Understanding the Complexity of Design

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Introduction

This is almost a purely algorithmic approach which is often applied on computer science.

Real Complexity

A measure of uncertainty in achieving the specified functional requirements.

Imaginary Complexity

The uncertainty associated with a designer's lack of knowledge.

Underlying Assumption

"The more coupled the design problem, the more complex it is."

- Look for interaction among design variables and targets.
- May be modelled by a series of linear equations where distance of the coefficients from the diagonal is an indicator of complexity.

Targeted Approaches to Complexity in Design

Measuring Artifact Complexity

Measuring the complexity of engineering artifacts may serve as a surrogate for problem or solution complexity.

In the case where a standard framework (or system) is used, artifact complexity can be gauged based on the effort required to document it.

Formalism

In any apparently predictive formalism the application of certain larger contexts generated impredicativities that the original formalism cannot handle.

Classic Example

This statement is false.

"If the statement is true, then it is not false, but if it is not false, then it must be true, but it cannot be true because it says it is false, but if that is true, then it *is* false, but, but, but. . . *ad infinitum*."

Rosen's Approach

Implications for Technology and Design

The Human Factor

"In design, the semantic, non-rational, non-algorithmic, impredicative, subjective, and unpredictable nature of humanity is inescapable, because artifacts are always designed for human use, usually designed by humans themselves, and situated within a larger context of a complex world economy."

In the author's view it is not surprising that design based on a Newtonian perspective have failed to achieve sufficient maturity. The suggested alternative is to assume that design is complex.

The emergence of the science of complexity is largely credited to these realizations:

1. many interesting and unsolved problems are complex in nature,
2. complexity spans a wide variety of problem domains, and
3. complexity itself is an area worth studying.

Complex System

A large group of strongly interacting parts exhibiting nonlinear dynamical behavior.

May be classified as non-adaptive or adaptive.

Complex systems seem to operate in the following cycle:

1. coarse graining of information from the real world
2. identification of perceived regularities
3. compression into a schema
4. variation of schema
5. use of the schema
6. selection pressures affecting competition

The definition presented seems to indicate that complex adaptive systems violate the law of entropy. However, it is pointed out that CAS are open systems, exchanging energy with their environment. And some energy is used to change their internal state. Lastly it is pointed out that entropy only applies to closed systems, which resolves the apparent contradiction. CAS can often decrease entropy.

This model encompasses the three major subsystems of a *design system*,

1. the designer(s) of the artifact,
2. the artifact(s) being designed, and
3. the user(s) of the artifact.

- DAU system is situated in a larger environment
- Each subsystem (D-A-U) may not be singular

The authors establish the basis for accepting DAU as a complex adaptive system by considering each phase of the CAS cycle as it applies to DAU.

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Coarse Graining Of Information from the Real World

Characterization

1. In a DAU system, this is the problem definition stage of design.
2. It involves obtaining information from the real world.
3. It requires the designer and user subsystems to interact with the environment.

Problems

1. **DAU:** Trade off between coarseness and fitness.
2. **Design:** Trade off between spending time to understand the problem and delaying time to market.

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Identification Of Perceived Regularities

Characterization

1. Further refinement of the understanding of the problem
2. May result in requirements with associated constraints, criteria, and goals.
3. Primarily requires the designer and the users.

Problems

1. **CAS:** May mistake regularity for randomness.
2. **Design:** Difficulty in interpreting user and other data that describes the problem.

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Compression Into Schema

Characterization

1. Equivalent to the conceptual design phase in a DAU system.
2. Scope is narrowed in order to arrive at a solution space.
3. Results in a full system solution.
4. Involves the designer and artifact subsystems.

Problems

1. **CAS:** Difficulty estimating the continual evolution of the system.
2. **Design:** Marketplace often moves quickly.
3. **CAS:** Trade off between compression and time & computation.
4. **Design:** Trade off between the number of solution concepts and time & money.

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Variation of Schema

Characterization

1. Designer improves, tests, and refines the concept.
2. May require iteration of earlier phases.
3. Equivalent to the variation of schemata phase in CAS.
4. Primarily involves the designer and artifact subsystems.

Problems

1. **CAS:** Progress may be slow and methodical.
2. **Design:** Unsure how to engineer revolutionary or disruptive change.

Characterization

1. The artifact is released onto the marker.
2. May include a manufacturing process.
3. Primarily involves the artifact and the user subsystems.

Problems

1. **CAS:** Difficulty incorporating new data.
2. **Design:** Difficulty designing for the real world.

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Selection Pressure and Competition

Characterization

1. Free market forces at work.
2. Involves designers, artifacts, and users.

Problems

1. **CAS:** "Fitness is an elusive concept."
2. **Design:** Difficulty optimizing for constant change and imperfect environments.
3. **CAS:** Poorly adapted schemas due to mismatched time scales.
4. **Design:** Rapid or unanticipated market changes cause product failure.

Properties of Affordances

Relational Questions and Answers

Three questions to be answered:

- What is the nature of the relationship between users and artifacts? What determines how an artifact may be used?
- What is the nature of the relationship between designers and artifacts? Designers create the affordances of the artifacts.
- What is the nature of the relationship between designers and users? Users inform designers of desired uses.

Affordances

"The affordances of the environment are what it offers the [user], what it provides or furnishes, either for good or ill."

Properties of Affordances

Relational vs. Transformative Nature of Functions

Transformative Paradigm

This is a highly algorithmic (tidy) environment which is often referred to at the standard mechanistic paradigm for design.

Relational Paradigm

This is characterized by a high degree of coupling among designers, artifacts, and users.

Which idea is more critical hinges on the importance of interactions among designers, artifacts, and users.

1. When interactions are important, a relational affordance based paradigm is indicated.
2. When interactions are less important, a transformative (or mechanistic) based paradigm is indicated.

Summary

Due to its tightly coupled relational character, the concept of affordances more appropriately supports complexity in design than the transformative (mechanistic) paradigm.

Affordances are a powerful tool to help understand the design process.

Questions?