Transformational creativity, metacreativity

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Three types of creativity (Boden 1992)

1. *Combinational*: new combinations of familiar ideas
   - *input*: ideas; *output*: variations of ideas in the input

2. *Exploratory*: generation of new ideas by exploration of a space of concepts
   - *input*: a search space; *output*: points in the space

3. *Transformational*: involves a transformation of the search space so new kinds of ideas can be generated
   - *input*: a search space; *output*: points in a modifies space
“The difference between greater and lesser creativity lies not in how you solve problems, but rather in what problems you choose to solve.”

- Getzels and Csikszentmihalyi

- What is the programmer’s influence on what a creative program creates?
Creative Autonomy
1. **Autonomous Evaluation:**
   The system can evaluate its liking of a creation without seeking opinions from an outside source.
   
   - Any opinion is formed by the system itself
   - However, it may consult others at other times
   - Examples: preprogrammed evaluation, evaluation function learned from the user
Criteria for Creative Autonomy
(2/3)

2. Autonomous Change:
The system initiates and guides changes to its standards without being explicitly directed when and how to do so.

- External event and evaluations may prompt and guide changes
- The system decides when and how to change them
- The system decides if new standards are acceptable
- Fixed or learned evaluation functions can be used to bootstrap the process
3. **Non-Randomness:**
   The system’s evaluations and standard changes are not purely random.
   - The two first criteria could be easily met by random decisions
   - Not all randomness is excluded, however
Autonomy Requires Social Interaction

- What influences can a creative system experience to modify its standards?
- Introspection?
  - Cf. “uninspiration” and “aberration” in the search model of Wiggins
- Social interaction!
  - New influences, ideas, feedback
  - An apparent paradox: a system can only be autonomous if it is social
  - Think of the opposite: a system that is not influenced by external information can be argued to only express the programmer’s creativity
Transformational Creativity vs. Creativity As Search
Recap: Wiggins’ Model of Creativity as Search

- 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
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 \( \llbracket \cdot \rrbracket \) for rules R
  - \( \llbracket R \rrbracket(c) \) evaluates \( c \in U \) using R
- An interpreter \( \langle \cdot \rangle \) for search method T
  - \( \langle R, T, E \rangle(c_{in}) \) 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*
Transformational Creativity as Metasearch

- 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
  \( \langle L, L_L, [ ], \langle \rangle, R_L, T_L, E_L \rangle \)
Misc. notation/a reading guide

- \(F^n(X) = F(...(F(X)))\)
  i.e., \(F\) applied recursively \(n\) times

- \(F\diamond(X)\) = union of all recursive applications, i.e., all that can be obtained from \(X\) by \(F\)

- \(\langle R,T,E\rangle\diamond\{\top\}\) = everything that \(T_{R,E}\) can reach in universe \(U\)

- \(\langle E\rangle(\langle R,T,E\rangle\diamond\{\top\})\) = everything of value that \(T_{R,E}\) 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 \( T_{R,E} \)
  - \( \llbracket E \rrbracket(\llbracket [R](U) \rrbracket \setminus \llbracket R,T,E \rrbracket \Diamond \{\top\}) \) 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 \( R \)
  - \( A = B = \langle R, T, E \rangle \diamond \{\top\} \setminus \llbracket R \rrbracket(\underline{U}) \neq \emptyset \)
  - (Wiggins refers to this set first as \( B \), later as \( A \))

- **Pointless aberration:**
  the extra concepts are not valued
  - \( V = \llbracket E \rrbracket(\underline{B}) = \emptyset \)
  - Need to transform \( T \) to avoid the useless search
Possible Properties of Creative agents

– **Productive aberration:**
  \( T_{R,E} \) reaches some valued concepts outside \( R \)
  – \( V = [E](B) \neq \emptyset \)
  – Transform \( R \) to include the valued concepts?
  – (Possibly transform \( T \) to exclude unvalued ones)
Metacreativity vs Transformational Creativity
Transformational creativity ≈ something important is changed, leading to different creations

- Creative autonomy: goals are modified
- Creativity as search: rules R, search T (or evaluation E) is modified

- What could be the components of such systems?
  - (Ventura (2017) focuses on information, not sw)

- Who carries out the modifications?
  - Need for metalevel components
Self-awareness in Metacreative Systems

(Linkola et al, 2017)
Self-awareness as a Creative Trait

– Metacreativity = ability to reflect on and modify creative process
  – allows a creative system to evolve, and eventually to create artifacts outside the control of the programmer

– Self-awareness = ability to be the target of one’s own attention

– A self-aware creative system can be metacreative wrt itself
  – (In this course, “metacreative” means being creative about one’s own creativity)
Self-reflection and self-control

Self-awareness consists of two complementary components

– *Self-reflection*: ability to monitor and analyze one’s own behavior

– *Self-control*: ability to adjust or modify own behavior

In adaptive software architectures this is often refined as “MAPE” (Kephart & Chess, 2003):

– Monitor, Analyze, Plan, Execute

In this lecture, we refine based on *what* is reflected on and controlled.
Four Concrete Aspects of Creative Self-awareness

Generator Manager  Generator Manager  Interaction Manager

Goal

Generator  Artifact  Interaction

Two more aspects: time and meta-self-awareness
Different Aspects of Creative Self-awareness

What can creative systems be self-aware of?
- Artifacts
- Generator
- Goal(s)
- Interaction
- Time
- It’s own mechanisms for self-awareness
Artifact-awareness

- Awareness of what one produces
- Can one be creative without being aware of one’s own products?
- Being able to monitor/observe/measure one’s own output allows self-control, i.e., metacreativity
  - Modify your behavior to change what you produce
- A key capability in CC
  - cf. Wiggins, Ventura, Jennings, …
- Which component is artifact-aware, or the manager of artifacts? Typically the generator.
Generator-awareness

– Awareness of the component/models/processes that produce artifacts
– Control of the generator allows to change how and what is produced
– Simple cases for control: adjusting parameters of the generator, or changing training corpus
Goal-awareness

- Awareness of what one wants to produce
- Having explicitly represented goals allows to
  - measure artifacts against the goal
  - reason about the goals
  - modify the goals (cf. creative autonomy)
    - affect what is generated (to satisfy the goals)
- (Just a black box evaluation function does not count as goal-awareness)
Interaction-awareness

- Awareness of the outside world, of one’s own means of communication with the outside world
- Important in
  - evolving systems
  - agent-based creative systems
  - human-computer co-creation
  - human creativity
- E.g. modeling of other agents and of their preferences, plans for communication/collaboration
Time-awareness

– Awareness of past and future
– Helps learning, enables planning
– Different from the previous aspects: time is not an object
  – time can only be observed indirectly
  – time cannot be controlled
Meta-self-awareness

– Awareness of one’s own self-awareness
– Ability to reflect on processes/components for any of the previous aspects, and to control them
Summary: Aspects of Creative Self-awareness

Two additional aspects: time and meta-self-awareness
Summary

- Six aspects of self-awareness in creative systems:
  - artifact-awareness
  - generator-awareness
  - goal-awareness
  - interaction-awareness
  - time-awareness
  - meta-self-awareness
- Concepts useful to describe systems
- Components/architecture for systems
  - Focus on active roles and interaction of components