DIGITAL PHYSICS -- 6.895
TOPICS FOR TERM PAPERS

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GENERAL INFORMATION

Each student in 6.895 is to write a term paper on a topic related to the material covered in 6.895. After selecting a topic, you should give me a one page (or less) abstract of what you intend to write about for my approval. The abstracts should be in my hands by Tuesday, April 11, 1978. I would like many of you to be prepared to give an oral report to the class on the subject of your term paper prior to completing it. The term papers will be due on May 5, 1978. Some of the term papers will be reproduced and passed out to the class members, and will be the subject of classroom discussion. In order to cover as many topics as possible, I will only accept a limited number of papers on any one topic, on a first come first serve basis, so get the abstracts in early. You may select a topic from the list below, or you may think up your own topic, but I suggest that you check with me before going very far with an original subject.

CONSERVATIVE LOGIC PROOF

Prove the impossibility of constructing a circuit entirely of symmetric-majority-parity gates that exactly (except for timing) simulates the behavior of the conventional conservative logic gate.

TURING MACHINE

Show that one can construct a Turing machine out of conservative logic elements. The head must have no inputs or outputs other than what goes to or from the tape, and the tape must be an infinite structure (a kind of shift register) that does not generate any information other than what is on the tape.

A GP MACHINE

Show in detail how a conventional general purpose computer can be constructed of conservative logic. This design should minimize the excess storage requirements.

MEMORY-COMPUTATION TRADE-OFF

Using conservative logic as a model, write a scholarly paper on the problem of the relationship between the requirements of memory and computation. It seems that we can sometimes do a computation with a lot of memory and little computation (looking up the SIN of an angle in a table) or with a little memory and a lot of computation (using the circle algorithm to compute the SIN of an angle by iterating around the circle)

COMPLEXITY THEORY

Create a complexity theory (a la Kolmorgorov) about the complexity of some data, viewed as a

function of time, by considering the nature of the Conservative Logic circuits that can generate the data.

COMPUTATIONAL COMPLEXITY

Create a theory of computational complexity by looking at the attributes of conservative logic circuits that perform computations. Derive measures of the lower bound of the number of gates in a circuit by considering how the circuit must be able to permute the inputs in order to get the outputs. Give arguments about what the number of wires in the circuits mean.

THE CIRCLE ALGORITHM

Show that the circle algorithm is stable. Use statistical or probabilistic reasoning if necessary.

DIGITAL CLASSICAL PHYSICS

Write a definitive paper on the conversion of systems of differential equations to systems of difference equations that retain the reversibility of the original system. Pay particular attention to the question of initial conditions. Discuss why and when the time-reversed equations are symmetric.

THE DIRAC EQUATIONS

Do a complete job of deriving digital forms of the Dirac equations, as we have done for the Schrodinger equations. Discuss the Physics and Philosophy of what you have done.

UNCERTAINTY

Consider the volume of space needed for the digital representation of the momentum of a particle in digital physics. Connect such a measure to facts about the energy, position and velocity of the particle.

PHYSICAL CONSTANTS

Develop arguments based on the discussed concepts of digital physics that predict the two parameters of digital physics; the unit of length and the unit of time.

ENERGY AND INFORMATION

Show that energy and information are simply related. Find ways of calculating the the number of bits per joule.

SPEED OF LIGHT

Do a study on the relationship between the speed of light (the speed with which particles can move while carrying a great deal of momentum information) and the array speed of one unit of distance (the cell to cell distance) per unit of time.

DETERMINISM

Digital physics is deterministic, but we cannot use that determinism to calculate the future any faster than it will be calculated by "space". This is a kind of unkowable determinism. Write a paper on the determinism of digital physics.

ZENO

Write a scholarly paper on Zeno's paradoxes in the light of the concepts of Digital Physics.