Philosophy 395 Computer Science 228 Symbolic Systems 210	**Lecture 5 — Digital State Machines**	Philosophy of AI Stanford University Winter Quarter, 1989–90

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> [digitality is] … a practical means to cope with the vagaries and vicissitudes, the noise and drift, of earthly existence.

- **Intro**
  a. Today: digitality
     a. Informal!
  a. Specifically, claim: **computer = digital state machine**
     a. Some immediate comments
        a. Predicate on processes (cf. fsm)
        a. non-intentional
     a. Will get back even later today to the interaction between digitality and semantics.
  a. Right off
     a. contrast with "analog".
     a. But "analog" should be a predicate on representation.
     a. NB: lewis's article: has to do with way in which things are implemented.
     a. So: keep "analog" out as an opposite.
     a. Stay with "digital" or "discrete".
  a. So: question is what it is to say of something that it is a digital.

- **Preliminaries (Haugeland)**
  a. Typically: digital system.
     a. Reason: things aren't digital or not; rather, regularities; ways they are treated.
     a. Puts paid the idea that whether digital or not is a matter of description. So is everything. Standard confusion (cf. Searle's epistemological vs. ontological).
  a. Idea: exact reproducibility, interchangeability, etc.
     a. Cf. Haugeland: characteristic properties:
        a. copyability: flawless copying
        a. complexity: composite
        a. medium-independence

        [⇒ resistance to buffeting]

    a. I think compositionality business is distracting, so set it aside (get back to it later)
    a. Point of Haugeland: better at properties digital systems have than at what the essence of digitality itself is.
a. More literally:
    a. set of types
    b. set of feasible proecdures for reading and writing tokens of these types
    c. specification of suitable operating conditions, such that
    d. under these conditions, procedures for read-write cycle are positive and reliable

    ⇒ But

    a′ Types is just standard ϕ of science
    b′ "reading" and "writing" are merely effective coupling
        — Cf. syntactic!
        — needs emphasis!
    c′ Yes, things happen in situ
    d′ So this is really it: **reliability**
a. But:
    a. Suppose a continuous (still intuitive) world, but in which things were exact!
    a. Could meet his criteria!
    a. So something odd going on

a. 1st conclusion: digitality is a way that the world sustains reliability.

    a. Think this is by far the most important fact.
    a. H defines digitality as reliability. Doesn't claim it. So leaves me hungry.

a. Discreteness

a. Intro to Goodman
    a. Project: arts, etc. (scores)
    a. Metaphysical stripe: nominalist
a. His approach: digitality
    a. Doesn't use the term much (until a late section).
    a. Talking intentional (will get back to that)
    a. Has five criteria «put on board»
        a. Syntactic (character indifference (reflexive, symmetric, & transitive)
            i. **disjoint** (no token of more than one type)
            ii. **finite differentiation** (can in principle determine which type it is of)
                — density destroys finite differentiation, but ¬dense doens't guarantee f.d.

- — NB: these criteria apply to composite (compound) types, as well as atomic.

b. Semantic
   i. **non-ambiguous** (at the level of types)
   ii. **disjoint** (no co-reference!)
      — these two together entail no redundancy
   iii. **finite differentiation**

a. Only first two immediately relevant.

a. Disjointness
   a. fundamentally: no "ambiguity" in the token-type relation
      a. Explain
   a. Us: talking at the level of properties anyway.
   a. Does this mean it is irrelevant? Not necessarily; against a background

a. 2nd conclusion: digitality is defined against a (larger, threatening) background of possibility

a. Finite differentiation
   a. Separateness (discontinuity)
      a.

   a. My reconstruction: in order for us to tell, has to be an effective route (via perception, measurement, etc.) into us, that keeps them separated.
   a. G. claims: separateness is necessary but not sufficient (unary case).
   a. But if they (reliably) did discriminable things, leading to a parting of the ways, would satisfy his criteria.

a. 3rd conclusion: need separationbecause otherwise uncontrollable influences will buffet it around.

a. Furthermore, this separation needn't be metaphysical (cf. voltages in a machine). Cf. Haugeland's "operating conditions". Can be maintained.

a. Further topics

a. Semantics

   a. In an intentional system, can apply the same criteria to the semantic domain.
   a. Note, however, that the effective separability isn't so clearly useful
      — since semantic connection isn't effective

a. So some examples:
    a. Fractions
    a. The calculus
    a. Second hand on the clock

a. Continuity in computation

    a. Semantics:
        a. Some counter-examples
            a. Real-values (so not notational systems) in G's sense.
            a. Context-dependence
        a. But these, strictly speaking, aren't the point.
        a. Real question is whether machine is digital
    a. Some examples of continuity
        a. VSLI (Carver Mead)
        a. Conclusion: notion of computation isn't inherently digital.
        a. Rather: computation proved useful because it was reliable.
        a. In cases where reliability doesn't matter (especially immediate cases), can go continuous!
        a. So notion is important, but not constitutive.
    a. More outré cases
        a. Real indices
        a. No theoretical problem.
        a. But how to implement. Symbolically!
        a. Does that mean the representation is at the level of abstraction (cf. data abstraction).
        a. No!
        a. Support for earliier conclusion

a. 4th conclusion: Current systems are digital because of reliability.

a. Second-order digitality (indefiniteness)
    a. Cf. H's second article
    a. Continuous but precise ⇐ definite
    a. Question: is it true that second-order digital is continuous?
    a. Problem: **notion of continuity is second-order digital!**
    a. …
a. ⇒ font change semantics, etc. Most exciting development in AI. Inarticulate, etc.

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- **General notes**
  - Compare and contrast Haugeland's & Goodman's notions of "digitality".
  - Haugeland's "second order digital"
  - Use "discrete" and "continuous" instead of "digital" and "analog"
  - Differentiate "precise" and "indefinite", noting how latter is more like Haugeland's second-order digital. But where does that leave precise–continuous, on his reconstruction?
  - Apply discrete to a representational system: can apply to any of:
    - syntactic domain
    - semantic domain
    - interpretation relation
  - Talk about clocks?
  - C&C: denseness vs. continuity (cf. Haugeland's claim that digital implies non-dense more than non-continuous).
  - Try to sort out Goodman's nominalism (i.e., epistemic vs. ontological discontinuity) ⇐ at appropriate "level of analysis"
  - NB: on common construals, neither mutually exclusive nor exhaustive.
  - Note non-intentional nature of basic intuition (will come back next time to merge of digital and intentional characterisations)
  - Make obvious point about how "analog" should be a predicate on representation (intentionality). So use "continuous" and "discrete".
  - Get to: indefiniteness = second-order continuity? All the way up!
  - Use examples of the calculus: syntactically discrete, semantically continuous.

- **Specifically computational issues**
  - Effective computability
    a) Can an "analog" computer compute something that a digital machine cannot (falsifying Turing's thesis)?
    b) Can an "analog" computer compute something efficiently that a digital machine cannot (falsifying Turing's thesis)?
  - Analog computers: spaghetti-sorting machine

- **Possible exam questions**
  - Describe whether an "analog" clock is analog or digital (in the various terms used in class), with respect to both (effective) operations and (non-effective) interpretation (though of course the act of interpretation requires effective access to it).

— Discuss Dewdney's spaghetti-sorting machine, in terms of the various notions of digitality and continuity (developed in class? distinguished in the papers? formulated in the prior question?)

Notes on Readings

- **Notes on Goodman**
  - — Fundamental notion is that of **definite differentiation**
    - — can be absolutely discriminated, in spite of our inability to make indefinitely precise measurements.
  - — Analog (continuous) representation is dense.
  - — double requirement (of notational systems)
    - — complete determinacy sign ⇒ symbol
    - — complete determinacy symbol ⇒ sign
  - — distinguishes notational scheme from notational system
  - — distingiushing properties
    a. Syntactic (character indifference (reflexive, symmetric, & transitive)
       i. **disjoint** (no token of more than one type)
       ii. **finite differentiation** (can in principle determine which type it is of)
         - — density destroys finite differentiation, but ¬dense doens't guarantee f.d.
         - — NB: these criteria apply to composite (compound) types, as well as atomic.

    b. Semantic
       i. **non-ambiguous** (at the level of types)
       ii. **disjoint** (no co-reference!)
         - — these two together entail no redundancy

       iii. **finite differentiation**

  ⇒ Disjointness is kind of like non-ambiguity for the object-type relation, rather than for the syntactic-semantic type relation.

  ⇒ Differentiation is a pseudo-epistemic cast of the notion of digitality

- **Notes on Lewis's "Analog and Digital"**
  - — Clearly has a different notion of analog than Goodman: has to do with the direct representation in virtue of a physical property.
    - — X,Y,Z,W multiplier, and variable resistor (pot): both differentiated and non-dense.
    - — analog: representation of numbers by physical magnitudes

    [⇒ neither continuous nor analogical (simulacrum)]
  - — … unidigital magnitudes

— digital: differentiated multidigital magnitudes

- **Notes on Haugeland**
  - **Digital**

    — Characteristic properties:
      — copyability: flawless copying
      — complexity: composite
      — medium-independence
      [⇒ resistance to buffeting]
    — Other
      — Goes on to talk about
        — reading & writing
        — tokens of various types
      ⇒ These are both gratuitous:
        — "reading" and "writing" mean no more than that they participate in various effective actions.
        — token/type talk is merely because scientific regularities occur at the level of properties (a big notion)
    — positive procedures: somthing that can succeed (value-judgment!) with absolute, unqualified precision.
      ⇒ Value–loaded characterisation
    — detail
      — Haugeland: digital device is:
        a. set of types
        b. set of feasible proecdures for reading and writing tokens of these types
        c. specification fo suitable operating conditions, such that
        d. under these conditions, procedures for read-write cycle are positive and reliable
      ⇒ But
        a′ Types is just standard ϕ of science
        b′ "reading" and "writing" are merely effective coupling
        c′ Yes, things happen in situ
        d′ So this is really it
      — Conclusion is that Goodman has more to say that Haugeland.

  - **Analog**

    — Characteristic properties
      a. Smoothness — continuity

b. Sensitivity — every difference makes a difference
c. Dimensionality — only certain "dimensions" of variation are relevant

⇒ Surely, what is discrete are the regularities, not the things, so this packs into a single claim of continuity.
— Placing it on the regularity doesn't make it back into "analog", however — since it is the effective regularities!

— Haugeland claims that his notion of **approximation** is better than Goodman's continuity (which requires a notion of between — inapplicable, e.g. to pictures).
⇒ really mean something like invulnerability to small influences.

— H's "second order digital", he claims, is necessary for digital simulation. Not clear to me that these are related.

——end of file ——