Universal Computation and the Information Age:

How 240 years of philosophy and mathematical logic led to a thesis in 1936, whch led to all computer technology, and in turn is revolutionizing production and reorganizing social-economic life globally in the 21^{st} century.

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1 Description

"Universality[1]" and the entire age of programmable machine computation was born in the 1930's with the all-important Church-Turing thesis on universal computation, and the description of a Turing machine—the culmination of some 240 years of intellectual work. Starting from a viewpoint of the mutual interrelatedness of science, technology and social-economic life

[1] The Stanford Encyclopedia of Philosophy defines this property of modern computers as: "...the remarkable fact that anything that is computable can in fact be computed by one machine, a universal Turing machine." (See: `http://plato.stanford.edu/entries/turing/`) Unlike all previous calculational devices and unlike any complex machine, our *universal* computers of today are a special kind of 'machine' which can be internally reconfigured (re-programmed) to emulate any other possible calculational device, and do anything for which there is an "effective procedure", from physics differential equations to playing computer games.

(philosophical monism), this class examines the intellectual concept and history of universal computation *and* its social-organizing significance, which has become manifested as the Information Revolution.

The class will be divided into thirds:

1. First we trace the intellectual history of universality, primarily by looking at the work of philosophically inclined mathematicians interested not in computers, but in examining the validity of the foundations of mathematics. These include Leibnitz, Boole, Peano, Frege, Hilbert, Russel, Turing, Gödel and von Neumann. This includes the struggle to establish a system of logic which encompasses all valid instances of human inference (First Order Logic), studying the system's completeness and issues of the decidability of problems. This led to Turing's thesis on Universal Computation[2] and the maturing of the idea of an algorithm, one which is programmable and executable *on a machine.* Concepts of information *per se*, of its measurement, transformation and its dependence on physical systems, will also be covered briefly (*e.g.*, Maxwell's Demon in physics, Shannon's theory), and perhaps quantum universal computation (esp. Feynmann, Deutsch).

2. Secondly, we trace the history of the realization of ever more convenient, smaller and faster *physical* systems (machines) which were developed to actualize such a universal computer (using paper tapes, solenoids, vacuum tubes, magnetic systems, silicon semi-conductors, quantum q-bits, *etc.*), leading to the mid-20^{th}-century electronic revolution, and the struggle by the physicists, engineers, mathematician and computer scientists building these early machines to come to grips with the amazing consequences of the Church-Turing thesis, the ambiguous roles it assigns to hardware and software, *etc.*

3. Third, we make an overview of the social consequences of this monumental intellectual-technical project in what can be seen as Phases I & II of the Information Revolution involving,

   (a) Phase I. Social production—bringing the mass-production Fordist-Taylor industrial era to a close. How the reach of universality ex-

[2] "On Computable Numbers, with an Application to the *Entscheidungsproblem*," Alan Turing, 1936.

tended from scientific computation and digital control technologies to automation and robotization of production, smart machines, flexible manufacturing, nano-technology, self-assembly concepts and these technological concepts affected the characteristic social practise of "infomated work," executed by an emerging class of "information" or "knowledge" workers who perform computer-mediated work, largely freed from physical labor. The characteristics of these "smart machines" and of workers with highly transportable skills, are an intriguing echo of this thesis in mathematical logic—a situation which is not an accident, but a characteristic of the present age, and which is as yet not well understood.

(b) Phase II. The development of new electronic *networks* of production, commerce and personal life principally associated with the internet and world-wide web—a marriage of communication with distributed universal-computation machines (*i.e.*, micro computers).

We end by considering competing sociological theories regarding the potential created for employees in the new economy—at least for certain categories of employees—by universal computation manifest in societal form. We consider its potential to diminish the division of labor based on increased transportability of skills, and to increase employee prerogatives in the process of work as compared to the Taylorism of industrial society, its increased imperatives for formal and constant education (which democratizes employment in so far as education is democratized), and its elimination of physical pre-requisites for most classes of work, and with this, any rationalé for gender work distinctions, *etc.*

2 Reading list

This is In preparation and will be largely drawn from prevous courses:

- Part 1 from my course, "The Intellectual History of Information: 1680-2001" and my work on quantum computing;
- Parts 2 and 3 from "Steam Engines and Computers—From Industrial Proletarians to Information Workers" and my lectures on technolog-

ical history and social transformation given in "Social Dynamics of Medicine, Science and Technology" (STS 275). : "From Mid-Feudal Europe to the Information Revolution."

3 Requirements

This is a 300-level research seminar. The major requirement is a substantial (15-20 page) term paper, ideally with drafts that undergo a process of review leading up to a final version at the end of the course.

Students are expected to do the reading in a thorough manner, actively participate in class discussions and make e-mail submissions of brief summaries, questions or critiques of the readings before class. The instructor post these to a class-accessed web site as an aid to in-class discussions and student preparation.

There will be occasional in-class assignments where students would write a short commentary at the start of class to test for comprehension and insight.

The first third of the class will include conceptual outlines of some famous proofs and concepts from mathematics and symbolic logic which non-specialists will be able to follow, and which are necessary for understanding the *intellectual* history of universal computers.

4 Class prerequisites

There are no prerequisites. The class is open to juniors, seniors and interested graduate students, with sophomores by permission of instructor.