Simulation of Collective Intelligence

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January 29, 2009

1. Collective Intelligence
   - Example Problem
   - Definition
   - Analysis or Design?
2. Simulation
   - Software
   - Models
   - Algorithms
   - Model Specification
   - Methodology
   - Examples
3. http://sci.collectivae.net/

Assume that you are on a team to map out illegal wood cutting activities in the Amazon area in South America. Each member of the team is equipped with a light-weight plane with GPS navigation. The whole mission will take some given number of days. There is no central meeting place, neither at the start nor at the end of the mission. Each day you fly over some area and identify wood-cutting activities by writing down the GPS coordinates of your observation. You identify *all* such activities; after the mission, the reported activities will be compared with entries from a database with legal wood cutting activities. While flying, you can fly at either a relatively high or low altitude. Flying high means that you cover more area, but the information you collect is less detailed; flying low means the opposite. You will stay overnight at the place where you end up just before dusk. We assume, however unrealistic, that there is sufficient fuel supply throughout the Amazon area. Every night, the (partial) maps of all members are collected through telecommunication by some central authority, the collective map is updated and the resulting map is communicated back to all members. This is the only possible communication between the members during the mission.

Ask yourself two questions:

- What best strategy can I think up that will yield a good collective map as quickly as possible?
- How can we effectively use computer simulation in order to decide about these strategies?

- Collective intelligence is the capacity of human communities to evolve towards higher order complexity and harmony, through such innovation mechanisms as differentiation and integration, competition and collaboration.
- Collective Intelligence: exploring the next step in human evolution.
- Collective Intelligence is [...] dedicated to improving the efficiency of social ecosystems and accelerating the flow of capital to good.
- Collective Intelligence, The Invisible Revolution.

Working definition coined by the Massachusetts Institute of Technology (MIT) Center for Collective Intelligence:

Groups of individuals doing things collectively that seem intelligent

Related research streams:

- Self Organisation (SO)
- Complex Adaptive Systems (CAS)
- Multi-Agent Systems (MAS)
- Population-based Adaptive Systems (PAS)
- Swarm Intelligence (SI)
- Swarm Engineering (SE)

AEGIR[4]

- Adaptivity
- Emergence
- Global-local
- Interaction
- Rules
- Redundancy
- Robustness
- Randomness

- Analysis studies – purpose is to learn about and to get better understanding of phenomena as observed in nature, including human nature
- Design studies – purpose of design studies is problem solving (in its broadest meaning)

- Social Sciences
  - Schelling Segregation
  - Growing Artificial Societies
  - Artificial Anasazi
  - Human Learning Environments
- Biological Sciences
  - Primate Dominance Interaction
  - Self Organised Patchiness
  - Division of Labour

- Economic Sciences
  - Agent-based Computational Economics
  - Iterated Prisoner's Dilemma
  - Ecological Economics
- Science of Philosophy
  - Shared Extended Mind
  - Altruism

- Collective Robotics
  - Swarm Robotics
  - Evolutionary Robotics
  - Cooperative Robotics
- Computer Networks
  - Peer-to-Peer Protocols
  - Self-star Properties
  - Grid Computing
  - Autonomic Computing

- Insect-based Computing
  - Package Routing
  - Paintbooth Scheduling
  - Data Clustering
- Agent-based Computing
  - Automated Negotiation
  - Trust and Reputation
  - Computational Mechanism Design
- Games and Movies
  - RoboCup
  - SimCity
  - SPORE
  - Evolving Creatures
  - Crowd Simulation

- Swarm
- RePast
- NetLogo
- Newties
- Breve
- Mason
- Starlogo
- FramSticks
- Ascape
- CORMAS
- MOISE+
- AgentSheets
- LEADSTO
- SDML

Most researchers *just start somewhere* when constructing models of collective intelligence.

- Cellular Automata
- Multi-Agent Based Systems
- Boolean Networks
- NK-Model
- Particle-Based Models
- Game and Decision Theory
- Formal Logics
- Knowledge Systems

- Evolutionary Methods
- Co-evolution
- Learning Classifier Systems
- Neuro-Evolution
- Collective Intelligence (COIN)
- Particle Swarm Optimisation

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Control Loop
1:  initialise individuals
2:  initialise world
3:  while true
4:      for each individual
5:          observe the world
6:          perform an action
7:      end for
8:      world: determine new observations
9:      world: process costs and benefits for all individuals
10: end while
```

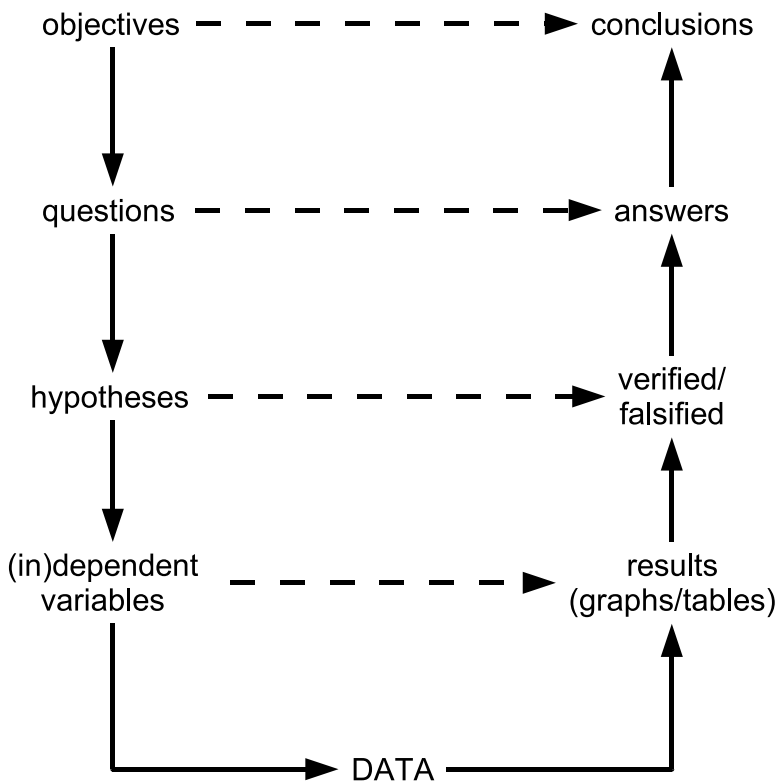
Recipes:

- basic
- internal models
- diversity
- non-determinism
- adaptivity

Recipe: **BASIC**

1: Determine action set for all individuals
2: Determine observation set for all individuals
3: Determine action $\longrightarrow$ observation functions
4: Determine costs for individuals for functions from 3
5: Determine benefits for individuals for functions from 3
6: Determine observation $\longrightarrow$ action functions for all individuals

Recipe: **BASIC + adaptivity**	
1:	Determine action set for all individuals
2:	Determine observation set for all individuals
3:	Determine action $\longrightarrow$ observation functions
4:	Determine costs for individuals for functions from 3
5:	Determine benefits for individuals for functions from 3
6:	Choose and implement mechanism that generates observation $\longrightarrow$ action functions for all individuals


objectives
conclusions
questions
answers
hypotheses
verified/
falsified
(in)dependent
variables
results
(graphs/tables)
DATA

- House sparrows
- Epidemic modelling
- Biological pattern formation
- The art-gallery problem
- Multi-asset surveillance
- Flood modelling

On http://sci.collectivae.net/ you can download Scientific Handbook for Simulation of Collective Intelligence.

http://www.collectivae.net/
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