Depth in Strategic Games

Frank Lantz  NYU Game Center
Aaron Isaksen  NYU Game Innovation Lab
Alexander Jaffe  Spry Fox
Andy Nealen  NYU Game Innovation Lab
Julian Togelius  NYU Game Innovation Lab
Is there a well-defined property of game systems that corresponds to what designers and players mean when they refer to “strategic depth”? 
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Preliminary Observations

Frank Lantz  NYU Game Center  frank.lantz@nyu.edu
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Preliminary Observations

• game design and computer science
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• game design and computer science
• tractable, but not currently known
Preliminary Observations

- game design and computer science
- tractable, but not currently known
- existing research
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Preliminary Observations

- game design and computer science
- tractable, but not currently known
- existing research
- laying a foundation
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Clarifying the Question

Frank Lantz | NYU Game Center | frank.lantz@nyu.edu
Clarifying the Question

- “deep” ≠ “good”
Clarifying the Question

- “deep” ≠ “good”
- a spectrum, not a binary
Clarifying the Question

• “deep” ≠ “good”
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• psychology-independent
Clarifying the Question

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- abstract, simplified strategic games
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• “d”
Why Ask the Question?
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- conceptual tool to improve design discussions
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- conceptual tool to improve design discussions
- suggest directions for design exploration
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Why Ask the Question?

• conceptual tool to improve design discussions
• suggest directions for design exploration
• pure curiosity and knowledge
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Why Ask the Question?

- conceptual tool to improve design discussions
- suggest directions for design exploration
- pure curiosity and knowledge
- general questions about AI and “machine aesthetics”
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Our General Approach
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Our General Approach

• strategic games as problem-solving tasks
Our General Approach

• strategic games as problem-solving tasks
• different “flavors” of hardness
Our General Approach

- strategic games as problem-solving tasks
- different “flavors” of hardness
- complexity theory
Our General Approach

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- existing properties:
Our General Approach

- strategic games as problem-solving tasks
- different “flavors” of hardness
- complexity theory
- existing properties:
  - state-space
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Our General Approach

- strategic games as problem-solving tasks
- different “flavors” of hardness
- complexity theory
- existing properties:
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  - branching factor
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Our General Approach

- strategic games as problem-solving tasks
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- complexity theory
- existing properties:
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  - branching factor
  - “traditional” hardness
Our General Approach

• strategic games as problem-solving tasks
• different “flavors” of hardness
• complexity theory
• existing properties:
  • state-space
  • branching factor
  • “traditional” hardness
• observing characteristics of real-world games
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• existing properties:
  • state-space
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• observing characteristics of real-world games
• building a model
Characteristics of Depth

- Large community of dedicated players
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- Life-long learning with regular improvement
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- Vast body of knowledge and strategic analysis
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• The Skill Chain (eg, Elo)
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- The Skill Chain (e.g., Elo)
- The Strategy Ladder
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The Strategy Ladder

Frank Lantz  NYU Game Center  frank.lantz@nyu.edu
The capacity for a game system to allow for a ranked sequence of approximate solutions
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The Strategy Ladder
The Strategy Ladder

• Strategies - complete algorithmic descriptions
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The Strategy Ladder

• Strategies - complete algorithmic descriptions
  • when & how to search

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The Strategy Ladder

- Strategies - complete algorithmic descriptions
  - when & how to search
  - when & how to evaluate
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The Strategy Ladder

• Strategies - complete algorithmic descriptions
  • when & how to search
  • when & how to evaluate
  • when & how to use heuristics
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• Computational Resources
Depth in Strategic Games

The Strategy Ladder

• Strategies - complete algorithmic descriptions
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• Computational Resources
  • Number of operations
The Strategy Ladder

- Strategies - complete algorithmic descriptions
  - when & how to search
  - when & how to evaluate
  - when & how to use heuristics
- Computational Resources
  - Number of operations
  - Working memory
Depth in Strategic Games

The Strategy Ladder

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  • Number of operations
  • Working memory
  • K-complexity “footprint”
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  - Win rate
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  • Quality of move selection
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- Steps
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• Steps
  • What is the model’s output?
The Strategy Ladder

Frank Lantz
NYU Game Center
frank.lantz@nyu.edu

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Alex: \( d = 4 \quad d = 0 \quad d = 1 \)

Paper: \( d = 4 \quad d = 4 \quad d = 1 \)
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The Strategy Ladder

Perfect Play

Solution Strength

Computational Resources

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The Strategy Ladder

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The shape of this curve reveals something important about the game’s underlying structure.

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Applications of the Model
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Applications of the Model

• Conceptual tool for speculation
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Applications of the Model

• Conceptual tool for speculation
• Direct observation of real games at low CR levels
Applications of the Model

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• Complete analysis of small games, toy games
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Applications of the Model

• Conceptual tool for speculation
• Direct observation of real games at low CR levels
• Complete analysis of small games, toy games
• Research tool for observing how d changes as you change aspects of the rule set
Observations: Search vs. Heuristics

- Games of low $d$ fail by having *simple* best avail strats
Observations: Search vs. Heuristics

- Games of low $d$ fail by having *simple* best avail strats
- Simple strategies
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- Games of low $d$ fail by having simple best avail strats
- Simple strategies
  - pure search
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- Games of pure search
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- Games of pure search
  - don’t “feel” deep
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- Games of pure search
  - don’t “feel” deep
  - don’t support life-long learning
Observations: Search vs. Heuristics

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• Games of pure search
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• Complex strategies
Depth in Strategic Games

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  - insight
- Semi-ordered game structure allows for heuristics as a form of search-compression
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Next Steps
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• Further refinement of the model
Next Steps

• Further refinement of the model
• Application to simple games
Next Steps

• Further refinement of the model
• Application to simple games
• Development and analysis of toy games
Next Steps

- Further refinement of the model
- Application to simple games
- Development and analysis of toy games
- Full Analysis of toy versions of real games
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Next Steps

- Further refinement of the model
- Application to simple games
- Development and analysis of toy games
- Full Analysis of toy versions of real games
- Partial analysis of real games
Next Steps

• Further refinement of the model
• Application to simple games
• Development and analysis of toy games
• Full Analysis of toy versions of real games
• Partial analysis of real games
• Further exploration of search vs. heuristics