Evolutionary Computation in Games: Dealing With Uncertainty

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Me

• Research in Artificial Intelligence and Computer Graphics (Intelligent User Interfaces)
• Focus on Virtual Cinematography and Player Modelling
Tutorial

- Evolutionary Computation in Games
- Uncertainty
- Uncertainty in Games
- Examples
Evolutionary Computation In Games

Generate optimal player/game

- Objective functions
  - Player: performance/human likeness
  - Game: player experience, balance, duration...

- Domain
  - Player: controller/strategy
  - Game: content configuration
Galactic Arms Race

- Evolving weapons
- Interactive Evolutionary Computation
  - Objective function is human evaluation
- Compositional Pattern-Producing Networks

Uncertainty

- Noise
- Robustness
- Approximation
- Dynamic Problem
• Noisy objective function evaluation
• **Same** evaluation, **different** values
  - Genotype v.s. phenotype
  - Environment/Sensor noise
Robustness

- Variations of the *design variables*
- Variations of the *environment*
Approximation

- Objective function is an approximation of the real problem
- Evaluation is time-consuming
- No real fitness available
- Additional evaluation necessary
- Rugged fitness landscape
Dynamic Problem

- Optimum moves during optimization
  - Environment
  - Objectives
  - Representation

- Linear/non-linear motion
- Oscillation
- Random jumps
Uncertainty in Games

- Affects the quality of content/agent
- Sources?
Uncertainty in Games

• Affects the quality of content/agent

• Sources:
  - Player
  - Sensors
  - Dynamic virtual environment
  - Complex virtual environment
  - Slow execution
Examples

• Automatic Camera Control
• Experience Driven Procedural Content Generation
• Simulation Based Optimization
Example 1: Automatic Camera Control
Virtual Camera

- Camera
- Action
- Frame
Automatic Camera Control

- **Abstraction Layer**
- **High Level Properties**
- **Automatic Configuration**
- **Automatic Animation**
Inputs

Composition Properties

Camera Properties

Animation Properties

Visual and Motion Properties

Virtual Environment

Camera Controller
Inputs

Subjects

Environment Geometry

Visual and Motion Properties

Virtual Environment

Camera Controller

Camera
CamOn

Camera Controller

Visual and Motion Properties

Objective Function

Solver

Animator

Camera

Virtual Env.
Objective Function

Property 0

Property 1

Property N

Object. Func. 0

Object. Func. 1

Object. Func. N

Weight 0

Weight 1

Weight N

Sum

Objective Function
Objective Function: Properties

- Visibility
- Vantage Angle
- Projection Size
- Frame Position
Objective Function: Domain

Camera

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>α</th>
<th>β</th>
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Position

Orientation
Main source of uncertainty?
Main source of uncertainty: Dynamic Problem
Dynamic Problem

- Subjects and other objects move in the virtual space
- The frame properties might change
- The geometry of the subjects might change
Possible Solution

• Restart
Possible Solution

- Restart
- Simple
Possible Solution

- Restart
- Simple
- No time
Possible Solution

- **Restart**
- Simple
- No time
- Waste of information
Possible Solution

- Restart
- Simple
- No time
- Waste of information
- Might be the only solution
Challenges

Information Reuse
how to store and reuse information about the landscape?

Population Diversity
how to avoid premature population convergence?
Information Reuse

• Explicit memory
  - Data structure: landscape fingerprint, optima
  - Ruse part of the population

• Implicit memory
  - Multiploidy/Diploidy

• Information validity
  - Generational
Population Diversity

• Diversity after change
  - Hypermutation
  - Variable local search

• Diversity throughout the optimization
  - Random immigrants

• Multiple populations

Hybrid Genetic Algorithm

- Hybrid Lamarckian-Darwinian evolution
- Explore if early convergence
- Early convergence if:
  - No improvement for one frame
  - Complete occlusion
Example 2: Experience Driven Procedural Content Generation
EDPCG

Capture player experience → Model the effect of game content → Optimize player experience
Challenges

• How to capture **Player Experience**?
• How to evaluate the **quality** of content?
• How to **optimize** game content for Player Experience?
Capturing Player Experience

• Subjectively
  - Asking players: self-report questionnaires (ranking, preferences)

• Objectively
  - Physiology (GCR, EEG, EMG, BVP,…); eye-tracking; facial expression; speech

• GamePlay-Based
  - Player game preferences (what players do relates to their experience)
Content Quality

• Direct utility/fitness
  - A direct mapping between content and quality; e.g. number of jumps in a platform game

• Simulation-based
  - An AI agent (human-like?) plays the game for a while and content is evaluated through playing style

• Interactive fitness
  - Real-time evaluation via a player or players
Optimize Content

Player Experience Model

Content Representation

Content Quality

Content Optimizer
Main sources of uncertainty?
Main sources of uncertainty:
Noise, Robustness
Noise
Dealing with Noise

• Explicit average
  - Multiple samples per evaluation
  - Average with neighborhood
  - Interpolation

• Implicit average
  - Increase population size

• Selection scheme
  - Threshold for selection

• Noise might be useful...

Robustness
Dealing With Robustness

• Optimizing Expected Fitness
  - Average in the neighborhood
  - Average with similar previous values
  - Add noise and increase population

• Multi-Objective Optimization
  - Fitness v.s. Robustness
  - Measure of robustness

Robustness measure 2: $f_j^R = \frac{\sigma_{f,j}}{\sigma_{x,j}}$
Example 3: Simulation Based Optimization
Evolving Strategy Game Units

• Objective: complementarity

• Balanced units sets stronger than unbalanced ones
Problem Characteristics

- 21 attributes in the gene
- Objective function based on 6 matches player 200 times
- 1 minute per evaluation
Time Consuming Evaluation

- Long experimental time
- No possible "real-time" execution
- Applies also to agent learning
Main source of uncertainty: Approximation
Motivations

- Time consuming evaluation
- No available analytical fitness
- Noise Reduction
- Rugged landscape
- Smart population initialisation
Approximation Methods

- Simplified simulation
- Data-driven functional approximation
- Evaluations reduction
  - Fitness inheritance
  - Fitness imitation
  - Fitness assignment
Dealing With Approximation

Combine approximated function with real-function

Individual Based Control

- Random
- Best
- Most uncertain
- Most representative

Generation Based Control

Whole population every N generations

Future Work

• Experiment these techniques in games
• Use games as a benchmark for uncertainty
• Other forms of uncertainty?
References


- Paolo Burelli. Interactive Virtual Cinematography. IT University Of Copenhagen, 2012


EvoGAMES 2013
Bio-inspired Algorithms in Games
Submission deadline: 1 November 2012
Vienna, 3-5 April 2013

Thank you! Questions?