3/31/10

Guest Lecturer: Brian Arthur
- *External Professor, Santa Fe Institute and Intelligent Systems Lab, PARC*
- Wrote <u>The Nature of Technology</u> released in August to rave reviews.

Graduated 40 years ago from IEOR at Berkeley
Specialized in applied mathematics and optimization

Gives brief recollection about time at Berkeley and time under Dreyfus
- Recalls emphasis on solving problems by referring back to the basic theory and first principles

Doesn't focus on received literature

"The epistemology of technology is obviously at its beginnings" – Vincenti (Stanford Aero engineers)
- Arthur had lunch with him – posed question "Why do engineers not write about technology philosophy?"
- o Answer: "Engineers like questions they can solve."

Technology is like music - someone knows all the details, but it is difficult to answer the deeper question of "what is music?"

Motivation for writing – Compared to other areas, philsophy of technology is a scarce field

What is technology? Dictionaries don't help
Some questions about technology-
1. What exactly does technology *mean*?
2. What in its deepest *essence* is technology?
3. Can there be a *theory* of technology?
- o A systematic framework of technology that would teach us how to think about it
4. What is *innovation* (or invention) and how do these work? Most authors simply claim that there is a "creative act" and leave it at that

His quest was based on these 4 questions.

More questions about technology-
5. Does technology (the whole) evolve?
6. What is the relation between science and technology?
- o Much debate in this area - commonly believed that technology is inspired by science, but it has also been argued that science is inspired by technology
7. How does the economy form and reform from is technologies?
8. Is (post) modern technology different?

Although the field of technology is often studied by social scientists and historians,

Arthur sought to learn several technologies from the ground up (engineering detail) to study.

Claim: Karl Marx had insights about the intertwined nature of economy and technology

Poses the question of "is current technology different from what we had before?"

How do technologies come about?
- Clearly has a strong background in engineering technologies

Tried to gain a great understanding in a dozen technologies

Question: Question about the rhetoric of technology "evolving"
Answer: No answer

Standard Approach (From an economic perspective) to technology
- Doesn't define "technology" very well

Treats technologies as *en-bloc* entities (closed objects) and doesn't look inside them - makes it hard to see where they come from

Much of thought about technology has come from economists
- Historians are concerned with how history came into being

Social scientists have been interested in technology intuitively.
  o Q: Why?

A: much of the economy comes out of technology

Many Social Scientists treat technology as closed entities
- Don't examine how they came about or why

Don't take technologies apart

Engineers take technologies apart
- This thinking isn't done by philosophy

However, some historians do "open" the proverbial box

Three Definitions of Technology
   1. Technology (singular): a means to fulfill a purpose
        E.g. Turbojet, PCR
   2. Technology (plural): The large bodies of technologies
        E.g. electronics, biotech
   3. Technology (whole): The collective of technology
        E.g. "the wonders of technology"

Principles of technology
   1. Technologies are *constructed* objects (from components, assemblies, parts, stages)
2. Each *component* is a technology itself; technologies are recursive, but not perfectly

hierarchical
> 3. All technologies rely on some *phenomenon*, usually several

Dissects the jet engine in the book and finds all the technologies that comprise it
- Finds means to ends within phenomenon or sub technologies

Someone who is cooking up a new technology is much like the conductor in an Orchestra

Question: When you say each component is a technology, at what point does it stop being a technology?
Answer: Once you cannot break it down any more.   Technologies are finitely fractive.

Part 1: Does Technology Evolve? And if so, how?
- Two meanings to evolution
> 1. Something that changes and modifies itself over time
> 2. Everything of a certain class is descended from its predecessors

Brief history of Darwin and how Samuel Butler got into Darwin
- Butler wrote and essay "Darwin among the machines"
Called for theory of evolution for technology

George Basalla: The Evolution of Technology
- Uses Darwin's mechanisms - variation and selection of fitter designs
Applies to technological selection as well
How does one get something that is radically novel?

Darwin's mechanism doesn't work - radically new technologies don't come about from small changes
- Photo: 1960 Jet Engine

How precisely do novel technologies (species) originate?
- An observation: Technologies are constructed from existing technologies
Photo: Whittles Jet Engine
> o Short explanation of turbine principles
- Photo: Joseph Schumpeter
> o "Add as many mail-coaches as you like, you will never get a railway"

How a technology is structured
- Base concept or principle
E.g. Principle of a clock is to count the beats of some stable frequency
A base assembly - combination that achieves this principle
- Ancillary

The process of invention
- Distilled down it really is seeing a principle, and putting together the ways to make this work from functionalities that already exist… plus solving the sub-problems this

creates.
- Example: PCR multiplication

This is really problem solving
- Gary Starkweather and the laser printer
- Seeing the combination is easy

Achievement is solving the sub-problems
- Modulating the laser at 50MHz
- Scanning at several hundred lines a second

Invention isn't that mysterious
- Arise out of solving sub-problems
- Arise out of pre-existing technologies, because what else could they come from?

We are entering an era of-
- Everything being connected
- The ability to sense objects remotely -> automatically configuring technologies

The ability to react appropriately depending on what we sense ("intelligence")

Silent Economy: The unseen conversations between technologies; manipulations and calculations
- Example: Put in a card to get a boarding pass at the airport

Emergence of sensing by photonics, electronics
- "Conversations" are happening everywhere

Economy developed a muscular system in the 1900's, now it is developing a nervous system.
- Automatically configuring technologies
- Make assessments and give a proper reaction
- Epigenetic
- Use of proteins to control what gets expressed genetically.
- Very biological
- Post modern technology creates a set of objects that are self-monitoring, self-producing, self-configuring

Biology is revealing itself to be rather mechanistic and able to be understood
- Viewing the world as holistic
- Doesn't look from the top down, but looks at the pieces and how they come together
- This is bringing about a change and a new world view

Allowing into our view, a lack of perfection

Robert Johnson quote
- Initially we thought
  ◦ Power came from technology
  ◦ Clockwork universe was revealed and understood

Pure order thinking

- Now we accept
  - Unpredictability
  - Technologies that communicate with each other

We are growing up, by not looking for perfection

"We trust Nature but hope for Technology."

"We fear Technology is taking over but we hope for it.   h

The conversation is taking place quietly, through myths and stories like Star Wars.

Hope for the future is being placed in technology
- Longer life
- More food

Safer cities

Yet our trusts lie elsewhere

Is technology reducing us to a client?
- Star Wars
- Fear the unnatural, be drained of personality like the clones in star wars

Question: The notion of technology as biology sounds a lot like Artificial Intelligence.
Answer: Not saying that technology is artificially intelligent. Any system that can sense and reconfigure itself to react appropriately can be said to be intelligent. This doesn't mean it is cognitively intelligent. You can drop the word "intelligent" and say that many technologies are starting to show qualities of self-healing automatic reactions that correspond one to one with things you see in biology.