Computational Approaches to Creative Language: Modelling Creativity

Caroline Sporleder

Computational Linguistics
Universität des Saarlandes

Sommersemester 2010

11.05.2010

Computational Models of Creativity

Boden (1990, 1999)

Creativity

generation of ideas that are novel and valuable

Value

typically negotiated by social groups.

Types of creativity

P-creativity

- psychological creativity
- idea is new to a certain individual

H-creativity

- historical creativity
- idea is new with respect to whole of human history

Novelty

Combination Theory

- Novelty = new combination of old ideas,
  e.g., William Harvey's idea of the heart as a pump
- can be produced by the same set of rules that produced 'old' ideas
  $\Rightarrow$ no fundamental novelty

Novelty

Combination Theory

- Novelty = new combination of old ideas,
  e.g., William Harvey's idea of the heart as a pump
- can be produced by the same set of rules that produced 'old' ideas
  $\Rightarrow$ no fundamental novelty

Example: The creativity of language

$S \rightarrow NP\ VP,\ NP \rightarrow Det\ N,\ VP \rightarrow V\ PP,\ PP \rightarrow P\ NP$

$Det = \{the,\ a, \ldots\}$

$N = \{squirrel,\ table, bathroom, policeman, fire\ extinguisher \ldots\}$

$V = \{walk, talk, sleep, insinuate \ldots\}$

$P = \{in, on, at, into, for \ldots\}$

Novelty

Combination Theory

- Novelty = new combination of old ideas,
  e.g., William Harvey's idea of the heart as a pump
- can be produced by the same set of rules that produced 'old' ideas
  $\Rightarrow$ no fundamental novelty

Example: The creativity of language

$S \rightarrow NP\ VP,\ NP \rightarrow Det\ N,\ VP \rightarrow V\ PP,\ PP \rightarrow P\ NP$

$Det = \{the,\ a, \ldots\}$

$N = \{squirrel,\ table, bathroom, policeman, fire\ extinguisher \ldots\}$

$V = \{walk, talk, sleep, insinuate \ldots\}$

$P = \{in, on, at, into, for \ldots\}$

The fire extinguisher walked into the bathroom.

AI models of creativity

Two types of models

- combinatorial creativity
- exploratory, transformational creativity

Combinatory Creativity

Based on association and analogy

- neural networks (parallel distributed processing, PDP)
- case-based reasoning

Exploratory, transformational creativity

Rely on notion of conceptual space

- an accepted way of thinking in a particular domain
- defined by a set of enabling constraints for the generation of structure in the space

$\Rightarrow$ conceptual space can be explored or transformed.

Examples

- language: rules and lexicon
- music: tonal harmony (home key etc.)
- architecture: style of a particular architect

Exploratory (E-)Creativity

Computational model must

- define concpetual space
- provide ways of moving through it
- ideally there should also be a built-in way of evaluating new ideas

Examples

- human: explorations of the tonal harmony space
- models of scientific (mathematic) discovery, e.g., BACON (Langley et al., 1987), DENDRAL (Lindsay et al., 1993)
- aesthetics, e.g., Palladio (Hersey & Freeman), AARON (Cohen, McCorduck)
- no similarly successful systems in linguistic domain!

Transformational (T-)Creativity

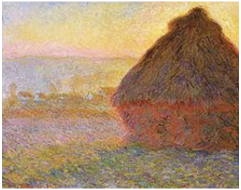
More difficult to model

- involves transformation of (some of) the fundamental dimensions of the conceptual space, e.g., by dropping constraints
- intrinsic evaluation becomes more difficult: system must adjust 'old values'

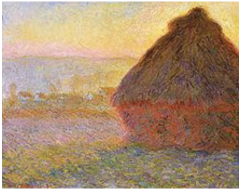
Examples

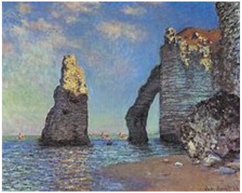
- atonal music
- computational models often based on Genetic Algorithms (GAs), e.g., generate new images from existing images using humans as the 'fitness function' (Karl Sims)
- Automatic Mathematician (AM) (has heuristics for changing heuristics and a simple hard-wired notion of mathematical interestingness)

Human Creativity: Examples

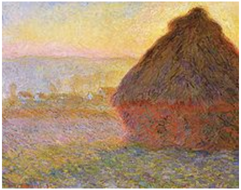


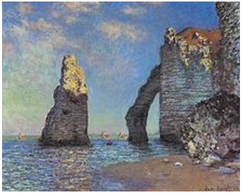
Human Creativity: Examples

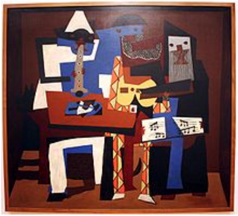




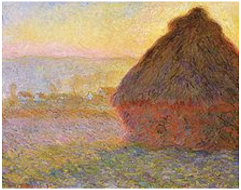
Human Creativity: Examples

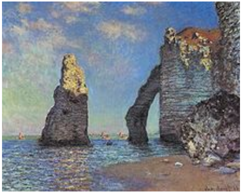


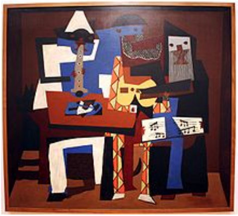




Human Creativity: Examples







Paintings:
Claude Monet: Haystacks (sunset), 1890-91
(http://en.wikipedia.org/wiki/File:
Claude_Monet_-_Graystaks_I.JPG)
Claude Monet: The Cliff at Éretat after the Storm, 1885
(http://en.wikipedia.org/wiki/File:
Claude_Monet_The_Cliffs_at_Etretat.jpg)
Pablo Picasso: Three Musicians, 1921
(http://en.wikipedia.org/wiki/File:
Picasso_three_musicians_moma_2006.jpg)

Machine Creativity: Examples (AARON, Cohen, 1999)

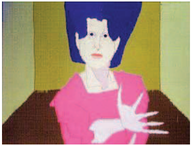


Figure 7
Screen Image 1992.

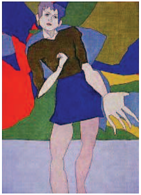


Figure 8
Painting from fig. 9.
Oil on Canvas 1993.

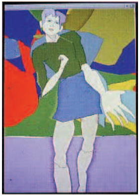


Figure 9
Screen Image 1993.

(from: Harold Cohen: *Colouring without seeing: A problem in machine creativity*, 1999, p. 5. `http://crca.ucsd.edu/~hcohen/cohenpdf/colouringwithoutseeing.pdf`)

Formalising Boden's ideas: Ritchie, 2006 (1)

Spaces

- conceptual space (CS): typical items as currently defined
- well-formed and logically possible items (WF)
- all items in medium type (all)
- $CS \subseteq WF \subseteq all$

$\Rightarrow$ transformations extend CS into WF

Formalising Boden's ideas: Ritchie, 2006 (2)

Modelling creativity

needed:

- a method to define the space intensionally
- a method to determine similarity within the space
- methods to move around the space (exploration)
- methods to change the space (transformation)

Formalising Boden's ideas: Ritchie, 2006 (3)

Spaces and Transformations

- artefact set is determined by rule application, space is changed by adding transition or expansion rules (cf. automata)
- space is defined by dimensions, space change by adding dimensions
- space is defined indirectly by prototypes and the similarity of artefacts to these prototypes, space change=?
- space is defined by constraints, space change by adding or removing constraints

Formalising Boden's ideas: Ritchie, 2006 (4)

Open problems

- no formal distinction between transformation and tweaking
- no formal definition of 'quality'
- need to know the space before computing it

References I

Boden, M.
Computational models of creativity. *Handbook of Creativity*, 1999, 351-373.

Boden, M.
The Creative Mind, 1990.

George Hersey & Richard Freedman.
Possible Palladian Villas (Plus a Few Instructively Impossible Ones). Cambridge, Mass.: The MIT Press, 1992.

Langley, P., Simon, H. A., Bradshaw, G. L., & Zytkow, J. M.
Scientific discovery: Computational explorations of the creative processes. Cambridge, MA: MIT Press. 1987.

Lenat, D. & Seely Brown, J.
Why AM and EURISKO Appear to Work, *Artificial Intelligence*, 23 (1984)

Lindsay, Robert K., Bruce G. Buchanan, E. A. Feigenbaum, & Joshua Lederberg.
DENDRAL: A Case Study of the First Expert System for Scientific Hypothesis Formation. *Artificial Intelligence* 61, 2 (1993): 209-261.

McCorduck, P.
AAARON's Code: Meta-Art, Artificial Intelligence, and the Work of Harold Cohen. W. H. Freeman & Co., 1990

Sims, K.
Artificial Evolution for Computer Graphics, *Computer Graphics*, 25 (1991) 319-328.

Ritchie, G.
The Transformational Creativity Hypothesis. *New Generation Computing* 24(3) (2006) 241-266.