EMBRACING THE DARK ART OF MATHEMATICAL MODELING IN GAME AI

Dave Mark – Intrinsic Algorithm
Kevin Dill – Lockheed Martin

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Administrivia

- Mid-to-Advanced Level Lecture
- References:
  - 2010 AI Summit Talk: Improving AI Decision Modeling Through Utility Theory
  - I/ITSEC 2011: *A Game AI Approach to Autonomous Control of Virtual Characters*
    - Best Paper: paper presentation
  - SISO SIW 2012: *Introducing GAIA: A Reusable, Extensible Architecture for AI Behavior*
    - Not published yet (end of March) – search for 12S-SIW-046
  - Behavioral Mathematics for Game AI

What Is Utility-Based AI?

- Calculate ***relative goodness*** of each option
  - Shades of gray
  - Finer granularity
  - Subtle nuance of the situation
- Guns and Grenades
- Reasonable Variation => ***Believability***

http://musicarmichael.com/category/music/

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AI Engineering

- "Like a giant bucket of floats…"

- Utility is complex to the novice
- ***So is C++!!***
- Software Engineering => tools
- We need ***Utility Engineering***

http://www.enasco.com/product/TB15671T

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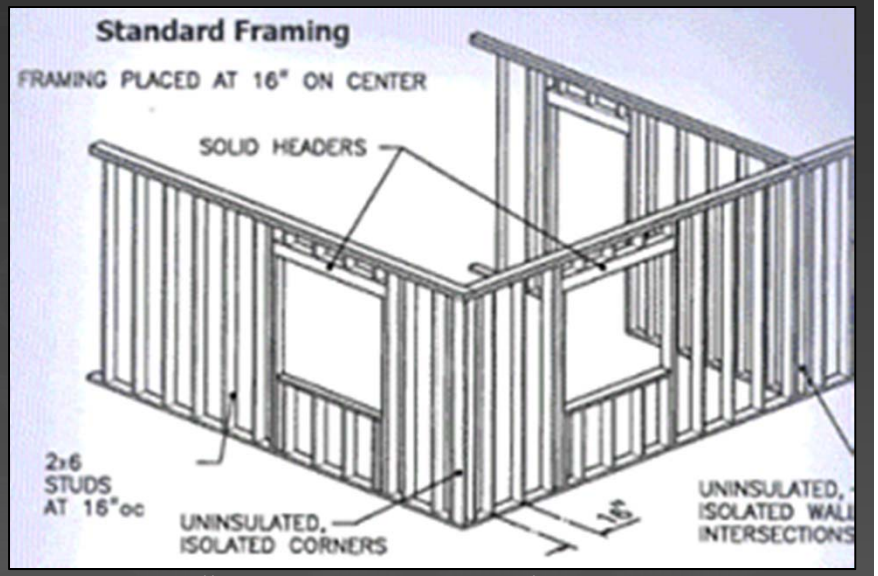
Design Patterns

- "Simple and succinct solutions to commonly occurring design problems"
  – Gamma et. al.



http://www.renovation-headquarters.com/walls-partitions.htm

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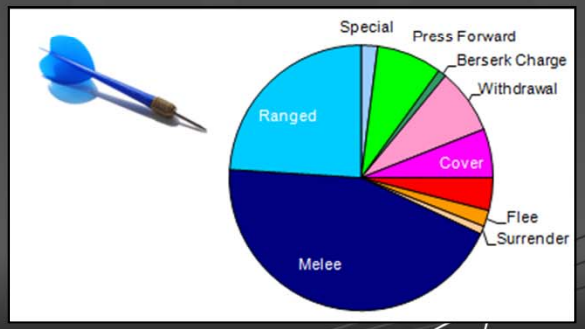
Absolute vs. Relative

- ***Absolute Utility*** (“***Rank***”) ← ***Divide Into Categories***
  - Always pick an option with higher rank over one with lower rank
- ***Relative Utility*** (“***Weight***”) ← ***Calculate “Appropriateness”***
  - Every option could be picked, but one with higher utility is more likely
  - “***Weighted Random***”
- ***You Can Use Both!!***



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Dual Utility AI

1. Eliminate weight <= 0
2. Screen on rank
3. Eliminate very small weight
4. Weighted Random

Completely Inappropriate

Something more important is going on

Avoid Artificial Stupidity!!

Random* but *Reasonable

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Considerations

- Modular decision making
  - Each consideration examines a single aspect of the situation
- Each consideration can:
  - Set a minimum rank
  - Apply a bonus to the weight
  - Apply a multiplier to the weight

$$R_O = Max_{i=1}^{n}(R_i)$$

$$W_O = \left(\sum_{i=1}^{n} B_i\right) \cdot \left(\prod_{i=1}^{n} M_i\right)$$

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Example: Sniper

- Shoot / No-Shoot
- Shoot Considerations:
  - Clear line of sight
  - Clear line of retreat

http://www.imfdb.org/wiki/Bangkok_Dangerous

Pattern: Opt Out

- Consideration: "***Do not do this!!***"
- Simply set M = 0

1) Weight <= 0
2) Screen rank
3) Very small weight
4) Weighted Random

$$R_O = Max_{i=1}^{n}(R_i)$$

$$W_O = \left(\sum_{i=1}^{n} B_i\right) \cdot \left(\prod_{i=1}^{n} M_i\right)$$

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Example: Guard

- Engage Decision
  - He attacks me
  - He attempts to enter
  - Poor chat choice

http://www.histquest.com/index.php?id=51

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Pattern: Opt In

- Consideration: “***Do this!!***”
- Stand guard – “***Default Option***”
  - Fixed values: Rank 0, Weight 1
- Engage
  - Default R = -1
  - Each consideration can set R = 10

1) Weight <= 0
2) Screen rank
3) Very small weight
4) Weighted Random

$$R_O = Max_{i=1}^{n}(R_i)$$

$$W_O = \left(\sum_{i=1}^{n} B_i\right) \cdot \left(\prod_{i=1}^{n} M_i\right)$$

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Pattern: Inertia

- While executing, retain some rank
- Engage
  - Default R = -1
  - Each consideration can set R = 10
  - Execution History consideration
    - Set R = 7 while executing

1) Weight <= 0
2) Screen rank
3) Very small weight
4) Weighted Random

$$R_O = Max_{i=1}^{n}(R_i)$$

$$W_O = \left(\sum_{i=1}^{n} B_i\right) \cdot \left(\prod_{i=1}^{n} M_i\right)$$

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Example: Guard

- Options:
  - Guard
  - Engage
  - ***Ring the Alarm***

http://www.histquest.com/index.php?id=51

Pattern: Commit

- Like inertia, but ***increase*** rank
- Engage / Ring the Alarm
  - Default R = -1
  - Each consideration can set R = 10
  - Execution History consideration
    - Set R = 11 while executing

1) Weight <= 0
2) Screen rank
3) Very small weight
4) Weighted Random

$$R_O = Max_{i=1}^{n}(R_i)$$

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Pattern: Is Done

- *"I'm done executing –*
  do something else now"
- ***Is Done*** consideration:
  - Am I currently selected?
  - Have I finished execution?
  - If so, M = 0

1) Weight <= 0
2) Screen rank
3) Very small weight
4) Weighted Random

$$R_O = Max_{i=1}^{n}(R_i)$$

$$W_O = \left(\sum_{i=1}^{n} B_i\right) \cdot \left(\prod_{i=1}^{n} M_i\right)$$

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Example: Sniper

- Shoot / No-Shoot
- Shoot Considerations:
  - Clear line of sight
  - Clear line of retreat
  - Delay between shots

http://www.imfdb.org/wiki/Bangkok_Dangerous

Pattern: Cooldown

- Don’t do the same thing twice in a row
- Evaluate time since last selection
  - Fixed delay (M = 0 for 15 sec)
  - Variable delay (M = 0 for 10-20 sec)
  - Tiered delay
    - M = 0 for 8-12 sec
    - M = 0.5 for 18-22 sec

1) Weight <= 0
2) Screen rank
3) Very small weight
4) Weighted Random

$$R_O = Max_{i=1}^{n}(R_i)$$

$$W_O = \left(\sum_{i=1}^{n} B_i\right) \cdot \left(\prod_{i=1}^{n} M_i\right)$$

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Example: Sniper

- Shoot/Wait/Flee
- Shoot Considerations:
  - Clear line of sight
  - Clear line of retreat
  - Delay between shots
  - Number of shots fired

Pattern: Repeat Penalty

- Fire Option
  - R = 10 - (2 * shots_fired)
- Flee Option
  - R depends on situation
    - Shooting at me?
    - Looking at me?
    - Surrounding me?
    - Running away?

Repeat Penalty

1) Weight <= 0
2) Screen rank
3) Very small weight
4) Weighted Random

$$R_O = Max_{i=1}^{n}(R_i)$$

$$W_O = \left(\sum_{i=1}^{n} B_i\right) \cdot \left(\prod_{i=1}^{n} M_i\right)$$

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Something Harder

- Sniper Target Selection:
  - Side
    - US Military: M = 10
    - Civilian: M = 0.1
  - Rank
    - Officer: M = 16
    - NCO: M = 4
    - Enlisted: M = 1
  - Distance
    - 50-300 meters: 0.5 ≤ M ≤ 2
    - Otherwise: M = 0
  - Visibility — M = LOS_hits / LOS_attempts

1) Weight <= 0
2) Screen rank
3) Very small weight
4) Weighted Random

$$R_O = Max_{i=1}^{n}(R_i)$$

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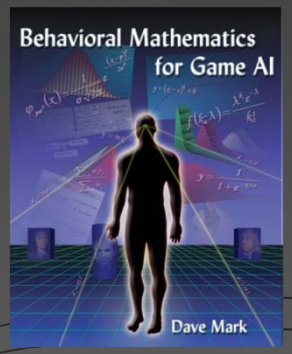

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