Selected Course Work and Projects

by Thomas Walker Lynch

Preface

Thomas is an American Citizen from Arizona. Most of his career was spent in Silicon Valley and Austin Texas, but he made up for not traveling when young by spending some time working in France, Switzerland, Taiwan, as well as having had research affiliations with universities in Barbados and the UK. He has studied Spanish, Japanese, and French, but does not consider himself to be fluent in these languages.

Thomas has an MS In Electrical and Computer Engineering 1996, and BS in Electrical and Computer Engineering 1986 both from UT Austin in Austin Texas. UT Austin has a public degree search facility on their website where these may be verified. Thomas initially studied in Iowa where he has family, then transferred.

Thomas took a wide variety of courses in math, physics, computer science, with a smattering of history, anthropology and linguistics. He graduated with many more hours than necessary. Some of these courses are summarized here.

A review of Thomas's studies reveals a person with an eternal curiosity about people, how they communicate and engage their world, and the processes they have developed for thinking about things. It is not a coincidence that Thomas is the primary founder of Reasoning Technology.

Without knowing about these courses some of his patents or publications might appear to have come from nowhere, when the actual case is that those works owe a great deal to his teachers and those who created curriculum.

Summary/Table of Contents

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UT Austin

Computation Theory

340L, taught in the Linguistics Department using Papadimitriou's book. We started with the definition of a Turing Machine, and proved one lemma after another until finally proving that the halting problem is not computable.

Computer Design

This was three courses. Dr Roth's logic design course, Dr. Minassian's 360N which had us design state evolving machines in every conceivable way, and Dr. Gonzale's classic computer architecture course. I should probably include a co-op stint with IBM in San Jose where I wrote a small part of the simulation code for a new mainframe. We coded in PLS.

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Artificial Neural Networks

I did a joint project for this course along with the Artificial Intelligence course, called *The Metadesign of Neural Networks.* The idea was to define a 'concept space', and then to design a network that was able to learn within that space.

As a first concrete example, I used a TMYCIN expert system to define a concept space. I then converted the expert into a neural configuration and weight values. For each neuron I used diode dendritic trees, resistor weights, and a summing threshold op amp. The whole thing was a wire wrapped affair on perf board. It worked.

In an improvement I introduced a distribution transforms to cause the neural network to be more redundant, though I did not modify the existing hardware.

After turning in the work I created a second example. The neurons were configured to act as logic gates and placed in a configuration to form a binary adder. Due to the distribution transform the logic was tolerant to stuck faults. I demonstrated this with Spice simulation. It did work.

Artificial Intelligence

Note the joint project I did with the Artificial Neural Networks course described in the previous section. While doing the survey for the final paper I found some research at Southwest Research Institute, where they also converted expert systems into artificial neural networks. For the AI course Porter's TA said it was the best project they had ever seen. That "it is cool". Dr. Gosh also said the project was impressive.

Spice Simulation

Dr. Pillage taught us how the Spice simulator worked, set us up with a sparse matrix library, and then had each of us write our own Spice simulator. I requested and received permission to also take the next summer to write it.

My simulator made use of two dimensional time. I called the two dimensions u and t. Spice uses Newton-Raphson so a person might reason that by making time steps small enough the system should always converge. However, engineers like to use idealized models, for example a step forcing

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function, and these introduce discontinuities. It does not matter how small of step is taken, the discontinuity will still be there.

Now imagine that you are Kayaking down the stream of flowing time t and come to a waterfall. The waterfall is a step function. The simulator is at time t(n) and is computing the state for t(n+1). The time t clock is stopped but the time u clock is running. So in time u , you pick the kayak up out of the water and walk down the gently sloping trail until getting to the bottom of the waterfall. Then you put the kayak back in the water. We have arrived at the state of the system for t(n+1) yet we never encountered a discontinuity.

I am not sure if Dr. Pillage appreciated the work. After I submitted the report and was being question in his office, every time I mentioned the variable *u* he had a blank look. Finally he asked, “can it do voltage scaling?” “Well yes.” “Ok then we are good.”

I had thought two dimensional time would solve the Spice stability problem, but it uncovered two other problems. Namely those of numeric precision, and perhaps that of choices between what appear to be equally good next states.

Computer Arithmetic

While I was at AMD working on the design of numerics for microprocessors, Dr. Swartzlander who is one of the world’s experts on this very subject started teaching a course just down the street. What a blessing. In his courses he surveyed the literature on all the standard functions. I ended up doing a masters thesis with him.

Control Theory

In this course we learned how to evaluate the stability of transfer functions using linear methods. I made a deal with the professor to turn in a computer program that solved the homework problems instead of going through all that tedium. It turned out well, the program really did solve them.

Electromagnetics

Dr. Cardwell taught us how to use integral differential calculus in time changing 3D vector fields to solve Maxwell’s equations about every scenario a person can imagine. Including computing the capacitance and inductance

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of geometries, etc. It was the closest I will ever come to joining a Pythagorean secret society. I would love to go through this material again while instead using geometric algebra.

Sold State Devices

We studied Ben Streetman's book on the physics of semiconductor junctions and FET channels. Much of it had to do with the statistical distribution of quantum states, what happens at discontinuities between materials, and whether charges are mostly present in conduction or non-conduction bands.

University of Iowa

Differential Equations

This course picked up when the professor started talking about quantum mechanics. One of our major homework assignments is among my favorites. I wrote a 20 page walk through of solving the Schrodinger Equation for a particle in a box by using separation of variables and a generic polynomial series proposed solution.

Communications Theory

It was a surprisingly abstract and mathematical course. At its base it was about using carriers and modulation then demodulation for the transmission of messages. It included Shannon's information theory, the mathematics of modulation, the transfer functions of non-linear amplifiers, the relationship between messages and noise, and various codes such as the Huffman code and Hamming code. I probably had the only perfect final. I say *probably*, because when the professor told me he also said he had a few more to grade.

Materials Science

We learned about Miller indices and diffraction through crystal structures. We studied steel at the microscopic level and effects of alloying and quenching. We also discussed semiconductors. In the lab portion we tested the properties of metals by pressing divots with a Rockwell C hardness testing machine. We cycled metal strips until they broke. We made beams

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with various mixes of concrete, cured them under various conditions, and tested them for strength using a hydraulic press.

Thermal Dynamics

At first I was unsatisfied with this course because the old professor used standard units. In the first lecture he explained why g could not correctly be one. I have never used standard units in any formal course. However, the more time that has passed, the more incredible I realize his lectures were, apart from the first one. We began by defining the ideal gas model in Newtonian terms, and from that point used nothing more than mathematics to derive the rest of thermodynamics.

Earlier Courses Worth Mentioning

Electronics and Vocational Center

While in junior high I was invited to visit the high school before attending. The electronics teacher interviewed me, then asked me to teach his class that day. I repeated what I had read about how the silicon junction of a transistor worked. The teacher then arranged that for the next year that I would go to the Davenport Vocational Center some afternoons to study electronics instead of doing so at the high school. I obtained a technicians degree, though I was already working for Mast Keystone as a technician at age 15. I was their only technician who had to produce a permission letter from his parents to take the job.

FORTRAN

The school had a room with keypunch machines and teletypes. It was connected to an HP3000 via telephone and modem. There we wrote our FORTRAN programs. In the summer before my junior year I wrote FORTRAN for the Army Corp of Engineers as a summer intern.

Senior Year International Science Fair

I projected the Einstein special relativity transforms on to a sphere such that the speed of light became infinite. This curiosity worked its way up to International Science Fair, and resulted in an invite to observe a AAAS meeting.

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Junior Year Science Fair

Dave and I got ham licenses. I made a circuit that amplified demodulated signals at two neighboring frequencies and then ran them into an instrumentation amplifier on the theory it would cancel noise. Yes, and the signal also. I did not have a firm grasp of concepts such as bandwidth and noise. Being judged was a humbling experience.

Sophomore Science Fair

I explored the transfer characteristics of a single transistor at temperatures ranging from liquid nitrogen to flames. I still like this one. It was a clean device under test setup and the data was realiable.

Chemistry and Physics

I mention high school physics because Mr. Sweedy had done such a great job that I was able to pass out of the physics requirements at UT Austin. I mention Chemistry because Miss Sievert took us from Mendelev to Molecular Orbital bonding theory on the academic side, and by the end of our time in high school in the lab she had us synthesizing aspirin and identifying unknowns. There was also a phenomenal lower grade biology course that even included learning about such things as organelles and the Krebs cycle.

Iowa State Summer Program

I was invited to submit a research proposal to an Iowa State University program which brought high school students to the university for a summer. I arrived in Ames expecting to run the accepted proposal of doing Coulomb's charged plates experiment in a vacuum, but instead was given meaningless busy work. Out of boredom I started the experiment anyway while complaining of misrepresentation if I was not allowed to do it.

Then I was pulled into the program director's office, that of Lynn Glass. The man did not hide that he was upset. He wanted me to know in no uncertain terms why he was sending me home. He explained that I wasn't such a smart person to actually do the research in the proposal. He wanted to knock me down a rank or two so he went on to say that there did exist such truly smart people in the school system, much smarter than myself, and he gave as an example "a boy in the school system who had invented a

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calculus”. It seems he was not able to keep his own notes straight, because he was talking about me.

Infinitesimal Calculus

During junior high school analytic geometry course I came up with an infinitesimal calculus and applied it to solving area problems involving concentric circles. I had filled many notebooks of scratch work with this magic symbol that would be replaced with zero. It was a great exercise in operator precedence and algebra. The teacher, Mr. Tietje, gave me many nice complements over this. This type of calculus is different from what most people learn, but it was formalized by Abraham Robinson in the 1960s. I.e. it was correct. By the time I got to a real calculus course I had already derived some basic things such as the power rule and that the limit of 1/(1+x d)^n was exponential, so I found the derivations and proofs intuitive.

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