (3) workers' compensation claims and laws such as the Americans with Disabilities Act (ADA). These areas could benefit from both technologies by utilizing many of the buzz words of the decade, such as "functionality", "risk assessment", "fitness", "prevention", and "rehabilitation".

From Don's perspective, he saw the largest markets for Ariel Life Systems' products to be the medical community, followed by sports, research, education, fitness, health, aerospace, military, and industrial engineering. Specifically, he saw tremendous opportunities with physical therapy clinics (such as the one that my friend, Bob Wainwright, operated in New Jersey) which were on the rise since insurance carriers preferred the use of physical therapy rather than the costly expense of operations. Hospitals were a large target as well since nearly 50% of those facilities had rehabilitation departments. In addition, he was convinced that orthopedic surgeons could use the ALS system for pre- and post-operative evaluations and for rehabilitation.

Don also believed that the product analysis capability of the APAS could be employed. The APAS could be used to analyze prosthetic devices to ensure their maximum efficiency. Industrial medicine, safety and ergonomic products seemed to be natural areas for using Ariel systems internally. The U.S. Bureau of Mines was using APAS to develop safety standards. There were new medical markets, such as the neurological community, which could potentially utilize Ariel products for the diagnosis and treatment of conditions such as Parkinson's, Multiple Sclerosis, and for neurorehabilitation independent of hospitals and clinics. Cardiac reha-

Manufacturing of the
Ariel Computerized Exercise System
http://arielnet.com/ref/go/4030

Ariel Life Systems Inc.
http://arielnet.com/ref/go/2742

bilitation, geriatric, and pediatric markets were also readily available markets.

The areas of research and education consisted of at least four hundred educational facilities in the United States which currently had biomechanical departments or laboratories. All of these facilities were potential consumers for both the APAS and the CES. In addition, though military and aerospace budgets were diminishing, Ariel technology had great potential for advancement in the areas related to human performance.

Of course, there was our old reliable and familiar favorite—sports. At that time, at least 25 million individuals played at least one round of golf in the United States. The potential market for golf analysis using the APAS to produce video cassettes of an individual's playing was approximately ten percent of this population, many of whom would purchase repeated analysis as they progressed through a teaching program. Several hundred APAS units would be needed to meet the demand for golf analysis. Similarly, with some five million tennis players in the United States, we felt there was an opportunity for a potential 250 facilities to provide tennis analysis through the use of the APAS.

The rise of health clubs had grown to about 25,000 in the United States. With the growth of rehabilitation services in these facilities, and the expanded use of personal trainers, the potential for the CES appeared to be enormous. Dr. Brucker estimated that at least 2,000 of the higher-end facilities could use the CES. I showed him some literature and pictures from the New York Excelsior Club as well as a health club in Miami, Florida which had capitalized on the name and the CES.

Of course, there was the on-going appeal of Olympic competitors. In the early 1990s, the Australian, Czechoslovakian, Finnish, French, German, and Spanish Olympic facilities had Ariel technology. We were also informed that there were plans to equip the new U.S. Olympic training facility scheduled to be built in the San Diego area with Ariel equipment.

College and professional sports would also constitute an important market since I had already worked with many of them. The Philadelphia Eagles and the Denver Broncos had purchased our CES many years previously. We had performed biomechanical analyses for football teams, including the New England Patriots, Washington Redskins, and the Dallas Cowboys and several baseball clubs, such as the New York Yankees and the Kansas City Royals.

Don also saw other interesting potentials which could be applied to the field of industrial engineering such as the analysis of car crashes, air bags, and related subjects. He also agreed with our previous interest in working with insurance companies and within the legal community to quantify injuries, risks, and analyze claims.

It seemed the potential for both product lines was limitless. However, Dr. Brucker's first task was to manufacture the CES, build a sales and marketing team, and construct advantageous financial programs for potential clients.

From Dr. Brucker's point of view, I had two major functions in the new marketing company. One was product development and the other was in sales. My responsibility in sales was to be the "genius" or "expert" that the other sales staff members could use to explain the system and to provide product credibility. My other job was to continue to develop new software options and create additional exercise machines which could address different muscle groups or were tailored for specialized fields such as physical therapy.

One of the first things I had my software engineers tackle was adapting one of the new, smaller, six-pound notebook computers which were just introduced to the market. These new computers were as capable of operating and demonstrating the entire system as the older computers were, but were cheaper, faster, and more attractive. Many customers may

See "Table of Contents" or "Index"

The Ariel Exercise Machines in the Ariel Fitness Club, Miami, Florida, 1982
http://arielnet.com/ref/go/2743

not have been impressed with the advanced sophistication that these newer computers possessed, but they were awed and amazed by the vividness of the screens and the graphics presentations.

Another one of my dreams had been to develop CES units which were for isolated muscle groups. For example, I developed a unit which allowed the person to sit on a seat and twist the upper body. Another unit was created so the person could move in three dimensions. This was extremely difficult because the software algorithms had to process many degrees of freedom simultaneously.

Our technologies at a convention

A unique opportunity arrived with one project that involved my old friend, Dr. Ira Jacobs. Ann and I had first met Ira on a trip to Canada five years earlier when he was a Canadian university professor. At that time, he had a contract with the Canadian military to train their special forces for fitness in cold water environments. Since he had been extremely successful with their training, the United States Navy in San Diego arranged with the Canadian government for him to work with the Seals. The goal was to improve the training, conditioning, and performance of the US Navy Seals in cold water environments.

Since Dr. Jacobs had used our Computerized Exercise Machines with the Canadian military, he also wanted to use the CES to help train the U.S. Navy Seals at their San Diego facility. This was an especially important project for me because it was to help my adopted country of America in ways that were meaningful and patriotic. I had always loved the United States but had never had any real means to demonstrate this affection. Helping the Seals gave me some satisfaction that I was contributing to the country which had been so good and welcoming to me as a foreigner. Although I had been a US citizen for many years, this was the first time that I felt like I was giving back something to my country.

Another completely different yet fun and unique project which we were involved with at ALS was working with the owner of the America^3 racing boat which was to compete in the America's Cup yacht race in 1992. The world of sailing and sailing as the competition was far from the athletic events that I had experienced in the past.

The America's Cup is a trophy awarded to the winner of the America's Cup match races between two sailing yachts. One yacht, known as the defender, represents the yacht club that currently holds the America's Cup and the second yacht, known as the challenger, represents the yacht club that is challenging for the cup. The timing of each match is determined by an agreement between the defender and the challenger. The America's Cup is the oldest international sporting trophy.

The trophy was originally awarded in 1851 by the Royal Yacht Squadron for a race around the Isle of Wight in England which was won by the schooner "America". The trophy was renamed the America's Cup after the yacht and was donated to the New York Yacht Club (NYYC) under the terms of the "Deed of Gift" which made the cup available for perpetual international competition. Any yacht club that meets the requirements specified in the Deed of Gift has the right to challenge the yacht club that holds the Cup. The winner of the race gains stewardship of the cup.

The history and prestige associated with the America's Cup attract not only the world's top sailors and yacht designers but also the involvement of wealthy entrepreneurs and sponsors. It is a test not only of sailing skill and boat and sail design but also of fund-raising and management skills.

The trophy was held by the New York Yacht Club (NYYC) from 1857, when the syndicate that won the Cup donated the trophy to the club, until 1983 when the Cup was won by the Royal Perth Yacht Club. The Royal Perth Yacht Club, represented by the yacht "Australia II", won the race and, with the victory, ended the longest winning streak in the history of the sport.

From the first defense of the Cup in 1870 through the twentieth defense in 1967, there was always only one challenger. In 1970, for the first time, there were multiple challengers, so the NYYC agreed that the challengers could run a selection series with the winner becoming the official challenger and competing against the defender in the America's Cup match. Since 1983, Louis Vuitton has sponsored the Louis Vuitton Cup as a prize for the winner of the challenger selection series.

AMERICA^3
Foundation
America's Cup 1992

May 28, 1992

Dr. Don Brucker
President
Ariel Life Systems, Inc. P. O. Box 1169
La Jolla, CA 92038

Dear Dr. Brocker:

This letter comes to thank you and all the Ariel staff for your tremendous support throughout the America's Cup competition. We really believe that the fitness of our grinders aided by the use of the Ariel CES equipment helped to give America^3 an edge over the competition.

We appreciate the time taken by Ariel personnel to train our coaching staff and to upgrade our equipment to state of the art.

Thank you Ariel Life Systems, for all your help and support - we

Sincerely,

Bill Koch
President & Skipper
America^3 Foundation

America's Cup yacht race in 1992

The involvement of ALS with the America^3 team was to work with them to assess their fitness levels and, based on the findings, teach them how to improve their physical training. I was surprised to discover how many individual yachtsmen's sailed on the yacht. But most of the members regularly trained on the CES at the La Jolla office complex and we were able to increase their strength and endurance levels.

We also used biomechanical analysis to evaluate some of the details that they wanted to know such as the angular position of the sail and the water during certain yachting maneuvers. These specific orientations were important for control techniques during turns was the way it was described to us.

The America^3 team won the America's Cup yacht race in 1992. All of us were very excited to have been a part of their preparation and celebrated their victory. Again, I was pleasantly surprised to discover the many uses that the CES had within the sporting world.

Of course, ALS was involved in working with other sports, including baseball. One of the salesmen Dr. Brucker hired was John D'Aquisto. John had been a professional baseball player for the Padres in San Diego but he was now one of the directors of sales. John was a fantastic salesman since he could make the system seem exciting to everyone to whom he presented.

The staff had a coordinated presentation system with each member presenting a different aspect in a polished and sophisticated manner. I was introduced when they needed someone to present a detailed, knowledgeable explanation about the process as well as the objective, scientific premise incorporated into the equipment, but they handled all of the sales details of the presentations.

There were many meetings at ALS's La Jolla office. My role was to present the scientific side of the technology. Don presented the business side of the company. During sales presentations, the marketing staff took over at that point. When Don was presenting to potential investors, Mr. Herb Lightstone explained to these potential investors what he perceived were the important factors based on his many years of business and investment experiences.

From the beginning of ALS, sales were brisk. This was enhanced by the extensive contact lists which we had given to them from our former customers at Ariel Dynamics, Inc. We had preserved the contact lists and the customer database so the ALS sales staff had immediately put this information to work for the new company. In addition, they had introduced ALS to the San Diego and La Jolla communities so that they were aware of the new company residing in their midst. The local area was very affluent and Dr. Brucker was confident that there would be an excited and enthusiastic group of individuals and, perhaps investors, who would want to become involved.

The manufacturing site was extremely busy trying to make equipment as fast as the sales staff could sell them. The marketing staff was continuously creating new flyers and brochures describing the products as well as contacting news media so they could create interviews about the amazing new products. The sales staff traveled continuously throughout the U.S. to trade shows and to visit individuals in their offices, hospitals, or laboratories. The results of all of these activities were impressive. ALS was producing, selling, and delivering many machines every month. They were far more productive than we had been at Ariel Dynamics.

With John D'Aquisto in a TV interview
http://arielnet.com/ref/go/2793

As time passed and the marketing and sales portions of ALS grew, I continuously had to travel to shows and demonstrations around the US. I was on the road more often than I was in California. Ann spent almost all of her time in Coto de Caza working on the non-ALS part of our business. She also had to deal with the orders for boards and packs which came from ALS so she was quite busy. Unfortunately, we had to be apart for more time than we would have liked. However, Dr. Brucker and the sales staff were unsympathetic about this situation so I acquiesced and continued to travel from city to city.

During one of the sales trips, I met Merry, a beautiful young woman who expressed an interest in the work I was doing. She also wanted to transfer to a California university to continue her studies. I was quite smitten by her and decided to help her in any way that I could.

Subsequently, she moved to California and attended a local college to complete her four years of undergraduate work. We lived together during this time and things progressed as they normally do between men and women. We had three daughters while she was completing her university work.

After she had finished school, she took the three girls and moved back to Texas. I continued to support them over the years and I am happy that they have done so well with their lives. At this time, my oldest daughter has finished college and is working in a law office; my middle daughter is working as an RN in a cardiac laboratory in a hospital; and my youngest daughter is still in college. I am proud of them and hope they will continue to do well and be happy.

ALS began to experience some turmoil during this time. Despite the excellent developments in manufacturing and the burgeoning sales, I was quite concerned about the way that Don was operating the company. Although this was Dr. Brucker's marketing company and did not affect the company that Ann and I owned, he was conducting the operation in ways that seemed excessive compared with the way that Ann and I had run our business previously. It was the surge of activity and Dr. Brucker's apparently excessive financial expenditures that were of such concern to us. Ann and I had run our business conservatively. Our business plan had been to receive an order for equipment, to collect payment, and afterwards, to ship the machine. We never had accounts receivable, which meant that no one owed us money. Therefore, we were never exposed to any debt. ALS was operating in the manner more like what is described in textbooks. The costs before sales were to be covered when the products were sold. Ann and I understood the concept but nonetheless, we

Merry, the mother of my 3 beautiful daughters

Tova, Nomi, and Ilana, my beautiful daughters

always told Dr. Brucker that we thought he was doing too much and too quickly.

I found it was difficult, if not impossible, to argue with Don regarding the operational side of ALS. Seemingly, ALS was profitable and the future appeared to have no limits. In addition, the man running the company as president and CEO, Dr. Brucker, had invented hard contact lenses and was himself a multi-millionaire. Don's philosophy was that he had done this before and he believed he could do it again.

In order to grow bigger and faster, Don and John D'Aquisto found local residents who were willing to invest substantial amounts of money in the company. This money was used for shows, travel, salaries, and manufacturing as well as other sales expenses. The company seemed to be doing exceptionally well. Dr. Brucker believed that the stages progressed from his investment and the growth of ALS, followed by small local investors who demonstrated confidence in him and the company, and would be followed by success in "going public" on the New York Stock Exchange.

After ALS had achieved a record of good sales and a promising future based on sales projections from the marketing staff, John D'Aquisto suggested to Dr. Brucker that now was the time to try to go public and raise more money. I did not like the idea, however, the others believed it was a good plan. Since the marketing company belonged to Don and not to me, I felt that these types of decisions should be his. I certainly voiced my disapproval. But Don felt that his previous experience with developing a small company and parleying it into a larger, hugely financially profitable result, was the path he was prepared to follow.

In order to secure the larger investors that he was seeking, Dr. Brucker arranged to meet and present the company to several Wall Street firms. He needed me to attend the meetings since I was the expert as well as a fantastic "show man" in demonstrating the products. Of course, Don had to buy a nice suit and tie for me, since my California attire would be inappropriate in New York City!

Ann accompanied Don and me as we flew first class to New York City. Dr. Brucker and his staff had organized several meetings including one with the firm J.P. Morgan. As soon as I had completed the demonstration of the software and hardware portions of the presentation, Dr. Brucker and his financial assistance began answering the financial questions.

Several months previously, Don had hired Price Waterhouse to evaluate the value and prospects of ALS. Following their positive evaluation, Price Waterhouse valued the company at forty million dollars. Since ALS was selling nearly seven million dollars of software and hardware, Price Waterhouse valued ALS at seven times the sale income. I was told that this is the normal upward evaluation.

The previous investors Don had found were known as "mezzanine investors" which was a term that I was surprised to learn even existed. This level of investors provides additional capital before the company puts out an Initial Public Offering, or IPO. These investors can recover a substantial return on their investment since they are willing to take a risk before any others who invest at a later date. This strategy to raise money was perfectly legal and substantiated by Price Waterhouse's prospectuses and numbers.

I learned later that there were approximately 60 investors, most of them from San Diego and some from New York. I personally had no involvement in this process and, in fact, was unaware of what Don was actually doing in the financial area of the business. As far as I was aware, I thought the company was making a good profit on the sales. I was so busy flying around the country and giving demonstrations in La Jolla, that I naturally assumed that these efforts were generating sales. Much later I was to discover the mistake I made by showing myself so liberally to these investors as I presented the technology. My job for ALS included presenting the technologies and I was apparently even better at this than I had realized. Dr. Brucker had capitalized on my demonstrations and accomplished his goal of raising millions of dollars from the investors who met him and saw the growth potentials of the products.

I naively believed that all of my traveling, presenting at trade shows, and continuously demonstrating at the La Jolla office, was a contributing factor to the growth in sales. The marketing and sales staff showed me many orders which were reflective of all of our efforts to promote the products.

Eventually Don was unable to hide the facts that things were not going as well as he had led me to believe. Even without the details, I began to suspect that something was dreadfully wrong, especially when I was informed that many people had invested substantial amounts of money in ALS. These investors were a significant source of money which formed, along with Don's continuous financial contributions, the substance of ALS, rather than product sales.

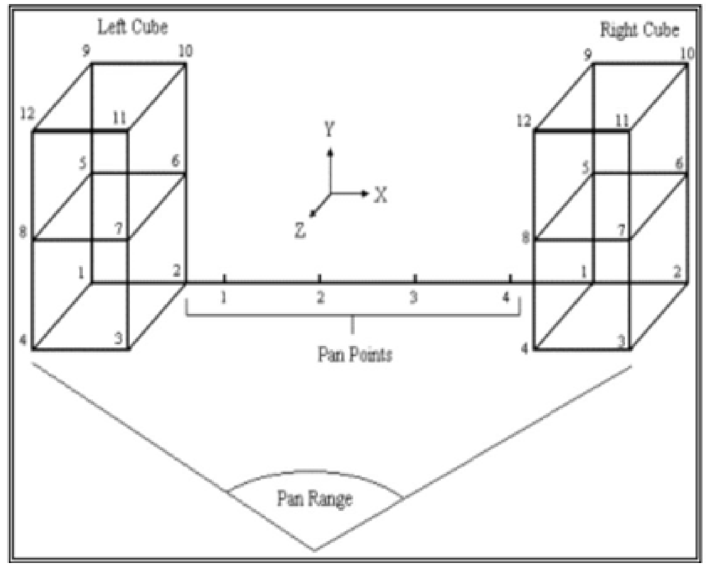
I had known that Don had made necessary contributions to cover recurring cash flow difficulties. I also knew that Don had involved a few outside investors because they were important people who would be useful in the future or were past friends of Don's. Clearly, my understanding or perhaps lack of any creditable knowledge was nowhere near the true story.

As I discovered more information about some of the things with which Don was involved, I became increasingly more concerned. At this point, I decided to call Herb Lightstone for help. Herb had been the person that my lawyer, Norman Zafman, had recommended to assist in developing and operating our CES business several years previously. He had also been involved with Don Brucker previously and had introduced us to each other. Herb was currently involved with ALS but only in a minor role. I was sure that Herb was unaware of the nature of the business in its current form. Herb drove from his home near Santa Barbara, CA, to

Biomechanical Analysis of Discus Throwing at the 1996 Atlanta Olympic Games

by

Gideon Ariel, Ph.D., M. Ann Penny, Ph.D., and Alfred E. Finch, Ph.D.



Panning cameras

La Jolla. After a few days of research into the business activities, Herb told me that many things were very bad and were probably going to get much worse in the near future.

It was clear that ALS had spent too much money on various marketing scenarios. It was soon learned that systems had been sent to customers to reflect greater numbers of sales than actually existed to indicate to Wall Street that sales were booming. However, these systems had not been purchased.

To add to Don's problems, the year was 1992 and came at the end of a period of economic recession. From November 1982 to July 1990 the U.S. economy experienced robust growth, modest unemployment, and low inflation. The "Reagan boom" rested on shaky foundations, however. As the 1980s progressed, signs of trouble began to mount. On October 19, 1987 stock markets around the world crashed. In the U.S., the Dow Jones Industrial Average lost over 22% of its value. Although the causes of "Black Monday" were complex, many saw the crash as a sign that investors were worried about the inflation that might result from large U.S. budget deficits. The American housing market presented another sign of weakness, since in the second half of the 1980s many savings and loan (S&L) associations, which were primarily private banks that specialized in home mortgages, went bankrupt. The collapse of the S&L industry negatively impacted the welfare of many American households and precipitated a large government bailout that placed further strain on the budget.

Although the 1987 stock market crash and the S&L crisis were separate phenomena, they demonstrated the growing importance of financial markets—and associated public and private sector debt—to the workings of the American economy. Other causes of the early 1990s recession included moves by the U.S. Federal Reserve to raise interest rates in the late 1980s and Iraq's invasion of Kuwait in the summer of 1990. The latter drove up the price of oil worldwide, decreased consumer confidence, and exacerbated the downturn that was already underway.

The recession of the early 1990s lasted from July 1990 to March 1991. It was the largest recession since that of the early 1980s and contributed to George H.W. Bush's re-election defeat in 1992. Although mainly attributable to the workings of the business cycle and restrictive monetary policy, the 1990-91 recession demonstrated the growing importance of financial markets to the American and world economies.

Although the National Bureau of Economic Research has concluded that the early 1990s recession lasted just eight months, conditions improved only slowly thereafter with unemployment reaching almost 8% as late as June 1992. The sluggish recovery was another key factor in George H.W. Bush's defeat for re-election to the U.S. presidency in November 1992.

Not only was President Bush not re-elected in November, but many of the investors to whom Don had sold shares began to experience the financial pinch. Some of the investors lost a lot of money in their other investments and now needed to recover the money that they had invested with Don. Unfortunately, another reflection of Don foolishly believing that he knew what he was doing was his failure to create investment papers to exclude the option for early demands for a return of their investment capital. When these individuals wanted their money returned, they were in a position to affect this demand.

Because Don had spent so much of his own money during the past three years on ALS, his French restaurant, and his wife's spa, he had exhausted his ability to repay his investors. He was over his head in debt, and had spent the many millions that he earned when he sold his contact lens business. He and the company were out of money and two investors forced the company into bankruptcy.

It is surprising to me, as I look back on this time, that these investors thought that they would be able to squeeze money from an obviously empty pocketbook. If Don had been able to repay them, he would have done so. I would have assumed that these investors were smart enough to recognize the reality of the situation and wait patiently for the market to recover. Then they would get their money plus the reward when the company was opened to the public. However, I guess I did not understand their situation any more than they understood Don's.

Unfortunately, ALS was forced into bankruptcy. It really seemed like an unnecessary result based on dreams of grandeur at least from my perspective. Ann and I had operated our business for twenty years in a small, controlled manner. We never exposed ourselves to debt or tried to do things that were outside our areas of expertise. We were small but extremely profitable. Don's dream of a huge enterprise that would become a public company never seemed realistic to me. Whether I was right or the times were wrong is a question with no answer.

Fortunately for Ann and me, ALS had only been a marketing company created to sell our products. They never owned our patents or our business. So, after ALS failed, we returned to our style of operation. The entire experience with ALS left a bitter taste, but we still had the best equipment and technologies available and now we could continue on our own.

Our business site was once again in Coto de Caza with a small staff. In this environment, we were able to attract the most creative and insightful software and hardware engineers. This climate was more suitable to our personalities and nurtured the creative instincts that we all shared. Now, we could focus on improving some of our biomechanical software options.

Almost immediately, we were contacted by our old friend, Coach George Dales, to come to Atlanta to analyze the 1996 Olympic Game events. Ann and I flew to Atlanta where George had reserved an entire conference facility to host the International Track and Field Coaches Association meeting which would precede the opening ceremony of the Games. I arranged for my old friend, Bob Wainwright, and a gifted colleague, Dr. Alfred Finch from Indiana State University, to join us in Atlanta.

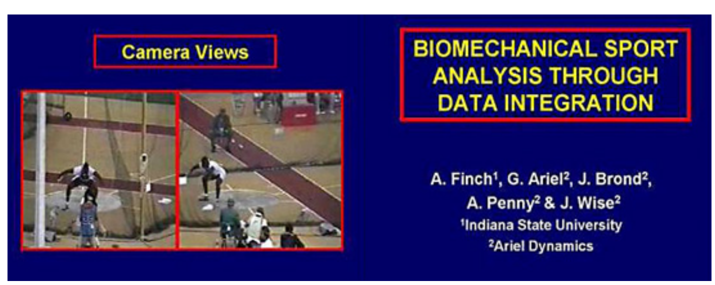
Coach Dales had secured tickets for all of us for the track and field events so that we could gather data for biomechanical analyses. The Atlanta Olympic Games Committee had awarded another biomechanical group the opportunity to place their cameras on the field. Therefore, we were forced to adapt to the situation. The four of us arranged our locations in the viewing stands at angles to each event so that we could cover the entire throw or track event that we wanted to analyze.

After we had collected the data, we returned to our "home base" and began the data processing. We were able to capture the data for each athlete, store it in our computers, and then send the data, via the Internet, to various universities around the world for processing. Then these researchers would return the results to us in Atlanta. We had little time for sleep during those hectic days, but we were able to accomplish an unbelievably complicated task. A tremendous amount of the work was done by Dr. Alfred Finch, and I was pleased and relieved that I had invited him to help me. Of course, Dr. Finch hardly slept at all so he may not have been as thrilled as I was.

However, we demonstrated that (1) we could collect video data under difficult circumstances, (2) process the video data quickly, (3) transmit the data to universities around the world, and (4) receive the processed data within twenty-four hours or less. This had never been tried before and I was so pleased to be able to show again coach Dales that he was right to trust my ingenuity.

After the enormously successful events in Atlanta, we returned to California. I was aware of new computer and other technological innovations in hardware. In addition, I envisioned revised or improved software for our biomechanical analysis system. My staff told me that my brain was constantly buzzing with new dreams and they were always trying to keep up with my new ideas. These were not complaints since they assured me that it was a pleasure to work in an environment of creativity. My style was to describe what I thought would be a great idea and give them complete freedom to develop the concept. These software geniuses enjoyed the challenges as well as the freedom to develop it in their own way. In my experiences with them, the best technique was to describe an idea and stand back and watch it become a reality.

We developed new software for the APAS system which allowed cameras to move, or "pan", as the subject of interest



Rudolf Buijs and me, 1999

performed. For example, an athlete running the length of the runway and taking off for the long jump was frequently filming by a moving camera following the individual. This "panning" technique of data acquisition required unique software for biomechanical processing.

Another software advancement we made was to develop a feature which we named the "Renderer". This program grew from our initial gait module which had been used extensively by the physical therapy community for analyzing patterns of walking motions. Physical therapists and university researchers were frequently confronted with patients possessing compromised physical abilities. Many of their patients presented problems that were most accurately diagnosed with motion analysis and force platform data.

The premise of the "Renderer" was to allow the biomechanical parameters to be visualized in three-dimensional space. The limb segments would appear as cylinders and the joint centers would be round and ball-like. Since more than one camera was used to collect the data, the results generated 6 degrees of freedom, that is, *x*, *y*, *z*, and 3 other orientations. Using these results, the calculated "stick figure" of the biomechanical analysis could now be animated in 3-D. By using cylinders and balls to represent the segments and joint centers, the resulting visual effects were more pleasing to many people than had been the "stick people". We also could present a human skeleton, rather than the "cylinder" figure, for those who preferred that image. We also allowed the researcher to present the model as an isolated image or have it super-imposed on the original video.

The software genius who created the "Renderer" was Mr. Rudolf Buijs. I first met Rudolf in Boston where I had traveled to meet with Dr. Carlo De Luca. In Dr. De Luca's laboratory was a wonderful Swedish researcher, Dr. Lars Oddsson,

Tennis analysis and visualization using the APAS/Renderer application
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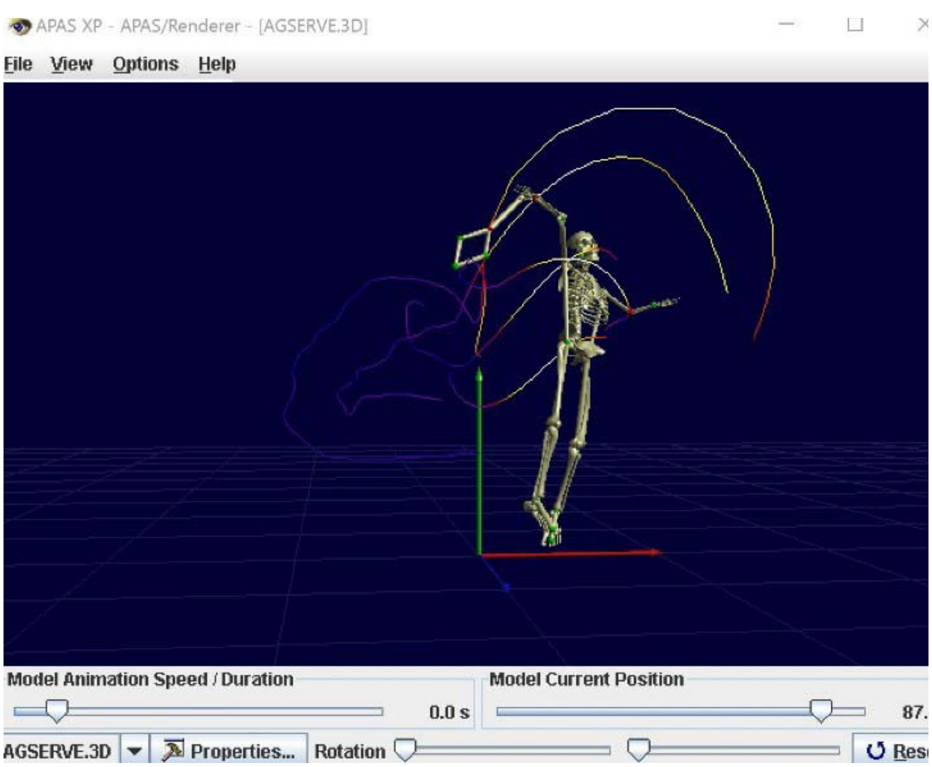

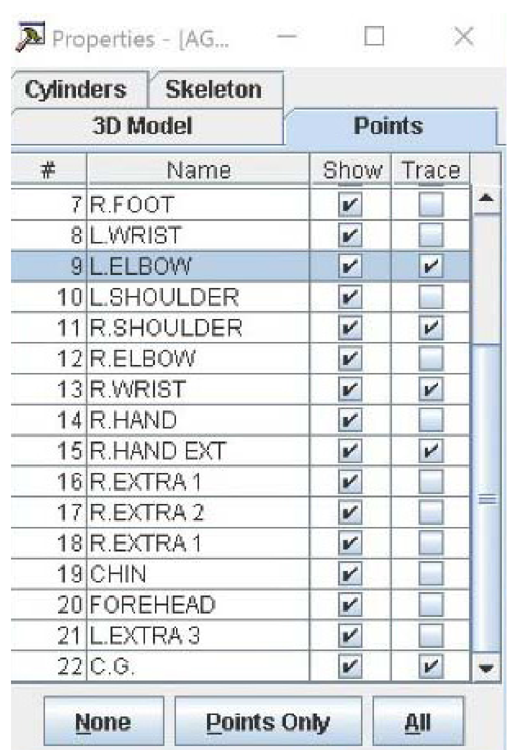

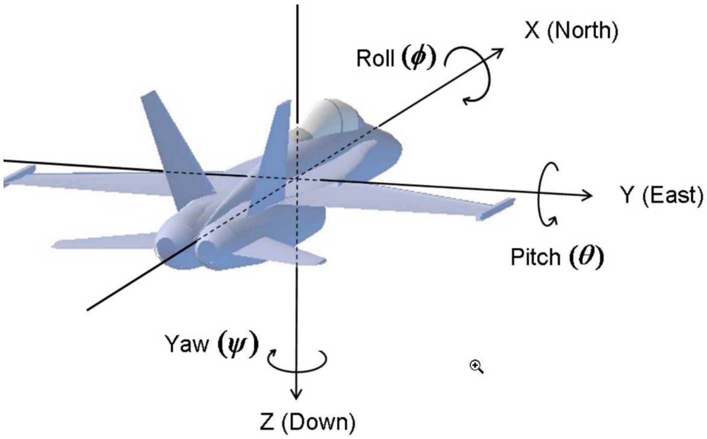

Euler angles represent orientation in 3D
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with whom both Ann and I had worked at the Karolinska Institute in Stockholm, Sweden. A friend of Lars, who was pursuing his M.Sc. studies, also worked in the laboratory. This was Mr. Rudolf Buijs. We soon became friends since we shared many of the same interests in biomechanics and research. Several years pasted after that initial meeting, until one day I received an e-mail from Rudolf describing some of his interests which he thought would be useful for our various projects. We met again several times and then he moved to California so we could work on implementing these ideas. A picture of the two of us is shown on the top right.

We worked with several university professors who specialized in gait analysis to test our new software option. They used different marker sets with some employing the Helen Hayes and other using the Kit Vaughn methods. All of these researchers were positive and enthusiastic about their results using our new “Renderer” program.

Our gait analysis program had been developed and utilized during the 1980s. With the development and incorporation of the “Renderer” program in the 1990s, our biomechanical system was made even more comprehensive.

Other systems, which relied exclusively on the use of marker sets, had several limitations. These systems are restricted in where and how the data can be recorded. They are restricted to filming in a laboratory with fixed camera locations and proper lighting requirements. They cannot film outdoors or travel to the location of a sporting event such as the Football World Cup or the Olympic Games. Additionally, they must use markers to obtain the data which means that the subject is required to perform with all of these items attached to their body. After these systems generate their results, they cannot integrate the video with the calculated figures. In other words, when they present their results, they cannot be compared with the actual data recorded. Our system had none of the limitations for filming outdoors, generating 3-D results, and incorporating the video and the calculated figures.

In addition, our entire biomechanical system was the only one currently available in biomechanics for a reasonable price. The other systems with three-dimensional analyses were priced more than fifteen times higher than ours.

Another positive aspect of the “Renderer” is that of accuracy. The model is accurate since it is based on data obtained on real human beings and is not merely a virtual representation of them. This was particularly important to our physical therapist clients since they worked with real patients who experience physical difficulties. They must be as accurate as possible in their assessment of the individual’s problems and in their prescription for resolving the issue. They would not be effective practitioners if they were only able to produce “virtual” models.

An important development affecting all of our biomechanical programs was the implementation of quaternions for many of the calculations because of the need to produce smooth animation. There are many situations, not just in our programs, which can result in orientation problems in three-dimensional space. For example, airplanes have encountered certain situations when the left-right, up-down, and side to side motions cannot be resolved.

I will describe an example of a problem which an airplane could experience. Imagine an aircraft pointing north and flying level with its heading and pitch are each at 0 degrees. These correlate with rotation about the “Y” and pitch which is rotation about the “X” axis. Now imagine the aircraft pitches up to the vertical. This would be zero heading and 90-degree rotation about X. This is a common “gimbal lock” configuration because if the aircraft keeps pitching up through the vertical, the heading suddenly changes from 0 to 180 degrees. If the plane actually changes that heading, the roll must change (rotation about Y) instantly by 180 degrees

Gimbal lock example
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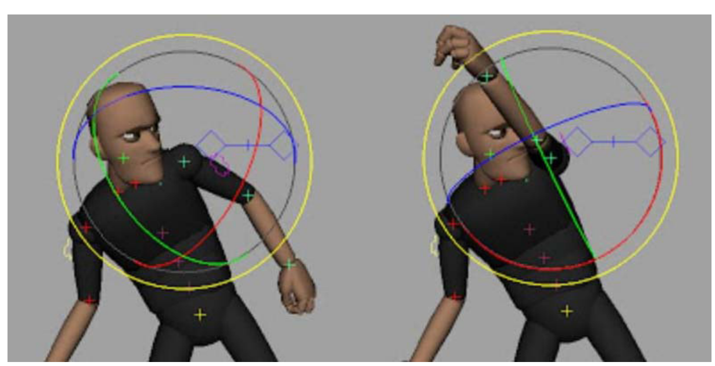

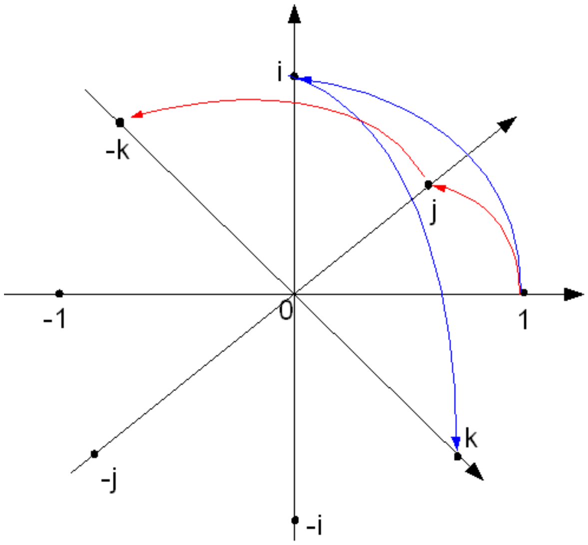

Quaternion
http://arielnet.com/ref/go/2746

and start reducing pitch. It is this sudden flip of the heading as pitch flips through the vertical axis and the instant change in a derivative of pitch that causes "gimbal lock."

In three-dimensional systems, this gimbal lock can cause issues if the application of pitch and roll are handled incorrectly. The model that does not simultaneously flip and roll correctly will rotate back up to the vertical and twist around the axis (and many other similarly related mathematical errors are possible). In physical systems, the requirement to suddenly rotate through the vertical by 180 degrees can cause mechanical problems. Just understand that with ordered vector rotations about the cardinal axis when it rotates through the vertical (in this case) the instant flip of the other rotation has the potential to result in a gimbal lock.

The same kind of flip problem can occur when analyzing human movement. Imagine an arm moved from a left to a right position while moving upward. This movement would result in changing coordinates. The angular calculation produces an extreme result which on a graph would appear to be a smooth movement suddenly interrupted by a spike with the curve continuing in a different plane.

It is not unusual to experience these types of "gimbal lock" situations in biomechanical analyses. We humans continuously demonstrate these movements in our everyday activities as well as during sporting events. Rudolf explained that the "gimbal lock" problem could be eliminated from our biomechanical results by implementing quaternions in our software.

The idea and subsequent development of quaternions were made by a remarkable Irish physicist, astronomer, and mathematician who also made important contributions to classical mechanics, optics, and algebra. Sir William Rowan Hamilton was born in 1805 and lived until 1865. His studies of mechanical and optical systems led him to discover new mathematical concepts and techniques. His best known contribution to mathematical physics is the reformulation of Newtonian mechanics now called Hamiltonian mechanics. This work has proven central to the modern study of classical field theories, such as electromagnetism, and to the development of quantum mechanics. However, in pure mathematics, he is best known as the inventor of quaternions.

In mathematics, the "quaternions" are a number system that extends the complex numbers. They were first described by Sir Hamilton in 1843 and applied to mechanics in three-dimensional space. A feature of quaternions is that multiplication of two quaternions is noncommutative. Hamilton defined a quaternion as the quotient of two directed lines in a three-dimensional space or equivalently as the quotient of two vectors.

Quaternions find uses in both theoretical and applied mathematics, in particular for calculations involving three-dimensional rotations such as in three-dimensional computer graphics, computer vision and crystallographic texture analysis. In practical applications, they can be used alongside other methods, such as Euler angles and rotation matrices, or as an alternative to them, depending on the application.

William Hamilton was the fourth of nine children born to Sarah Hutton and Archibald Hamilton who lived in Dublin, Ireland. Hamilton's father worked as a solicitor. By the age of three, Hamilton had been sent to live with his uncle, James Hamilton, who ran a school in Talbots Castle. His uncle soon discovered that his nephew, William, had a remarkable ability to learn languages and, from a young age, had displayed an uncanny ability to acquire them. By the age of seven, he had already made considerable progress in Hebrew. Before he was thirteen, he had acquired almost as many languages as he had years of age. These languages included classical and modern European languages, Persian, Arabic, Hindustani, Sanskrit, and even Marathi and Malay. He retained much of his knowledge of languages to the end of his life, often reading Persian and Arabic in his spare time and, although he had long stopped studying languages, he used them just for relaxation.

In September 1813, the American calculating prodigy Zerah Colburn was being exhibited in Dublin. Colburn was 9, a year older than Hamilton. The two were pitted against each other in a mental arithmetic contest with Colburn emerging the clear victor. In reaction to his defeat, Hamilton dedicated less time to studying languages and more time to studying mathematics.

Hamilton was part of a small but well-regarded school of mathematicians associated with Trinity College, Dublin, which he entered at age 18. He studied both classics and mathematics, and was appointed Professor of Astronomy in 1827, prior to his graduation, taking up residence at Dunsink Observatory where he spent the rest of his life.

During his academic career, Hamilton made important contributions to optics and to classical mechanics. His first discovery was in an early paper that he communicated in 1823 to Dr. Brinkley, who presented it under the title of "Caustics" in 1824 to the Royal Irish Academy. It was referred, as usual, to a committee. While their report acknowledged its novelty and value, they recommended further development and simplification before publication. Between 1825 and 1828 the paper grew to an immense size mostly by the additional details which the committee had suggested. But the paper also became more intelligible and the features of the new method were not easily seen.

In 1827, Hamilton presented a theory of a single function, now known as Hamilton's principal function, that brought together mechanics, optics, and mathematics and helped to establish the wave theory of light. He proposed it when he first predicted its existence in the third supplement to his "Systems of Rays", read in 1832. In these papers, Hamilton developed his great principle of "Varying Action". The most remarkable result of this work is the prediction that a single ray of light entering a biaxial crystal at a certain angle would emerge as a hollow cone of rays. This discovery is still known by its original name, "conical refraction".

The step from optics to dynamics in the application of the method of "Varying Action" was made in 1827. The ideas were communicated to the Royal Society which published in their "Philosophical Transactions" for 1834 and 1835, two papers on the subject. Like the "Systems of Rays," the ideas displayed a mastery over symbols and a flow of mathematical language almost unequaled. The common thread running through all this work is Hamilton's principle of "Varying Action". Although it is based on the calculus of variations and may be said to belong to the general class of problems included under the principle of least action which had been studied earlier by Pierre Louis Maupertuis, Euler, Joseph Louis Lagrange, and others, Hamilton's analysis revealed much deeper mathematical structure than had been previously understood, in particular, the symmetry between momentum and position. Paradoxically, the credit for discovering the quantity now called the Lagrangian and Lagrange's equations belongs to Hamilton. Hamilton's advances greatly enlarged the class of mechanical problems that could be solved. They represent perhaps the greatest addition which dynamics had received since the work of Isaac Newton and Lagrange.

While Hamilton's reformulation of classical mechanics was based on the same physical principles as the mechanics of Newton and Lagrange, it provided a powerful new technique for working with the equations of motion. More importantly, both the Lagrangian and Hamiltonian approaches, which were initially developed to describe the motion of discrete systems, have proven critical to the study of continuous classical systems in physics and even quantum mechanical systems. In this way, the techniques find use in electromagnetism, quantum mechanics, quantum relativity theory, and quantum field theory.

Hamilton knew that the complex numbers could be interpreted as points in a plane and he was looking for a way to do the same for points in three-dimensional space. Points in space can be represented by their coordinates, which are triples of numbers, and for many years he had known how to add and subtract triples of numbers. However, Hamilton had been stuck on the problem of multiplication and division

ISB Conference in South Africa, presentation by Rudolf Buijs
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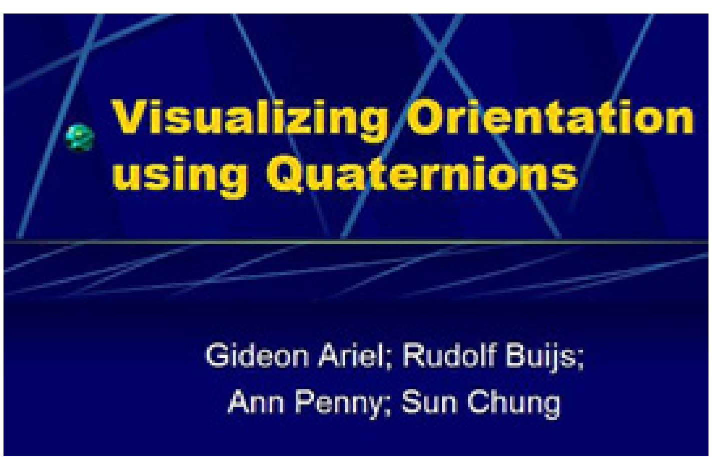
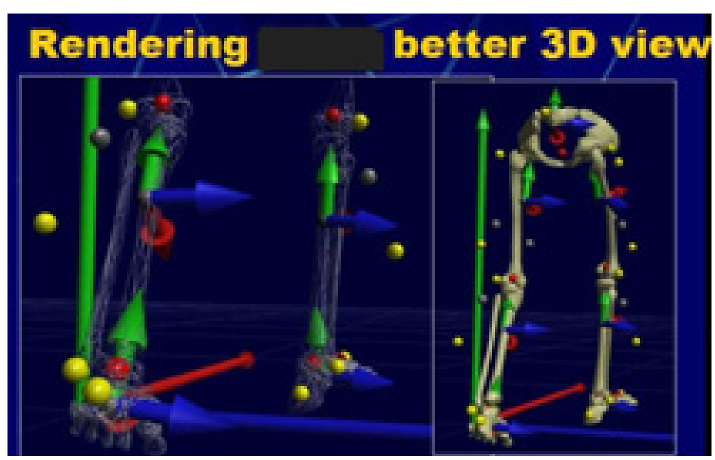
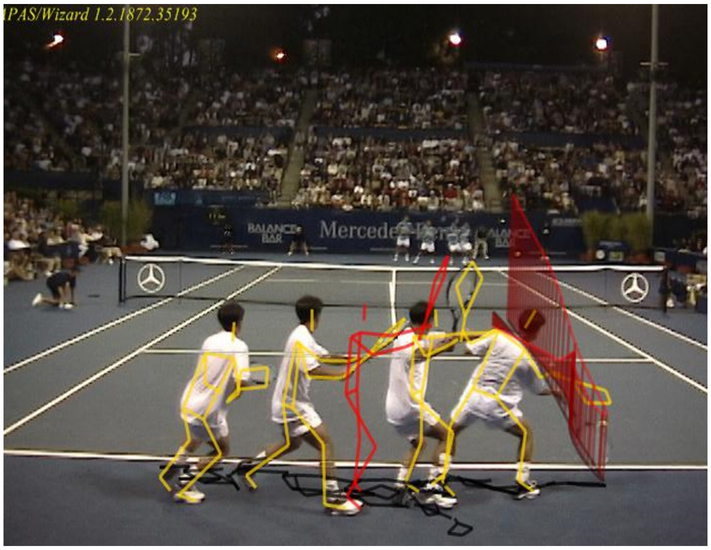






APAS/Wizard demonstrating "strobing"
http://arielnet.com/ref/go/2756

for a long time. He struggled to resolve how to calculate the quotient of the coordinates of two points in space.

Hamilton's great breakthrough in quaternions came on October 16, 1843 in Dublin. Hamilton was on his way to the Royal Irish Academy where he was going to preside at a council meeting. As he walked along the path of the Royal Canal with his wife, the concepts behind quaternions were taking shape in his mind. When the answer dawned on him, Hamilton could not resist the urge to carve the formula for the quaternions into the stone of Brougham Bridge as he paused on it. I could find no information about what his wife thought of this activity! Maybe she was familiar with the actions of a great mind at work. Although I do not compare myself to the genius of Hamilton, had I done the same thing, I am sure that Ann would have been impressed but not surprised if I had written on a stone wall!

On the following day, Hamilton wrote a letter to his friend and fellow mathematician, John T. Graves, describing the train of thought that led to his discovery. In the letter, Hamilton stated:

> *"And here there dawned on me the notion that we must admit, in some sense, the fourth dimension of space for the purpose of calculating with triples… An electric circuit seemed to close, and a spark flashed forth."*

Hamilton called a quadruple with these rules of multiplication a "quaternion" and he devoted most of the remainder of his life to studying and teaching them. Hamilton's treatment is more geometric than the modern approach which emphasizes quaternions' algebraic properties. He founded a school of "quaternionists" and he tried to popularize quaternions in several books. The last and longest of his books, Elements of Quaternions, was 800 pages long and was published shortly after his death.

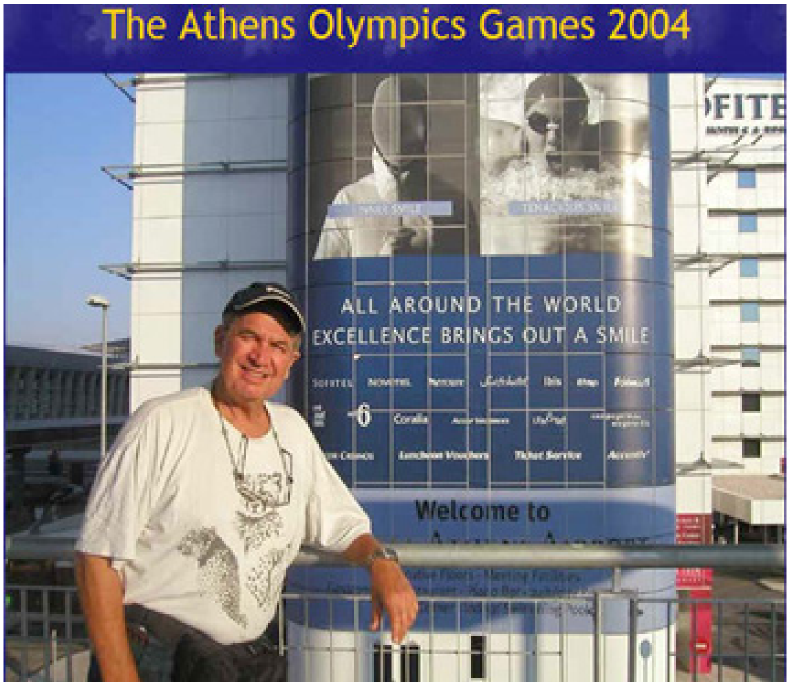
Today, quaternions are used in computer graphics, control theory, signal processing, and orbital mechanics, mainly for representing rotations/orientations. For example, it is common for spacecraft attitude-control systems to be commanded in terms of quaternions which are also used for telemetry of their current attitude. The rationale is that combining quaternion transformations is more numerically stable than combining many matrix transformations. In control and modeling applications, quaternions do not have a computational singularity (undefined division by zero) that can occur for quarter-turn rotations (90 degrees) that are achievable by many air, sea, and space vehicles. In pure mathematics, quaternions show up significantly as one of the four finite-dimensional normed division algebras over the real numbers with applications throughout algebra and geometry.

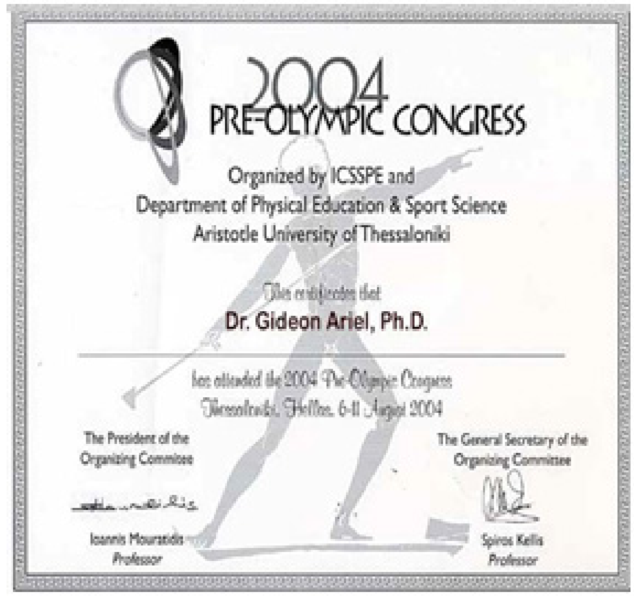
Quaternions have had a revival since the late 20th century, primarily due to their utility in describing spatial rotations. The representations of rotations by quaternions are more compact and quicker to compute than the representations by matrices. In addition, unlike Euler angles, they are not susceptible to gimbal lock. For this reason, quaternions are used in computer graphics, computer vision, robotics, control theory, signal processing, attitude control, physics, bioinformatics, molecular dynamics, computer simulations, and orbital mechanics. For example, it is common for the attitude control systems of spacecraft to be commanded in terms of quaternions.

A quaternion is a four-element vector that can be used to encode any rotation in a 3D coordinate system. Technically, a quaternion is composed of one real element and three complex elements and it can be used for much more than rotations.

Rudolf was tasked with further enhancing the "Renderer". Rudolf is one of those unique individuals who studies all of the time especially mathematics, astronomy, and computers. He had immediately recognized the problem with human motion analysis and "gimbal lock" situations. Obviously, human arm movement is smooth and does not flip or jump in the manner that one would assume by examining a graph with a "gimbal lock" occurrence. Rudolf explained that quaternions would easily resolve the situation since they could eliminate the problem in the same way that they had in aircraft and computer graphics.

Rudolf worked intensely for several months to develop the algorithms and software. After some time, the "Renderer" was ready for its introduction to the world of biomechan-





Presenting in the Athens Olympics, 2004
http://arielnet.com/ref/go/2752

ics. In order to solve this biomechanical situation, he developed a quaternion algorithm to eliminate these "gimbal lock" situations. We arranged for him to accompany us to a biomechanical trade show where we were presenting papers and demonstrating both the CES and the APAS. His paper "Visualizing Orientation using Quaternions" was well received, particularly since it provided a solution for biomechanists struggling with "gimbal lock" situations. We were the first ones in the world to solve this problem in the biomechanics of human movement. In our presentation in the ISB in South Africa, Rudolf presented this software option that we had developed to solve the "gimbal lock" problem.

Pre-Olympic Conference, Brisbane Australia, 2000
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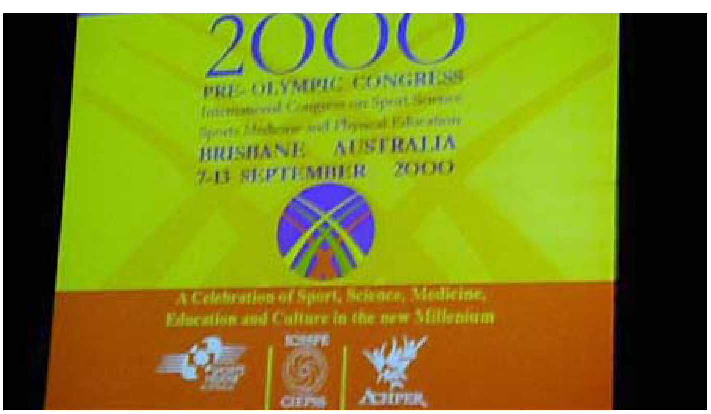

After the success of the "Renderer", we were asked by many of our clinical customers to provide an application which would assist them in a uniform, repetitive work flow. For example, doctors or insurance companies frequently wanted five trials of the same activity which they could compare to each other or to the patient's previous performance. Since the same activity was being repeated numerous times under the same conditions, it would be helpful if we could develop a method to simplify this task.

Rudolf once again set to work to create this application. We worked with our other biomechanical staff to create special subroutines to support this new application which

Utilizing high technology in sports
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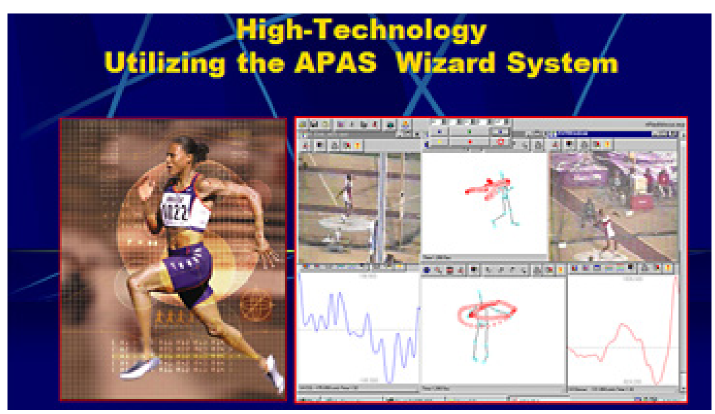
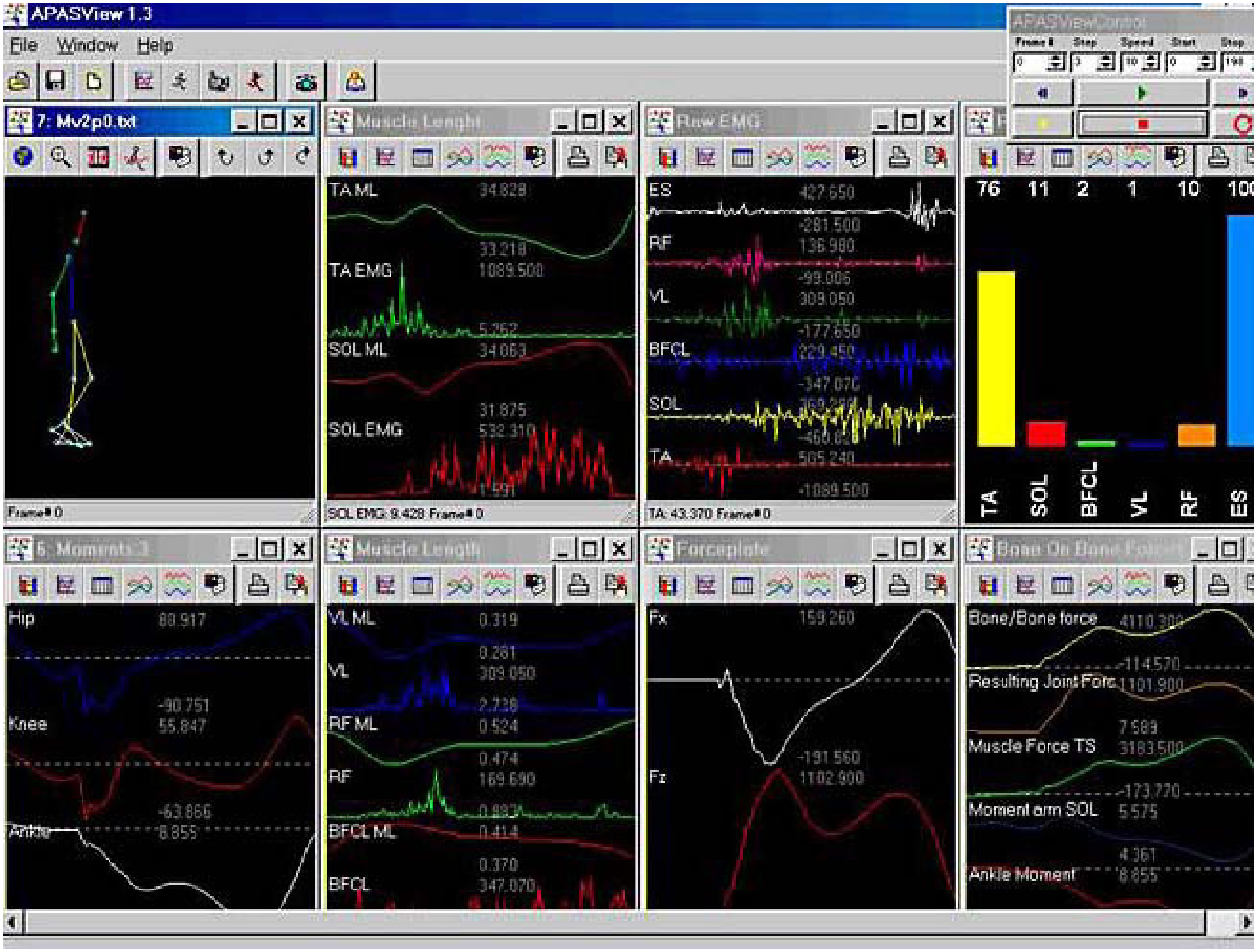


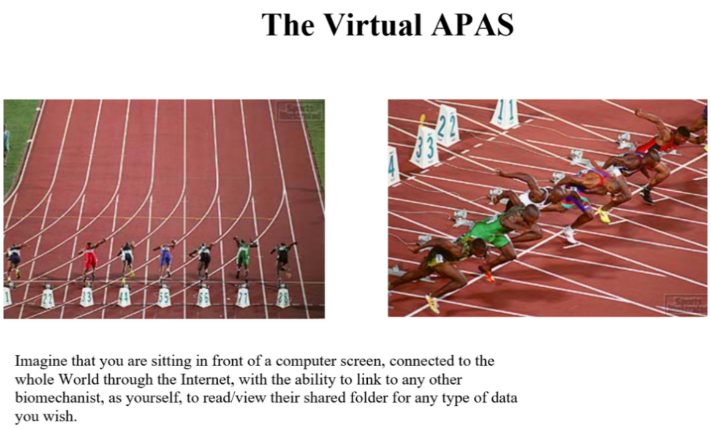


Force plate, EMG and kinematics integrated. The only system in the world
http://arielnet.com/ref/go/2751

had been named "Wizard". The "Wizard" allowed the user to capture the picture from either a computer monitor or a television screen. The model or template, for example the number of cameras, the scale factor, or the number of joints, could be defined. Following the biomechanical processing, the report could be standardized so that all of the trials, data points, pre- and post- activities, or whatever information was required could be presented in the final report. The final report could be customized, in addition, with pictures, graphs, EMG, or any other results which were calculated in our biomechanical process. The idea was to help the clinician create a professional-looking report. For presentations on the computer itself, we created the ability to embed the "stick figure" representation of the individual inside the video as the motion was viewed. Sometimes, a picture actually is worth a thousand words.

I also presented the "Wizard" technology and its application at the International Track and Field Coach's Association meeting in Athens before the 2004 Olympic Games. An advanced function in the Wizard was the ability to "strobe" the video so the coach or viewer could view multiple frames with data attached to the video. In other words, the person would be shown in one frame composed of several of the movements captured from the motions. This illustration would have the stick figure superimposed on each of the captured movements as illustrated in the figure above.

After the conference, when the Olympic Games in Athens were ready to proceed, coach Dales and I organized data collections for several of the field events. We organized filming of the shot put and the discus events. We traveled to Olympia, Greece, which was the site of the ancient Olympic competitions. It was a magical experience to be involved



Virtual APAS system
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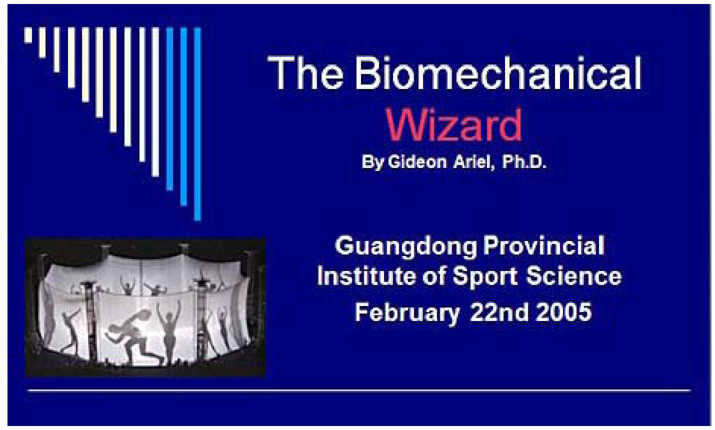

Presenting the Wizard in China
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with a modern event at the location which was the origin for all of the Olympic Games that have followed. It brought tears to my eyes to be at this beautiful location and remember that I had enjoyed the unique opportunity of participating in two Olympic Games.

Another one of our innovations had been to integrate the data collection using the Internet for analysis from any place on the planet. In the 1996 Olympics in Atlanta, we had already employed many of these techniques. By 2004 and the Greek Olympics in Olympia, we could use the Internet even more extensively. Now, we were also able to use cell phones and wireless connections.

The web, combined with Java, was an ideal platform to provide these kinds of services to a wide audience with interactive visualization demonstrations. This web concept allows for many different types of analyses and presentations. With advanced technologies, available on cell phones and wireless systems, we developed our biomechanical system to work with these devices. The schematic diagram on page 477 illustrates this concept:

The ability to collect data from major sporting events on the television and then analyze it would allow every person watching to become a biomechanist in his or her own home. In the late 1980s and early 1990s, we developed another amazing system, Virtual APAS, which provides a system to perform a biomechanical analysis from a standard television broadcast.

Imagine watching the Olympic Games on your own television set at home. It is possible to capture any activity from the television while sitting in your easy chair at home. The

Presenting in the Athens Olympics, 2004
http://arielnet.com/ref/go/2753

Web of biomechanics concept
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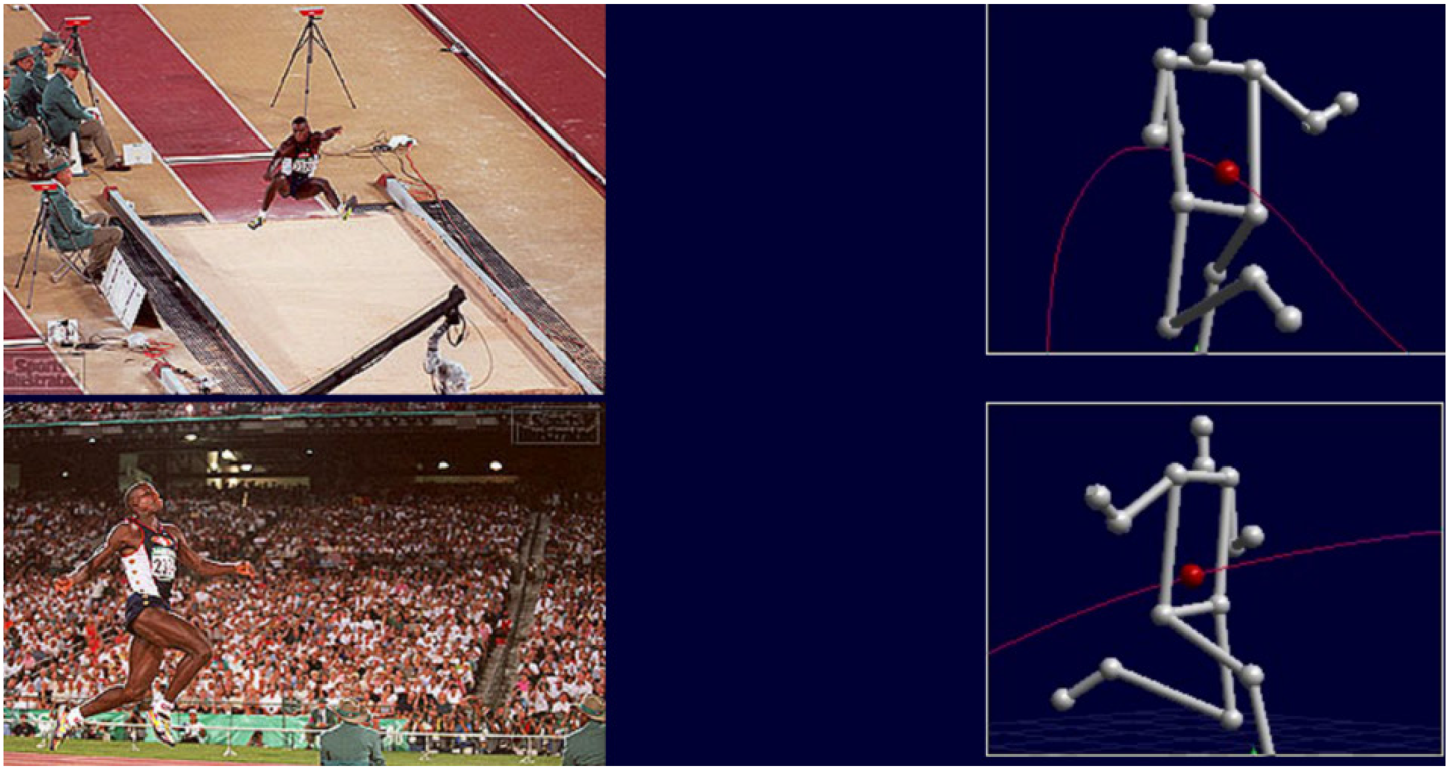


APAS analysis from TVs
http://arielnet.com/ref/go/2755

next step is to accurately calculate 2D and 3D coordinates provided that the video feed was captured from different angles (which the network usually shows as illustrated on the top right) and the dimensions of objects, such as the track width or the height of the number markers or even the size of the athlete, are known. Even if the cameras pan, zoom, or tilt, the Virtual APAS will allow calculation of the coordinates of the body's joints and analysis of the kinematics of the movement. The Virtual APAS was essentially the 21st century biomechanical system. The next challenge will be to use your smartphone to perform these analyses.

The following are only a few of the function that can be performed:

1. Locate and download your favorite biomechanical data from one convenient, easy-to-use interface.
2. Software that allows users to share biomechanical libraries with each other no matter where they are located. Virtual APAS provides a search capability for videos, 3D/2D files capability for users to communicate in forums of like interest.
3. Each biomechanist becomes a download/upload source
4. Each user's computer, when it is on, it becomes a shared directory

The procedures may follow the following scenario:

1. A user records and stores video files in a specific folder on his or her hard disk.
2. A central directory maintained by apas.com keeps track of which users are logged on cataloging by title

and researcher/biomechanist the activity in each user's special folder.

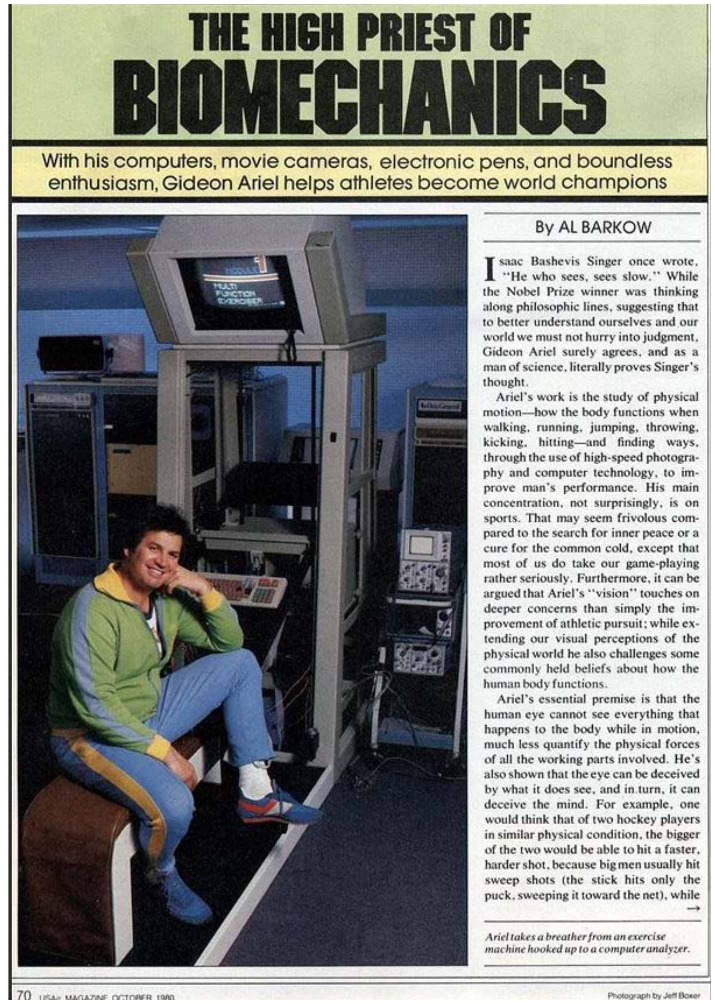
3. A user searches through the apas.com directory for a desired activity or sports. Once the activity is downloaded it can be used for further analysis or observation. This file can also be sent to another person as e-mail or attachment. Any user folder can be shared with the rest of the world.
4. apas.com monitors and publishes the catalogue of activities and sports world wide.

Real-time interactive visualizations on the web can be used for all types of applications, including e-sports analysis. For example, an athlete might want to compare himself to a professional or to himself before a training program. Professional visualizations can be created easily. This would allow the viewers to analyze simple questions such as "did Carl Lewis touch the line before takeoff? Could he have jumped farther? How does this jump compare to Bob Beamon's?" There are other questions including team formation analysis, race analysis, and comparisons of different athletic performances.

All things considered, it has been an exciting time with all of the new technologies and software improvements we added to our biomechanical system. It seemed that, no sooner had we integrated a new camera or new VCR or some other new device, another one would become available. Of course, the newest model was more exciting than the last one, so we had to have it. I am sure every wife or mother has watched their husband, son, or daughter who must have the newest gadget which they cannot possibly live without. That was our situation and it was one of the most exciting and stimulating times of our lives. It was almost like going to the toy store every day and all that occurred in the 1980's and 1990's before smartphones or the Internet.

In addition to all of the software programs that we created, we continued our efforts to improve the hardware design and develop new programs for our reclaimed Computerized Exercise Machine. This had been our first "baby" and it had come home to the family that loved it. Now we wanted to manufacture it again under our control.

For the manufacturing of the hardware, we had a surprising event when a stranger knocked on our door and asked if I was Gideon Ariel. That was not the surprising part. The shock was that he lived approximately a mile from us and had been hired previously by ALS to make the valve packs that they had used on the CES in the La Jolla facility. When ALS ceased to do business, this gentleman had been left with 100 units that he could not use and had no customers to buy them. Needless to say, we quickly concluded an arrangement to purchase these units for a fantastic price.



THE HIGH PRIEST OF
BIOMECHANICS

With his computers, movie cameras, electronic pens, and boundless enthusiasm, Gideon Ariel helps athletes become world champions

By AL BARKOW

Isaac Bashevis Singer once wrote, "He who sees, sees slow." While the Nobel Prize winner was thinking along philosophic lines, suggesting that to better understand ourselves and our world we must not hurry into judgment, Gideon Ariel surely agrees, and as a man of science, literally proves Singer's thought.

Ariel's work is the study of physical motion—how the body functions when walking, running, jumping, throwing, kicking, hitting—and finding ways, through the use of high-speed photography and computer technology, to improve man's performance. His main concentration, not surprisingly, is on sports. That may seem frivolous compared to the search for inner peace or a cure for the common cold, except that most of us do take our game-playing rather seriously. Furthermore, it can be argued that Ariel's "vision" touches on deeper concerns than simply the improvement of athletic pursuit; while extending our visual perceptions of the physical world he also challenges some commonly held beliefs about how the human body functions.

Ariel's essential premise is that the human eye cannot see everything that happens to the body while in motion, much less quantify the physical forces of all the working parts involved. He's also shown that the eye can be deceived by what it does see, and in turn, it can deceive the mind. For example, one would think that of two hockey players in similar physical condition, the bigger of the two would be able to hit a faster, harder shot, because big men usually hit sweep shots (the stick hits only the puck, sweeping it toward the net), while →

Ariel takes a breather from an exercise machine hooked up to a computer analyzer.

70 USAir MAGAZINE OCTOBER 1980

Photograph by Jeff Boxer

The High Priest of Biomechanics
http://arielnet.com/ref/go/2757

Both of us were happy and satisfied at the conclusion of this business transaction.

In addition to these newly acquired packs, we found what seemed to be a perfect solution. We had discovered a small machine shop business, owned by an engineer and a commercial airplane pilot, which they operated for clients like us. They were for all intents and purposes a custom engineering and machine shop. Their work was meticulous and of superb quality. We were extremely impressed by the quality of their work and contracted them to make the CES for us. We were able to provide them with complete packs for 100 units, so we were on the way to recovering our CES business but on our own terms.

We were back in the CES business as well as the further development of software for the APAS system. The additional development of unique biomechanical items makes our life even more exciting. But, twirling in my head, I had my most surprising idea in mind for Ann.