State Space Paradox of Computational Research in Creativity

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Outline

1. Computational Research in Creativity
2. Computational Assistance in Creativity
3. The Paradox of Creativity Research
4. Conclusion and Future Directions
5. References

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Retrospection

Computational Research in Creativity

I. SMI (Sudden Mental Impulse)

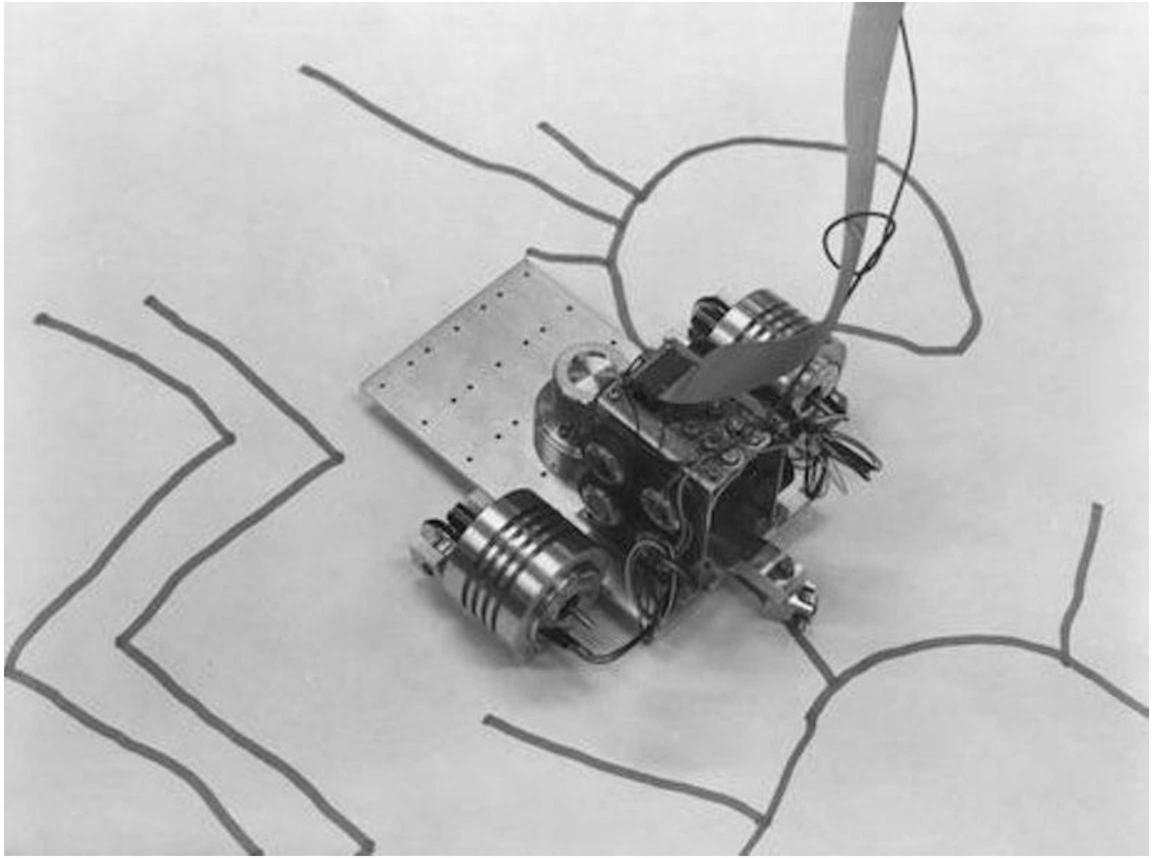
“**Sudden onset of a realization** that makes the solution of a very difficult problem / the creation of a remarkable possible result”

II. Computational Perspective

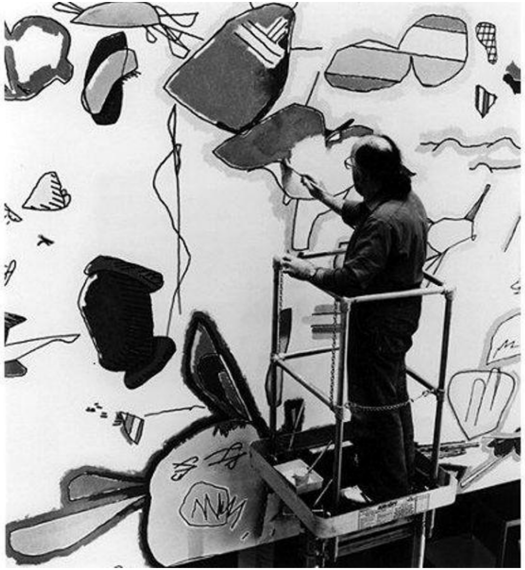
Examples

+ Harold Cohen and “Aaron”
+ Eve Sussman and “Serendipity Machine”
+ “Darcy” the artwork judge

Alan Turing and Turing Test



AARON
The 1979 exhibition, Drawings, at SFMOMA, featured this “turtle” robot creating drawings in the gallery. Collection of the Computer History Museum, 102627449.

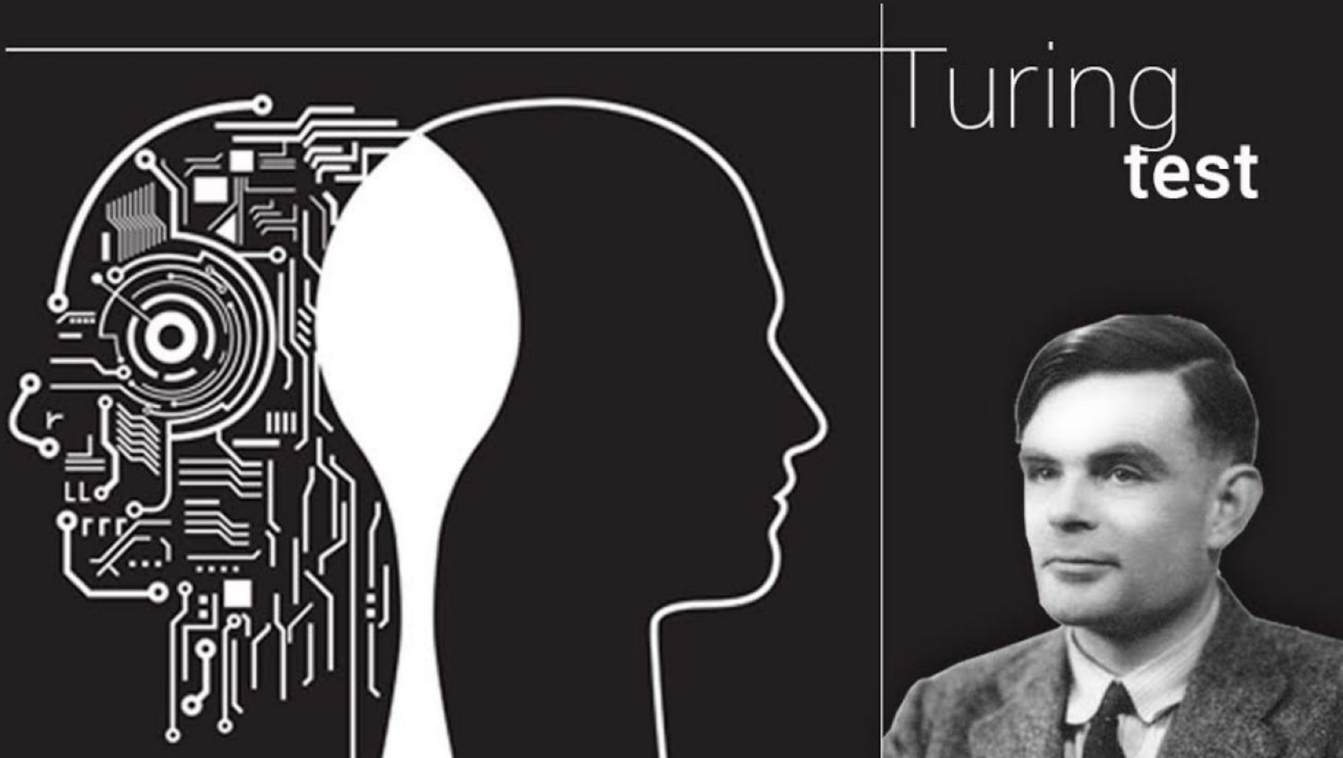


AARON and Harold Cohen
Harold Cohen coloring the forms produced by the AARON drawing “Turtle” at the Computer Museum, Boston, MA, ca. 1982. Collection of the Computer History Museum, 102627459.

AARON
AARON image created at the Computer Museum, Boston, MA, 1995. With color rules implemented urged by Edward Feigenbaum.

“We have many digital emulators of human activities but lack the litmus test for what is sufficiently creative, or intelligent.”

Up to now, Turing test is the best thing that ever comes up, but it still has its limitations.



2
Theoretical Background & Open-Ended Issues
Computational Assistance in Creativity

Procedural Approach

Rule based expert systems

Case based reasoning systems

Complex generative algorithms

+ Genetic
+ Annealing
+ Neural Nets

Representational Approach

Shape emergence

Object based representation

Complex recognition systems

+ Data mining
+ Petri Nets

Computer based research on creativity (A and B) vs. Digital system models of creativity (A or B)

Procedural Approach
A

Rule based expert systems

Case based reasoning systems

Complex generative algorithms
+ Genetic
+ Annealing
+ Neural Nets

Representational Approach
B

Shape emergence

Object based representation

Complex recognition systems

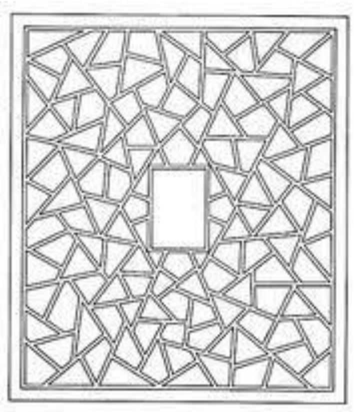
+ Data mining
+ Petri Nets

I. Procedural Approach

+ While representation is important, procedural approaches are built in order to approach machine intelligence.
+ Representation merely aims to facilitate the procedural objectives.

Procedural Systems		
	Procedural Schema	Representation Schema
Rule-based Systems	apply rewrite rules that have their left-hand side match problem representation	problem parameters-variables; rewrite rules; strategy for rule application
Genetic Algorithms	use meta-rules to mutate rewrite rules; generate solutions	problem parameter variables; rewrite rules; rule application strategy; rule mutation mechanism
Case-based Systems	match case; retrieve case; adapt case	case representation; case-base

Table 1
Procedural Systems for Design Creativity



Ice-Ray Windows by George Stiny
Rule based representation, shape grammar

I. Representational Approach

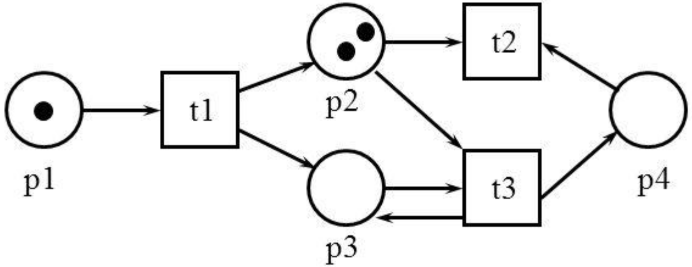
+ Shape grammar
+ More complex representations. (e.g. Early schema based linguistic representations, etc.)
+ Petri-Nets
+ Data mining

Representational Systems		
	Representation Schema	Procedural Schema
Shape Emergence and Grammars	geometric primitives; maximal shapes	combinatorial enumeration
Cognitive Schema	object based representation of functional, behavioral and physical characteristics	formal reasoning; heuristic reasoning
Recognition Algorithms – Data Mining, Petri-Nets	large data bases; process models	pattern recognition; heuristic search; abstraction

Table 1
Representational Systems for Design Creativity

The classical Petri net model

A **Petri net** is a network composed of **places** (○) and **transitions** (□).



- **Connections,** called **arcs,** are directed and between a place and a transition.
- **Tokens** (•) are the dynamic objects.
- The **state** of a Petri net, called **marking**, is determined by the distribution of tokens over the places.
    - **Initial marking** (1, 2, 0, 0)

Petri-Nets

A network composed of places and transitions.

3
Implication of theory, policy and practice
The Paradox of Creativity Research

I. The State Space of Creativity

+ All digital systems of creativity exist within **an implicit or explicit state space.**
+ “The state space represents any finite slice of time in the digital system’s functionality through *entities*, *operations*, *goals*, *heuristics*, and *predicates* that apply to moment in time.”
+ Model process of creativity in discrete terms.

Static & known
state space specifics

↓

Computation

↓

Determined outcomes

Goal

+ Determine if a given object is creative (Darcy)
+ Create an object that emulate creative features (Aaron)

Closed systems: digital applications
Input parameters and possible outcomes are predefined.

Evolving
state space

↓

Adaptation to circumstances

↓

Permutation

Varying Factors at Will

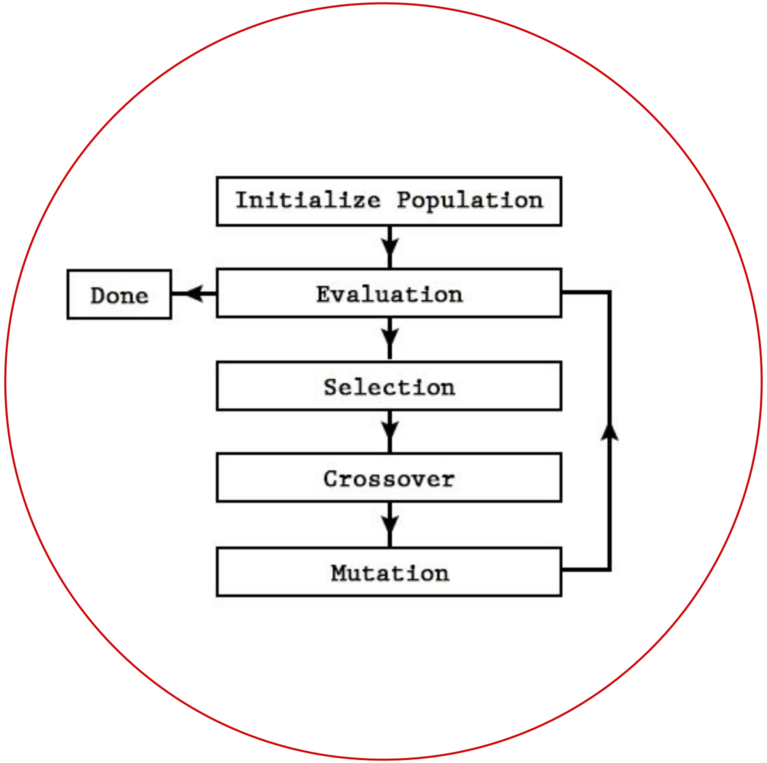
- \+ Modified initial states
- \+ Modified methods of operation
- \+ Modified scope of acceptable solutions

Open systems: human agents

The permutations are as endless as concepts carried in one's head

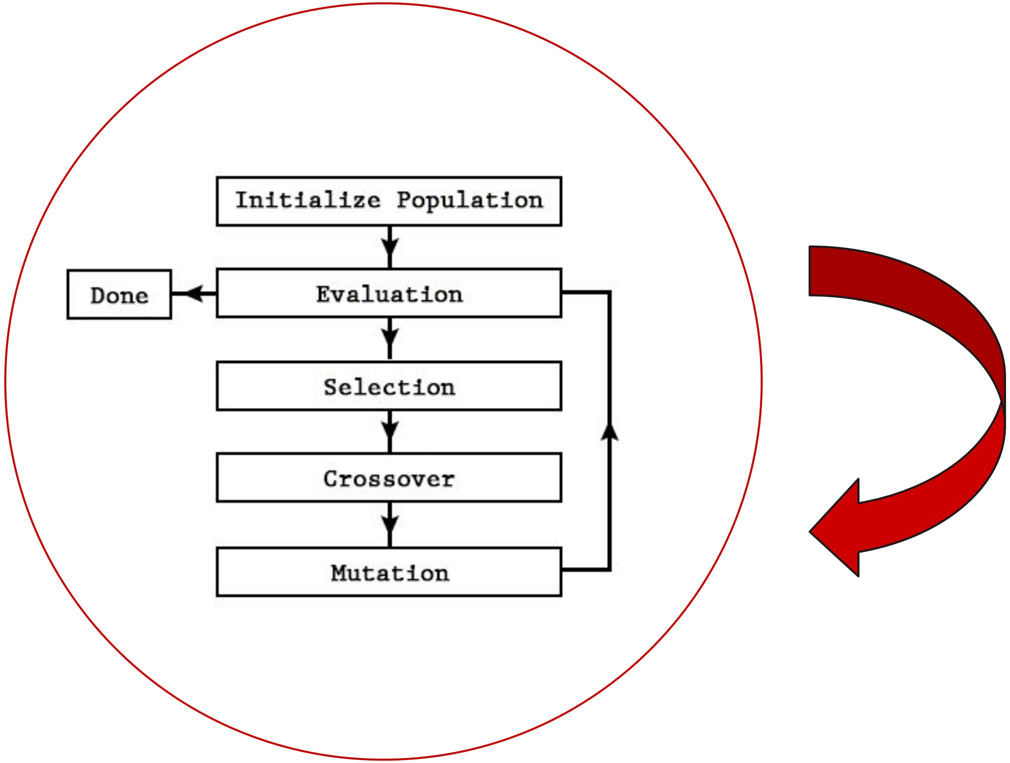
II. State Space Paradox (SSP)

+ Emulate open system’s behaviour
+ Example: genetic algorithm and its enhancement



Bounded by the range and complexity of symbol strings

Genetic Algorithm
Produce transformation on given genotypes



Another algorithm add permutation to symbol string

Enhanced Version Genetic Algorithm
Makes the outcome less predictable

II. State Space Paradox (SSP)

+ Emulate open system's behaviour
+ Example: genetic algorithm and its enhancement

This approach simply embeds one closed system (i.e. permutation of the genotypes) **inside another one** (i.e. generation of designs based on the genotypes)**!**

II. State Space Paradox (SSP)

+ SSP arises when attempts to replicate some aspects of creative behaviours by means of automated / computational closed systems.
+ **A closed system, in order to be creative, must redefine its own state space**

II. State Space Paradox (SSP)

Eg. Newell and Simon define a state space representation of *search* as

$$S_i = \{ I_i , C_i , T_i \}$$

I_i - *Initial state*

C_i - *Conditions on transitions from one state to the next*

T_i - *Terminal state*

II. State Space Paradox (SSP)

Eg. A creative computer system in Rosenman’s

$$S_i=\{ I_i, C_i, T_i\}$$

Define new S_j

Modify original S_i

$$S_j=\{ I_j, C_j, T_j\}$$

$$S_{i'}=\{ I_{i'}, C_{i'}, T_{i'}$$

II. State Space Paradox (SSP)

In either case, the new space is generated by the closed computer system which can only be achieved by applying C_i (the only operator set) to I_i or its descendants generated by earlier applications of C_i

$$\{I_j, C_j, T_j\} \subseteq S_i \qquad \{I_{i''}, C_{i''}, T_{i''}\} \subseteq S_i$$

$$S_j \subseteq S_i \qquad S_{i''} \subseteq S_i$$

III. Consequences of SSP

Inherent constraint of computer systems

+ Tautologically, computer systems are incapable of exhibiting the creativity we see in open systems.
+ Still, digital creativity applications can and will possibly invoke SMI response in human observer.
+ They are incapable of breaking out their state space boundaries.

III. Consequences of SSP

Rare nature of creativity

+ Creativity is sought after because they are scarce, a rare human act.
+ If there’s overabundance of creativity acts, we would no longer call them creative.

III. Consequences of SSP

Combining the two reasonings above, we get

+ If we were able to automate the creation of creativity, we would have an overabundance of so called creative objects.
+ Creativity is not absolute. It’s influenced by cultural context, time, space, etc. Attaining it through well-defined / rational means will inevitably run into SSP.

4

Conclusion and Future Directions

5

References

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Thank you!