From Skyrim to Metal Gear Solid - A buddy AI journey

Jonathan Tremblay
Player
Companion
Combat: targeting an enemy

Stealth movement

Understanding player
Targeting problem
Companions’ influence

- Strategies are poor
- Player needs to interact with their behaviour
- Player do not trust them
Attack: $a$
Health: $h$
Rules

• Entities select target to attack
• Blue team attacks first
• Attack value is subtracted from targets’ health
Strategies

- Target randomly
- Target lowest health
- Target highest attack
Lowest health

P

E₁

E₂

h:12
a:2

h:5
a:1

h:6
a:2
Lowest health

P

E₁

h:3
a:1

E₂

h:6
a:2

h:9
a:2
Lowest health

P

E₁

E₂

h:6
a:2

h:1
a:1

h:6
a:2
Lowest health

P

E₁

E₂

h: 4
a: 2

h: 0
a: 1

h: 6
a: 2
Lowest health

- P: h:2, a:2
- E₁: h:0, a:1
- E₂: h:4, a:2
Lowest health

- P: h:0, a:2
- E₁: h:0, a:1
- E₂: h:2, a:2
Lowest health

P

h:0
a:2

E₁

h:0
a:1

E₂

h:2
a:2
Highest Attack

$P$

$E_1$

$E_2$

$h:12$
$a:2$

$h:5$
$a:1$

$h:6$
$a:2$
Highest Attack

P

E₁

h:5
a:1

E₂

h:4
a:2

P

h:9
a:2
Highest Attack

- P
  - h: 6
  - a: 2

- E₁
  - h: 5
  - a: 1

- E₂
  - h: 2
  - a: 2
Highest Attack

P → E₁

h:5  a:2

E₁ → E₂

h:0  a:2
Highest Attack

P

E₁

E₂

h: 4
a: 2

h: 3
a: 1

h: 0
a: 2
Highest Attack

P

E₁

E₂

h:3
a:2

h:1
a:1

h:0
a:2
Highest Attack

- P (h:3, a:2) to E₁ (h:0, a:1)
- E₂ (h:0, a:2)
PSPACE-Hard [Furtak et al.]
Threat Ordering

• What is the threat of an enemy?
• Attack within respect of health
• The benefit of killing that enemy and not an other one
$M$ enemies vs. $N$ players
Strategies

- Threat ordering
- Closest
- Highest attack
- Lowest health
Tank level
Independent vs. Mimicking
Tank level - mimic
Heuristic vs. Optimal

% of The Optimal

% Trials (Cumulative)
Threat Ordering

- Approximation of a hard problem
- Insights on the cost of bad strategies
- 50% time finds optimal and usually within 1% of the optimal
Stealth movement
Sneaking
Sneaking
Sneaking
Sneaking
Sneaking
Can we compute an undetected path from A to B?
Assumptions

- Level geometry
- Enemies’ deterministic movement
- Cannot be detected
- Initial and goal position
Overview

• Defining the state space
• Rapidly exploring Random Tree (RRT)
• Presenting results
Discretized Space

- **Obstacles**
- **Seen**
- **Walkable**
Search Space

![Diagram of a 3D search space with a 2D configuration space and slices in time (t)]
RRT
RRT
RRT

- Run multiple times
- Randomly exploring the space
- None optimal paths
Clustering

[Smith 06]
Quick Demo
Understanding the player
Which path is the safest?
Defining risk

- Distance to the enemy
- Distance to the enemy’s field of view
- Nearly seen
- Shortest path
- \textit{etc.}
Which path is the safest?
What is a path?
Metrics

Distance to the enemy (DIST)

Line of sight cost (LOS)

Nearly missed (NM)
Distance (Dist)

- Scaled distance from player to enemy
- Summed over enemies
- Divided by length path
Los

- From player to enemy’s FOV.
- Cost function based on angle
- Scale to the distance
Nearly Missed

- Check the past and future positions
- Cost if seen based on time
Human study
# Results

<table>
<thead>
<tr>
<th>Level</th>
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<th>3</th>
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</table>

- Human: 10
- Dist: 10
- LOS: 8
- NM: 9
Evaluating level difficulty
Evaluating level difficulty
Evaluating level difficulty

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Red</th>
<th>Blue</th>
<th>Green</th>
<th>Magenta</th>
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<tbody>
<tr>
<td>Dist ($\times 10^{-3}$)</td>
<td>0.6</td>
<td>0.2</td>
<td>3.7</td>
<td>0.9</td>
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<tr>
<td>LOS ($\times 10^{-2}$)</td>
<td>0.7</td>
<td>0.02</td>
<td>13.8</td>
<td>0.4</td>
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<tr>
<td>NM ($\times 10^5$)</td>
<td>2.0</td>
<td>1.6</td>
<td>2.8</td>
<td>2.4</td>
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Metrics

• Quantitative metrics to measure player’s experience

• Metrics correlate with human perception of risk

• Help understand level design
So Far

- Companion makes better target choices
- Offline stealth path finding
- Understanding notions of stealth risk
Still to come

- Guard interactions planning
- Online stealth path finding for companion
Not presented

• Combat/stealth simulator
• Player simulator in the platformer domain
• Clustering similar paths
• Advance visualization of stealth space
• Automatically placing guards in a level
Special thanks

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- Nir Ricovitch
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- Alexander Borodovski
- Jonathan Campbell
References


Thank you

Jonathan Tremblay
jtremblay@cs.mcgill.ca
Adding combat
Threat ordering

\[
\max_{e \in E} \left[ e \cdot a \cdot (E_h - e_h) \right]
\]
Distance

\[
\text{Dist}(p) = \sum_{t=1}^{T} \left[ \sum_{e \in E} \frac{1}{d^*(g(p, t), g(e, t))^3} \right]
\]
\[ \text{LOS}(p) = \frac{\sum_{t=1}^{T} \left[ \sum_{e \in E} \frac{\text{Cost}(\theta(g(p,t), g(e,t)))}{d^*(g(p,t), g(e,t))^3} \text{Vis}(p, e, t) \right]}{L} \]
Nearly Missed

\[
\text{Seen}(\alpha, \tau) = \begin{cases} 
1 & \text{if } (\alpha_x, \alpha_y, \tau) \in \chi_{FOV} \\
0 & \text{otherwise}
\end{cases}
\]

\[
W^-(t, n) = \sum_{i=1}^{n} (n - i)^2 \cdot \text{Seen } (g(p, t - i), t)
\]

\[
W^+(t, m) = \sum_{i=1}^{m} (m - i)^2 \cdot \text{Seen } (g(p, t + i), t)
\]

\[
\text{NM(Path)} = \sum_{t=1}^{T} (W^-(t, n) + W^+(t, m))
\]