Social Creativity, Agents and Interactions

Simo Linkola
(slinkola at cs.helsinki.fi)
20.11.17
Example: Robotic Installation

Video 1 (3:32)

Video 2 (4:18) (no speech)
Outline

1. Sociality in Creative Systems
2. Multi-agent Systems in CC
3. Modeling the Environment
4. Systems Model of Creativity
5. Interaction and Agent Roles
6. Examples of Creative Social Agents
Sociality in Creative Systems
Why (Computational) Social Creativity?

- “Creativity does not happen in a vacuum”
- Interaction is essential for human creativity
  - Learning domain knowledge and skills
  - Cultural influence, etc.
- Interaction allows the system to potentially adjust its creative process during its lifetime
  - Transformational creativity
Sociality in Creative Systems

A single agent

Thousands of agents
Sociality in Creative Systems

- Elaborate design and interaction
- Real creative responsibilities
- Focus on a single agent behavior (or particular algorithms)

A single agent — Thousands of agents
Sociality in Creative Systems

- Elaborate design and interaction
- Real creative responsibilities
- Focus on a single agent behavior (or particular algorithms)

- Simple design and interaction
- Generation routines, minimal creativity
- Focus on emergent behavior
Sociality in Creative Systems

- Computational social creativity:
  - Research interests mainly in super-individual properties (emergence)
  - What are the individual properties and interaction types that cause certain phenomena? (proof-of-concepts)
- In this lecture we discuss both:
  - Computational social creativity
  - CC with a twist of (multiple) interacting agents
Sociality in Creative Systems

A single agent

Computational Social Creativity

Multi-agent Systems

Agent-based Models

Thousands of agents
Multi-agent Systems in CC
Multi-agent Systems

- Agents are autonomous and have local views
  - Agents take some individual responsibilities in the system
  - Agents can only “see” part of the system at any given time
- No central controlling agent
- There is always an environment, however, its role might be negligible
- Interaction between agents (either direct or indirect) is a central concept
- Two ends of a spectrum:
  - A lot of simple agents, focus on emergent behavior
  - A small set of intelligent agents, focus on fulfilling specific tasks
Characteristics of MAS in CC

- Mostly software agents
  - Some work on robotics
- Stationary societies
- Agents create artifacts in some domain(s)
- Agents have a way to evaluate artifacts
- Interaction is mostly direct
Nwana’s Software Agent Topology

SMART AGENTS

COLLABORATIVE LEARNING AGENTS

LEARN

INTERFACE AGENTS

COOPERATE

COLLABORATIVE AGENTS

AUTONOMOUS

Stationary Agent Societies

- Not really an open environment:
  - designers choose agents, their communication models, etc.
- Agents are (somewhat) homogenous
- Agents do not leave or enter after initialization
- Agents are generally assumed to be “well behaving”
- Agents may have connections to other agents at the initialization time
  - Even knowledge of all other agents
- In many cases, societies are run in iterative simulations
  - Useful for researching specific interests by simplifying the model
Artifacts

- Artifacts can be thought as solutions to a (search) problem
- Examples:
  - A piece of text generated with a Markov chain
  - An image created with genetic programming
  - A mathematical theory created via concept blending
  - Non-photorealistic rendering of an image

```plaintext
spec SPEC =
sort N
op ___+___ : N x N -> N
op p : N -> N
op s : N -> N
op zero : N
\forall x, y : N \cdot s(x) = s(y) \Rightarrow x = y
\forall x, y : N \cdot s(x) + y = s(x + y)
\forall y : N \cdot zero + y = y
\forall x : N \cdot s(p(x)) = x
\forall x : N \cdot p(s(x)) = x
end
```
Listing 4: A consistent partial approach to the integers (without order)
Evaluation

- Agents have some means to evaluate the artifacts they (and others) create
- E.g. Extract features from an artifact (and combine them)
- In ideal case, evaluation takes all the following into account:
  - Is an artifact novel?
  - Is an artifact of high value?
  - Is an artifact surprising?
  - Intention of the artifact?
- The situation and agent’s traits affect evaluation
  - E.g. agent’s memory, aesthetic preferences
- Designing good evaluation methods is difficult!
Evaluation: Examples

```
spec SPEC =
sort N
op __+__ : N × N → N
op p : N → N
op s : N → N
op zero : N
∀ x, y : N • s(x) = s(y) ⇒ x = y
∀ x, y : N • s(x) + y = s(x + y)
∀ y : N • zero + y = y
∀ x : N • s(p(x)) = x
∀ x : N • p(s(x)) = x
end
```

Listing 4: A consistent partial approach to the integers (without order)
Goal of the Agents

- **Cooperative**
  - All agents have the same goal, or
  - Agents benefit from fulfilling other agents' goals
  - Agents can also be called *altruistic*

- **Competitive**
  - All agents have their own goal they try to satisfy
  - Fulfilling a goal may render some other goals impossible
  - Agents can also be called *selfish*

- **Mixture**
  - Both cooperative and competitive agents

- **Intrinsic Motivation**
  - See e.g. Schmidhuber. 2010. Formal Theory of Creativity, Fun and Intrinsic Motivation
Modeling the Environment
Modeling the Environment

- Environment: agents and/or other (static) context
- Why model the environment? Suggestions?
Modeling the Environment

● Environment: agents and/or other (static) context
● Why model the environment?
  ○ A way for an agent to reason about its choices
  ○ Otherwise interaction happens by chance/randomly
  ○ Without modeling, the agent cannot adapt to different situations
Modeling the Environment

- Environment: agents and/or other (static) context
- Why model the environment?
  - A way for an agent to reason about its choices
  - Otherwise interaction happens by chance/randomly
  - Without modeling, the agent cannot adapt to different situations
- Modeling the environment allows the agent to gain interaction awareness
  - Reflection and control of the interactions
Modeling the Environment

- Most common approach is to use **reinforcement learning**
- Tries to maximize expected utility (reward) in the long run
- Selects “optimal” action in each situation (state)
- E.g. Q-learning
Modeling the Environment

SELECT ACTION WITH THE HIGHEST EXPECTED UTILITY

Plan next action
Modeling the Environment

EXECUTE THE PLANNED ACTION

Plan next action
Execute action
Modeling the Environment

OBSERVE UTILITY OR VALUE OF THE ACTION

Plan next action
Execute action
Perceive environment
Modeling the Environment

UPDATE MODEL BASED ON THE OBSERVED UTILITY

Plan next action
Execute action
Perceive environment
Update model
Modeling the Environment

START FROM THE BEGINNING

Plan next action
Execute action
Perceive environment
Update model
The Systems Model of Creativity
The Systems Model of Creativity

The Systems Model of Creativity

- **CULTURE**: Selects novelty
- **DOMAIN**: Transmits information
- **FIELD**: Produces novelty
- **INDIVIDUAL**: Stimulates novelty
- **PERSONAL BACKGROUND**: Repository of cultural knowledge/information
The Systems Model of Creativity

CULTURE

Transmits information

DOMAIN

Transmits information

FIELD

Selects novelty

SOCIETY

Produces novelty

INDIVIDUAL

Stimulates novelty

PERSONAL BACKGROUND

Brings about transformations of to the domain knowledge

Repository of cultural knowledge/information

Selects novelty

Produces novelty

Stimulates novelty
The Systems Model of Creativity

- Selects the knowledge that is worth preserving
- Repository of cultural knowledge/information
- Brings about transformations of to the domain knowledge
The Systems Model of Creativity

Relation to Boden’s P-creativity and H-creativity?
The Systems Model of Creativity

Relation to Boden’s P-creativity and H-creativity?

Selects historical creativity

CULTURE

DOMAIN

FIELD

SOCIETY

INDIVIDUAL

PERSONAL BACKGROUND

Selects novelty

Transmits information

Produces novelty

Stimulates novelty

Selects novelty

Produces novelty
Interaction and Agent Roles
Interaction

- Agents interact with each other one way or another
- We are mostly interested in direct interaction
- Some specific interaction types:
  - Negotiation
  - Voting
  - Collaboration
- Emerging social phenomena:
  - “Best friends”
  - Cliques
  - Gatekeepers
  - Other social structures
Interaction

- Communication model can be nearly anything:
  - Tell a friend
  - Report to a supervisor
  - Broadcast to peers
  - Write on a blackboard

- Interest in models which restrict communication
  - Broadcasting everything causes bandwidth problems
  - Agents are modeled to have limited resources
  - Interaction awareness one of the goals
    - Model the interaction and choose how to interact
Negotiation

- Agents negotiate over:
  - a contract
  - the terms of transactions
  - etc.
- Typical in Consumer - Producer models, e.g. e-commerce
- May happen between only two agents or a set of agents
- Typically iterative

Negotiation: Example

Agent A: Give me service X.

Agent B: I’ll give you service X if you give me service Y.

Agent A: Give me service X and I’ll give you service Z.

... etc.
Voting

- A set of agents $\mathbf{A}$
- A set of candidates $\mathbf{C}$
- Each agent in $\mathbf{A}$ votes by returning $\mathbf{C}$ sorted by preference
- Selected voting rule defines which candidate(s) get selected
- Voting rules:
  - Majority, Condorcet
  - Dictatorship
  - Run-off rules
  - Etc.
- No silver bullet, have to pick the “least evil” option (voting rule)
- Example: Agents vote for an artifact from a set of artifacts
Collaboration

- Special interest in creativity: brainstorming, game design, etc.
- Collaborating agents:
  - May produce more value and/or novelty
  - May be able to produce artifacts they could not alone
- Benefits from agents with reasonably different properties
- Agents need to be able to agree on critical decisions
- Often domain and generator dependent
  - Agents should share artifact representations or be able to translate them
  - What is communicated during the collaboration?
Emerging Social Phenomena

- Interest in computational social creativity
- Cliques / coalition formation
  - Agents form tight social circles where they like artifacts produced by the agents in their circle more than agents outside the circle.
- Gatekeepers
  - Some agents form a role of a “gatekeeper”, where they have substantially more control on the artifacts that are accepted to the domain than other agents.
- Etc.
Agent Roles in Computational Creativity

- **Designers-Clients (Zhang and Saunders)**
  - Designers are producers which create new designs (artifacts)
  - Clients are consumers which accept designers design
    - Clients can also give requirements for the designers

- **Critics**
  - Only evaluate artifacts, can be seen also as consumers
  - Should have sophisticated evaluation standard

- **Gatekeepers (e.g. Sosa and Gero)**
  - Individuals with high influence on the artifacts that are accepted to the domain
  - Emergent role forming as an aggregate result of social interactions

- **The roles depend on what is modelled on each occasion**

*Zhang and Saunders. Exploring Conceptual Space in Language Games Using Hedonic Functions (2014)*
*Sosa and Gero. Social Models of Creativity (2005)*
Examples of Creative Social Agents
Evolution of Culture (EVOC) by Liane Gabora

- Society of neural network based agents in a 2D grid-world:
  - Neural network encodes ideas for actions and detects trends which constitutes as fit actions
  - Body implements the actions
  - Agent’s goal is to attract a mate and make tools (two fitness functions)

- Cultural phenomena:
  - Imitation: agents copy neighbours actions, allows sharing of effective actions
  - Invention: agents can modify their previous actions
  - Knowledge-based operations: new ideas are generated strategically (i.e. not random)
  - Mental stimulation: before implementing an idea, the agent simulates its usage

- Interest in diversity of actions in the population as a function of time

Curious Design Agents by Rob Saunders and John Gero

- Agents aim to produce novel artifacts (spirographs)
- Agents have a model (SOM) of previously seen artifacts
- Agents evaluate the novelty of an artifact w.r.t the model
- Agents have different levels of preferred novelty
- Hedonic function follows the Wundt Curve
- Agents may give positive feedback of artifacts
- Emergence of cliques is observed
  - Agents that give positive feedback to each other
  - Agents in a clique have the same level of preferred novelty

Reflexive Looper by Sony CSL

- Part of Flow Machines project lead by François Pachet
- Musical companion which adapts to you
- Plays chords, drums, bass, etc.
- Video (4:09)
Social Models of Creativity by Ricardo Sosa and John Gero

- Study creativity in the DIFI-setting (Domain-Individual-Field-Interaction)
- Agents make designs in simple two-dimensional shapes
- Designers and adopters
- Findings about many individual and social aspects of creativity, e.g.
  - Change agents: trigger change cycles in a bottom-up direction
  - Gatekeeping: some adopters become gatekeepers by an aggregate result of social interaction
Summary

- Creativity does not happen in a vacuum
  - System's view of creativity as a conceptual framework
- Interaction is an important aspect in many creative systems
  - Direct and indirect interaction are both valid, focus on direct
- Cooperation and collaboration
  - Cooperation may produce results which agents are not able to produce alone
- A truly autonomous agent needs to have (learn) a model of its environment to be able to act intentionally
  - Interaction awareness!