Agent-Based Modelling

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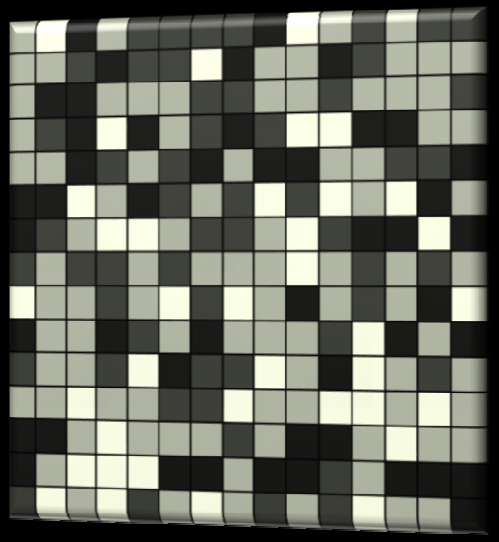
History

- Von Neumann machines:
  - Self-reproducing
  - Cellular Automata



- Object oriented programming (OOP)

Example: Boids

- Simple agents
  - 3 rules for movement

1. Separation
2. Alignment
3. Cohesion

- Complex, realistic movement
  - Small changes → different behaviour

http://cs.gmu.edu/~eclab/projects/mason/

Agents

- Interact with others and/or environs
- Intelligent and purposeful
- Goal driven and decision making
- Bounded rationality

Agents

- **Features**:
  - Autonomy
  - Social Ability
  - Reactivity
  - Proactivity
- **Characteristics**:
  - Perception
  - Performance
    - Motion
    - Communication
    - Action
  - Memory
  - Policy

N. Gilbert (2008) *Agent-Based Models*

Characteristics

Complex

Emergent

Chaotic

Dynamic

Interactive

Benefits

- Isolating prime mechanics
- Interaction of micro & macro
- What if? scenarios
- Finding equlibria
- Clarity & Transparency

Ontological Correspondence

- Entities organized in an easily comprehensible fashion
- Conceptual model validation
  - Embedded in theory
- Communication & Visualization
- Reproducibility

Drawbacks

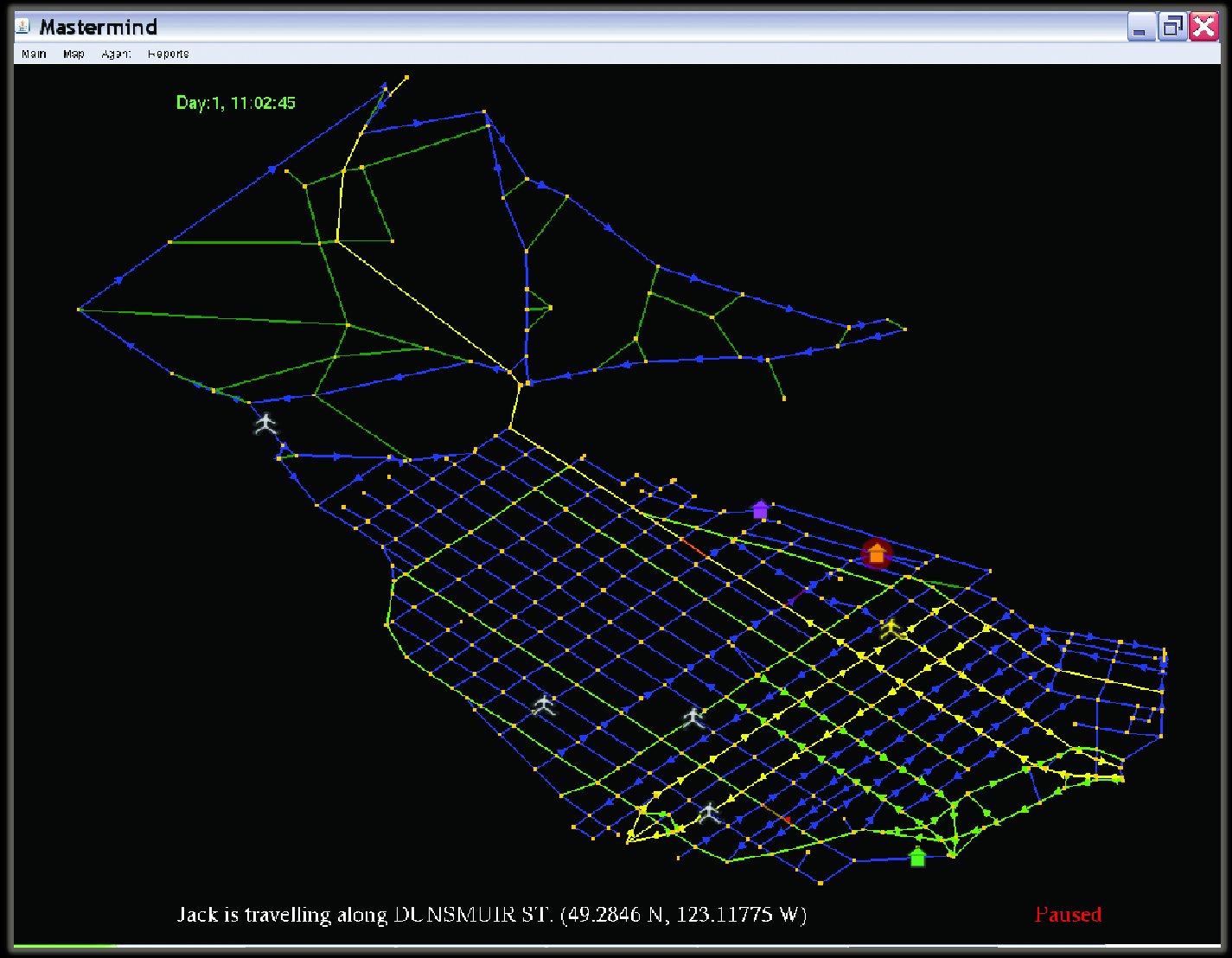
- Analysis
  - Not a replacement for analytical methods
- Operational Validation
  - Many assumptions
  - Improbable or unmeasurable IRL
- Difficult for prediction

Example: Sugarscape

- Mobile agents on a grid
- Collecting & metabolizing sugar
- Sugar: metaphor for any resource
  - Evolution, marital status, inheritance

http://sugarscape.sourceforge.net/

Example: Mastermind



Tasks & Requirements

- **Identify phenomena**
  - Agents, events, factors
- **Formalize domain concepts**
  - Formal methods, equations
- **Simplify!**
  - Reduce, group, isolate

Abstract State Machines

GoalManagement $\equiv$

forall g **in** $goalPool$ **do**

if $progress(g) = success$ **then**

CompleteGoal(g)

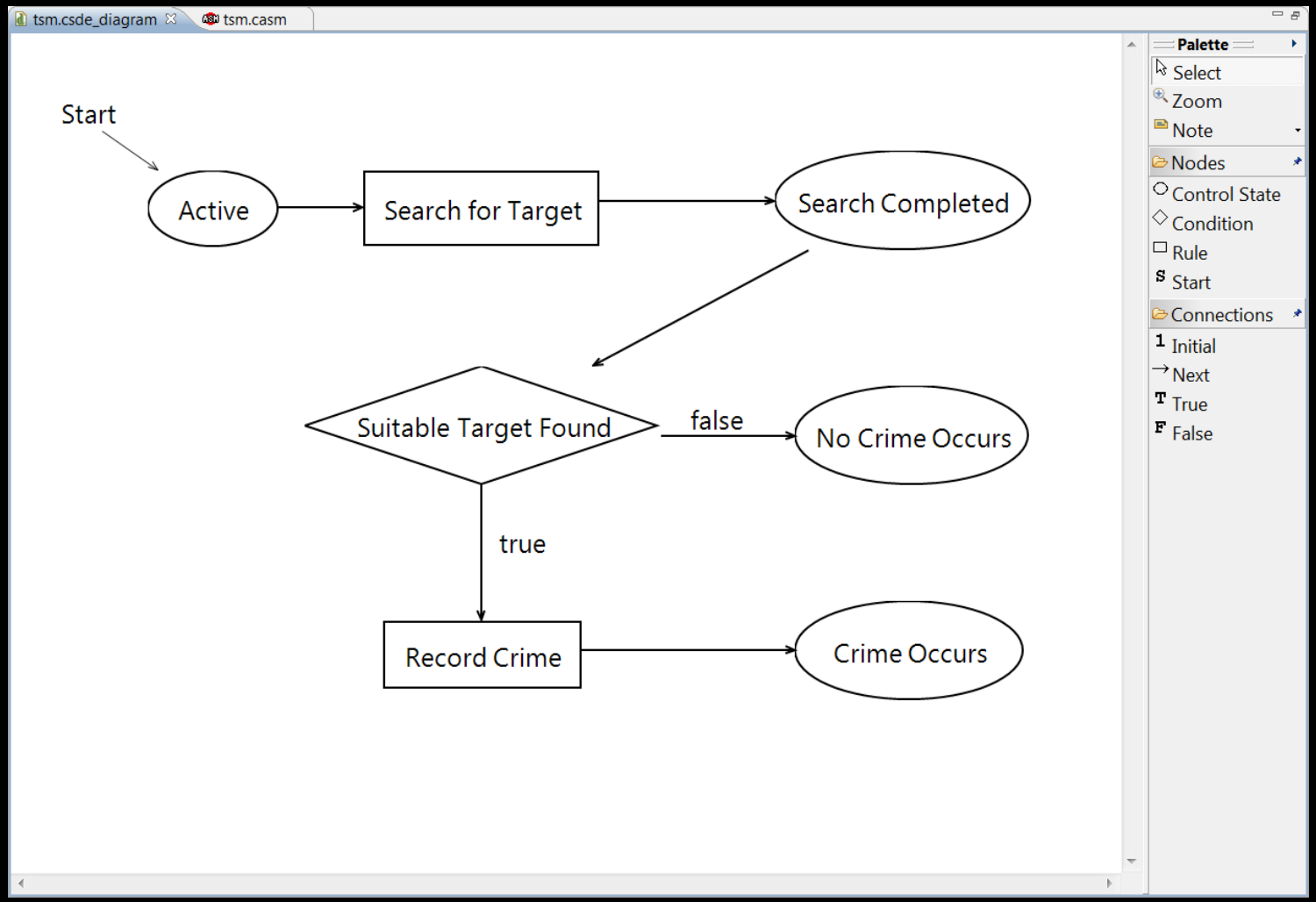
else if $progress(g) = failure$ **then**

CancelGoal(g)

else if $CanDecompose(g)$ **then**

DecomposeGoal(g)

Control State Diagrams

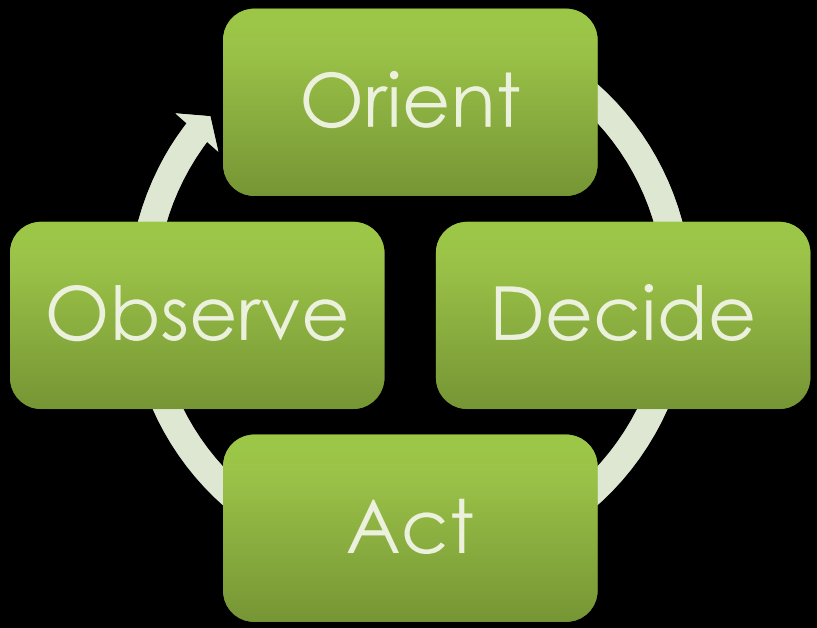


Agent Specifics

- Scenario parameters
- Variables
- Functions: what an agent can do
- Model of intelligence
- Logic

Models of Intelligence

- Reactive
- Beliefs, Desires & Intentions
- OODA

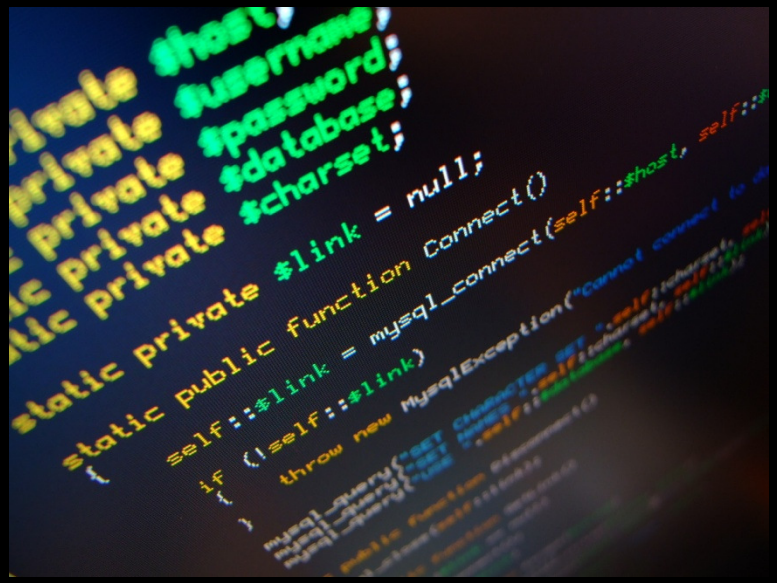


Implementing Logic

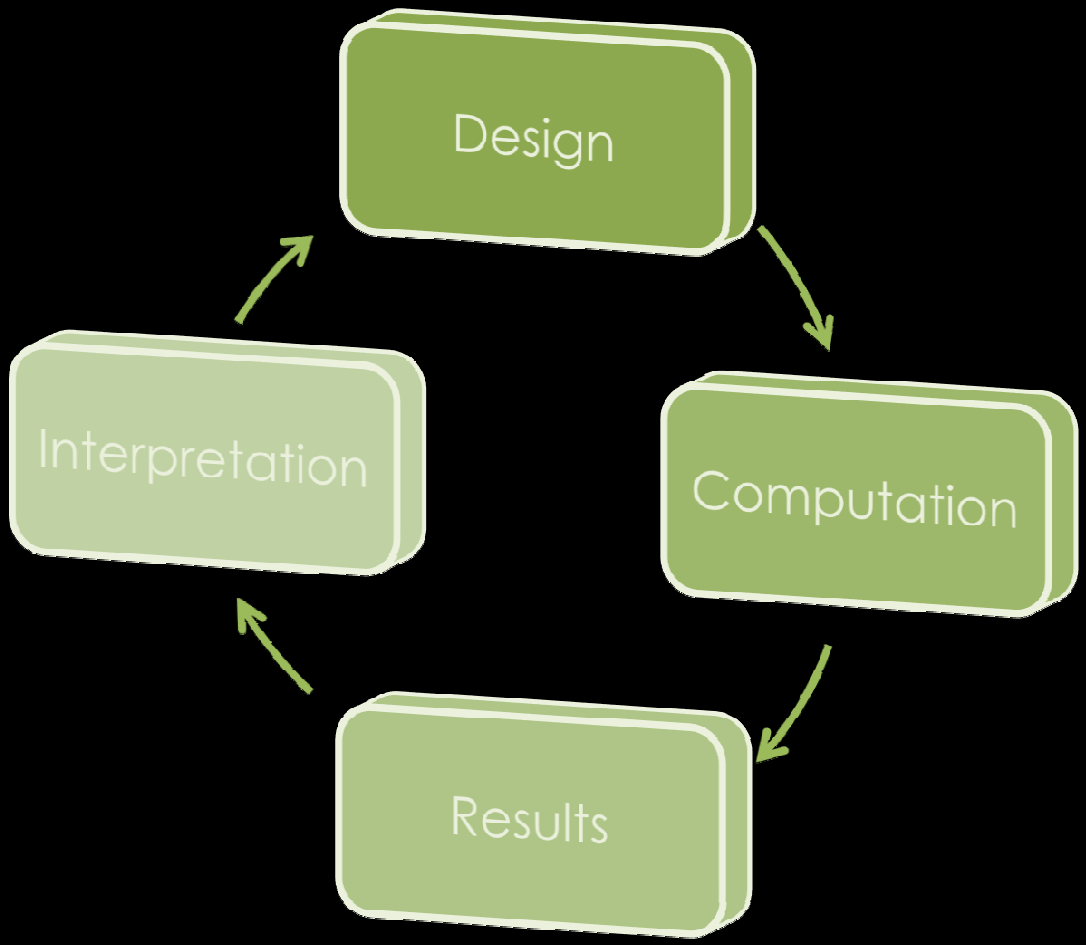
- Conditionals
  - state machine
- Fuzzy
- Deterministic/Non-Deterministic

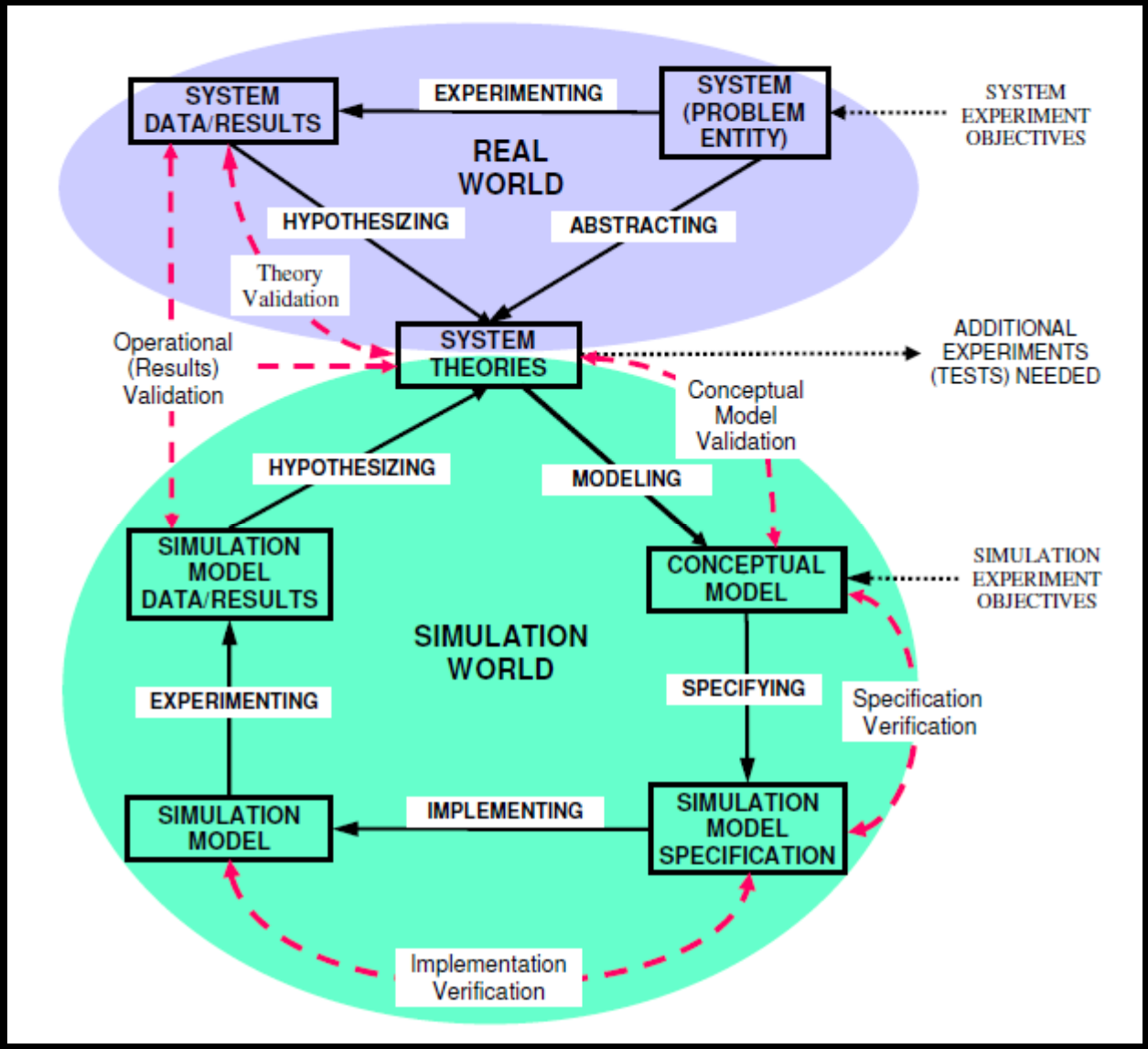
Programming

- Agent-Based simulation software:
  - Repast
  - MASON
- Object oriented programming
  - Java, Python, C#



Iterative Experimentation





From R. Sargent(2010) *Verification And Validation Of Simulation Models*

Hybrid Models

- Geographical CA/ABM Hybrid
  - Y. Xie, M. Batty, and K. Zhao (2007) "Simulating Emergent Urban Form Using Agent-Based Modeling: Desakota in the Suzhou-Wuxian Region in China"
  - 2 kinds of agents: developers, townships
    - Active at different scales
  - Cellular landscape: suitability variable

CoreASM

- **Abstract State Machine** paradigm
- Executable
  - Validation by testing
- Open source
- Interaction with Java