Formalization of creativity as search

Wiggins (2006)
Two useful abstractions (1/2)

Three types of creativity (Boden 1992)

(Recap from an earlier lecture)
1. Combinational: new combinations of familiar ideas
2. Exploratory: generation of new ideas by exploration of a space of concepts
3. Transformational: involves a transformation of the search space so new kinds of ideas can be generated

Q: How do their inputs differ? (How do the differences in input reflect what is done?)

– These can all be described as search!
Two useful abstractions (2/2)

- Separation of
  - specification (U, R, T, E)
  - “implementation” (\([.]\), \(<<.>>\))

- Allows one to
  - discuss “what” without going to details
  - change the specification at runtime
    - transformational/meta-creativity
Creativity as search


- A conceptual framework for talking about creative systems and their properties
- Views creativity as search (cf. search in AI)
- Looks like an architecture but is not intended to be used as one

- In this tutorial, a simplified version will be presented
Components of the framework

- Universe U contains all possible concepts
- Rules R define the acceptable conceptual space
- Evaluation function E assigns a value to a concept
- Method $T_{R,E}$ for searching U with respect to R and E
Components of the framework

- Universe $U$ contains all possible concepts
  - E.g., all possible sequences of words
- Rules $R$ define the acceptable conceptual space
  - E.g., those sequences that match a given meter
- Evaluation function $E$ assigns a value to a concept
  - E.g., does the text express the desired emotion
- Method $T_{R,E}$ for searching $U$ w.r.t. $R$ and $E$
  - E.g., produce poems using a generative grammar and expressions reflecting the desired emotion
U, R, T, E are system-specific

Recall this problem with four lines connecting the dots.

What was your

• Universe U?

• Rules/acceptable search space R?

• Evaluation function E?

• Traversal (search) method T?
Data mining tasks in computational creativity

– Mine, learn, or model:
  – the universe $U$ and/or rules $R$ for acceptable cases from existing examples
  – the evaluation function $E$ from recognized examples or from the user,
  – methods $T$ that leverage existing examples and their properties
  – changes to any of the above from experience and from interaction with others (cf. transformational creativity and social creativity)
Creativity as Search vs. Boden’s Three Types of Creativity

– Recall Boden’s three types of creativity
  – Combinatorial (combining old ideas to new ones)
  – Exploratory (generating new ideas within rules)
  – Transformational (also changing the rules)
– Wiggins’ model looks like exploratory search
  – A space defined by U, R and E explored by T
– However, Wiggins’ model is generic and allows U, R, E and T to be defined in various ways
  – E.g., T can be based on recombinations of existing ideas (leading to combinatorial creativity)
Higher Levels of Creativity – Transformational Creativity

Wiggins (2006)
Creativity as search: metalevel

Wiggins introduces the following additional notation:
- A language $L$, in which $R$, $E$, $T$ are expressed
  - $R \in L$, $E \in L$, $T \in L$
- An interpreter $⟦ ⟧$ for rules $R$
  - $⟦R⟧(c)$ evaluates $c \in U$ using $R$
- An interpreter $⟪ ⟪$ for search method $T$
  - $⟪R,T,E⟫(c_{in})$ produces $c_{out}$, concepts to traverse next

- This allows rules $R$ and search method $T$ (and evaluation function $E$) to be modified during runtime
  $\rightarrow$ Boden’s *transformational creativity*
Consider the transformational case where rules $R$ are modified in the creative process.

Formulate Wiggins’ model to search for artefacts and rules:

- E.g. in poetry: *at the same time*,
  1. select a set of poetic features (meter, number of syllables and lines, alliteration, rhyme pattern, …)
  2. generate a matching text

Metauniverse

\[ U_L = \{(R, c) \mid R \text{ is a possible rule set, } c \in U\} \]
Transformational Creativity as Metasearch

- $R_L$: metarules about valid $(R, c)$ pairs
- $E_L$: evaluation of $(R, c)$ pairs
- $T_L$: search method for $(R, c)$ pairs

- **Exploratory search w.r.t. $U_L$, $R_L$, $E_L$, and $T_L$ is transformational creativity**

- In more general, allow modification of $E$ and $T$, too, and search for tuples $(R, E, T, c)$
Formulation of Metasearch

– “Normal” search is defined by tuple
  \[ \langle U, L, [ ], \langle \rangle, R, T, E \rangle \]

– Metasearch:
  – The universe consists of all possible R, T, E, i.e., of expressions in L, i.e., \( U_L = L \)
  – A metalanguage \( L_L \) is needed to talk about L

– Metasearch is thus defined by tuple
  \[ \langle L, L_L, [ ], \langle \rangle, R_L, T_L, E_L \rangle \]
Notations by Wiggins

Misc. notation/a reading guide

– $F^n(X) = F(...(F(X)))$
  i.e., $F$ applied recursively $n$ times

– $F\diamond (X) = \text{union of all recursive applications, i.e., all that can be obtained from } X \text{ by } F$

– $\langle R,T,E \rangle \diamond \{\top\} = \text{everything that } T_{R,E} \text{ can reach in universe } U$

– $\llbracket E \rrbracket (\langle R,T,E \rangle \diamond \{\top\}) = \text{everything of value that } T_{R,E} \text{ can reach}$
Possible Properties of Creative Agents

- “Generative uninspiration”: $T_{R,E}$ does not reach anything valuable
  - $\llbracket E \rrbracket(\llbracket R, T, E \rrbracket \Diamond \{\top\}) = \emptyset$
- A milder form: a lot of (highly) valued concepts cannot be reached by $T_{R,E}$
  - $\llbracket E \rrbracket(\llbracket R \rrbracket(U) \setminus \llbracket R, T, E \rrbracket \Diamond \{\top\})$ is significant
- Transformation of $T$ is required
- Help from outside is needed, e.g., valued concepts
  - Learning, social aspects!
Possible Properties of Creative Agents

– “Aberration”: $T_{R,E}$ reaches concepts outside $R$
  – $A = B = \langle R,T,E \rangle \diamond (\{ \top \}) \setminus [R](U) \neq \emptyset$
  – (Wiggins refers to this set first as $B$, later as $A$)

– “Pointless aberration”: the extra concepts are not valued
  – $V = [E](B) = \emptyset$
  – Need to transform $T$ to avoid the useless search
Possible Properties of Creative agents

- “Productive aberration”: $T_{R,E}$ reaches some valued concepts outside $R$
  - $V = \llbracket E \rrbracket(B) \neq \emptyset$
  - Transform $R$ to include the valued concepts?
  - (Possibly transform $T$ to exclude unvalued ones)