IGDA日本 GDC 12 報告会

三宅　陽一郎 (IGDA日本 SIG-AI世話人)

2012.3.31

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自己紹介

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- Facebook: http://www.facebook.com/youichiro.miyake

- 講演資料・論文集:
  http://blogai.igda.jp/article/46500782.html

- 著書:
  「デジタルゲームの教科書」(共著:ゲームAI技術，ゲーム・プロシージャル技術)
  「デジタルゲームの技術」(ロングインタビュー)
  「ゲームプログラマのためのC++」(監修)

IGDA日本 SIG-AI メイリングリスト会員募集中！僕まで連絡！(@miyayou スパムとも言う！)
月一でゲームAIラウンドテーブル開催中。With @hudepen

ソーシャル系AIの流れ

- 日本ではあまり研究されていないが、海外では、会話(Narrative)の研究が2～3年前から、序々に大きくなりつつある。

Prom Week (UC Santa Cruz)

http://games.soe.ucsc.edu/project/prom-week

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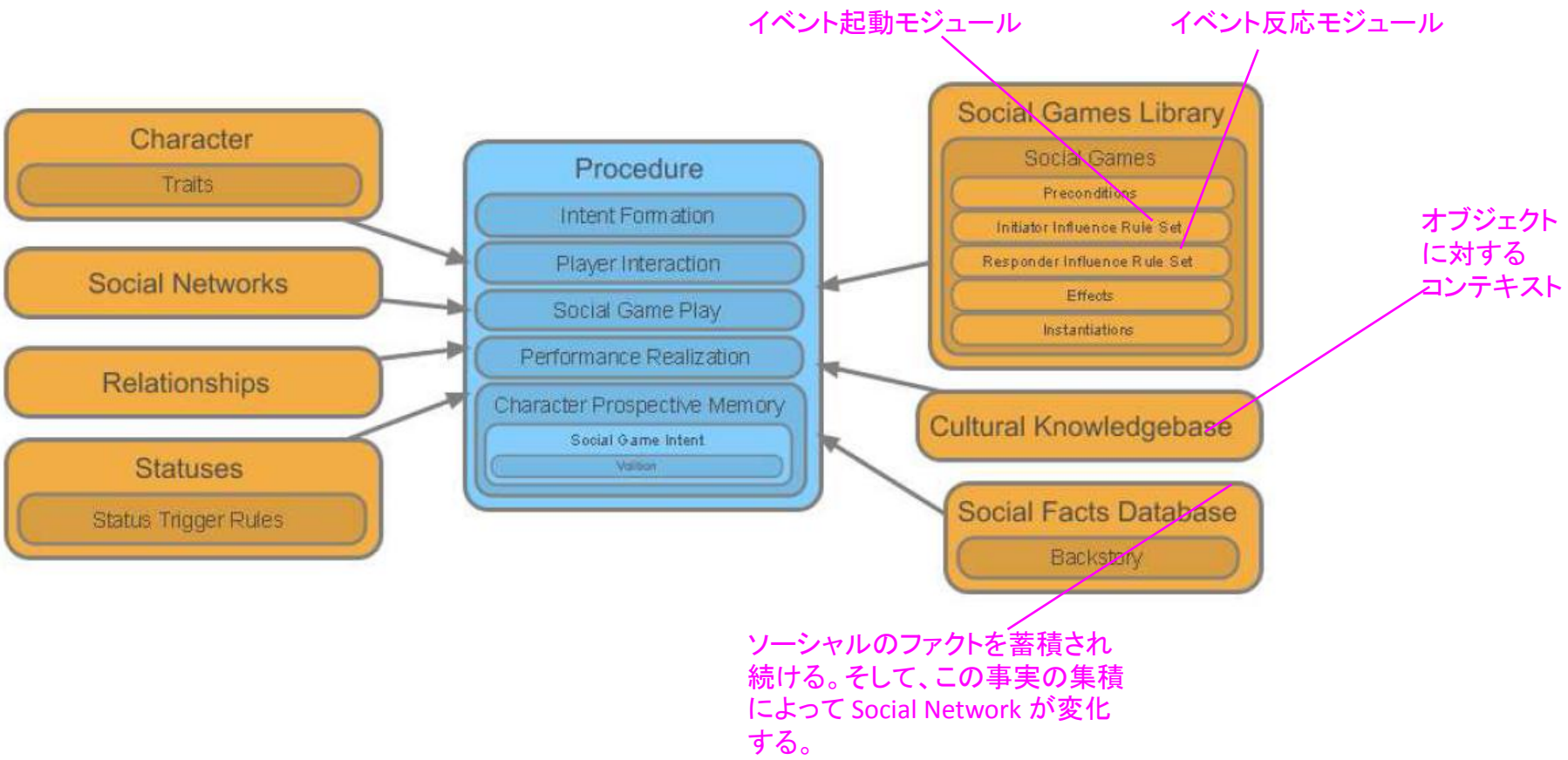
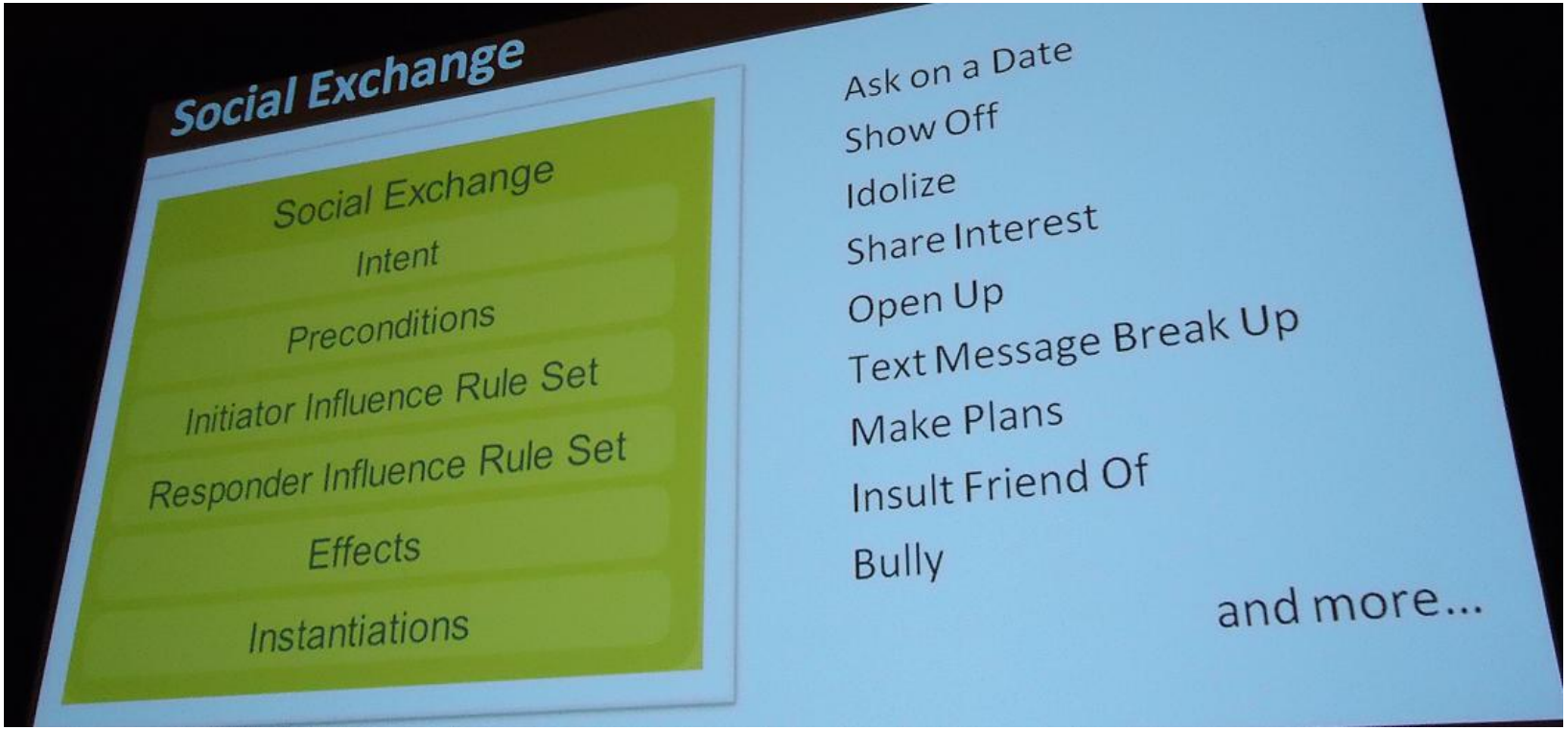


http://games.soe.ucsc.edu/sites/default/files/TheProm-ELOAI.pdf

Beyond Eliza: Constructing Socially Engaging AI

SPEAKER/S: Josh McCoy (Expressive Intelligence Studio at U.C. Santa Cruz), Richard Evans (Little Text People), Emily Short (Independent), Stephane Bura (Storybricks) and Michael Treanor (Expressive Intelligence Studio at UC Santa Cruz)

http://schedule.gdconf.com/session/6683/Beyond_Eliza%3A_Constructing_Socially_Engaging_AI



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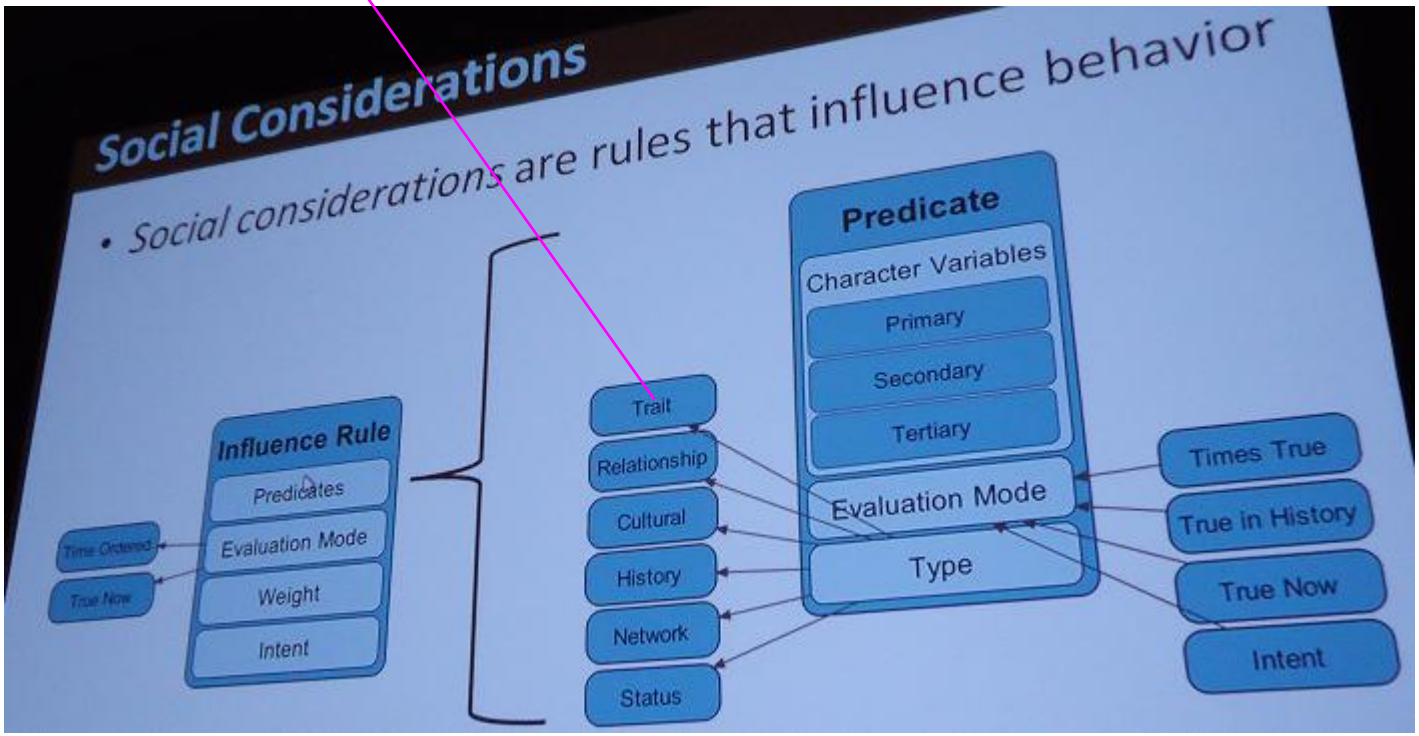
特徴



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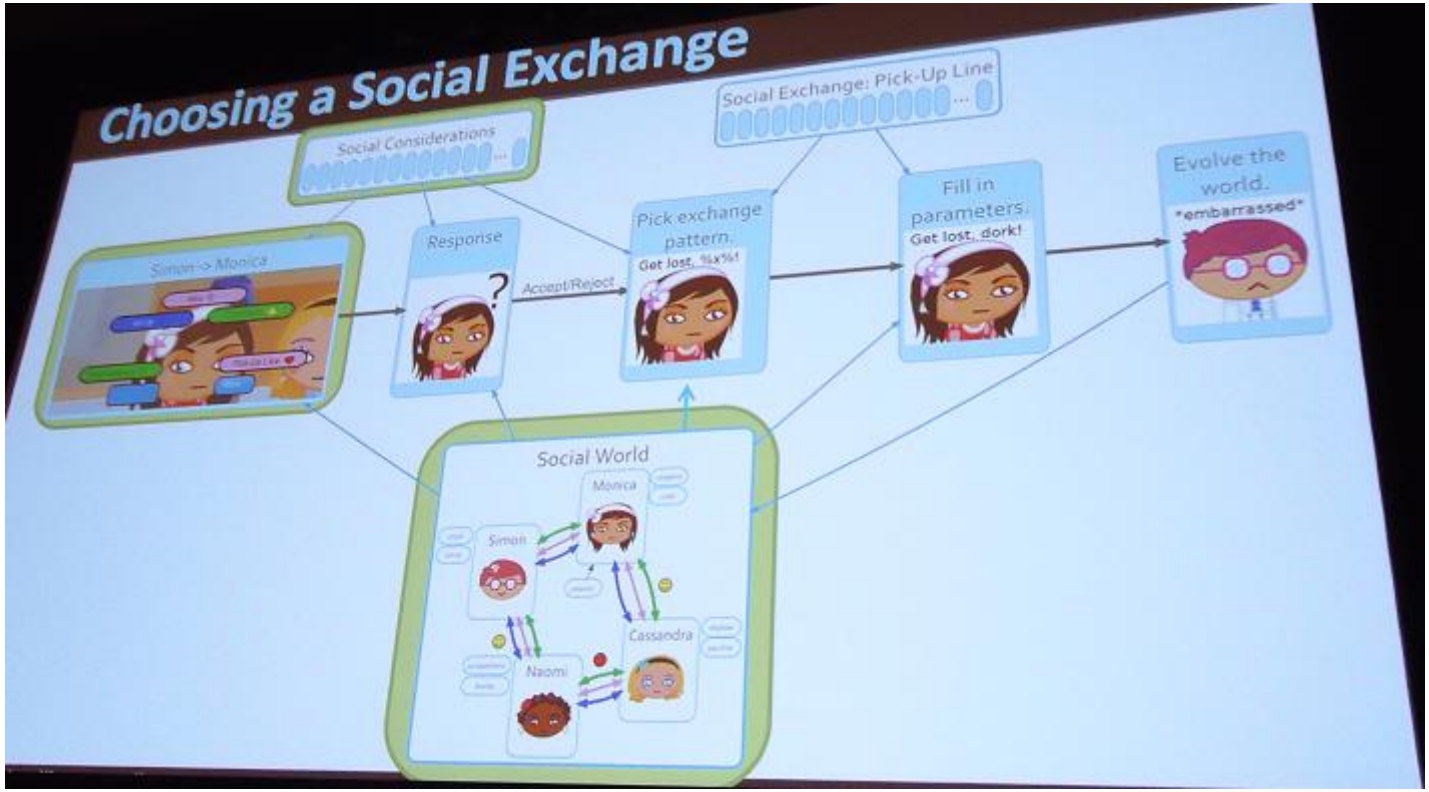

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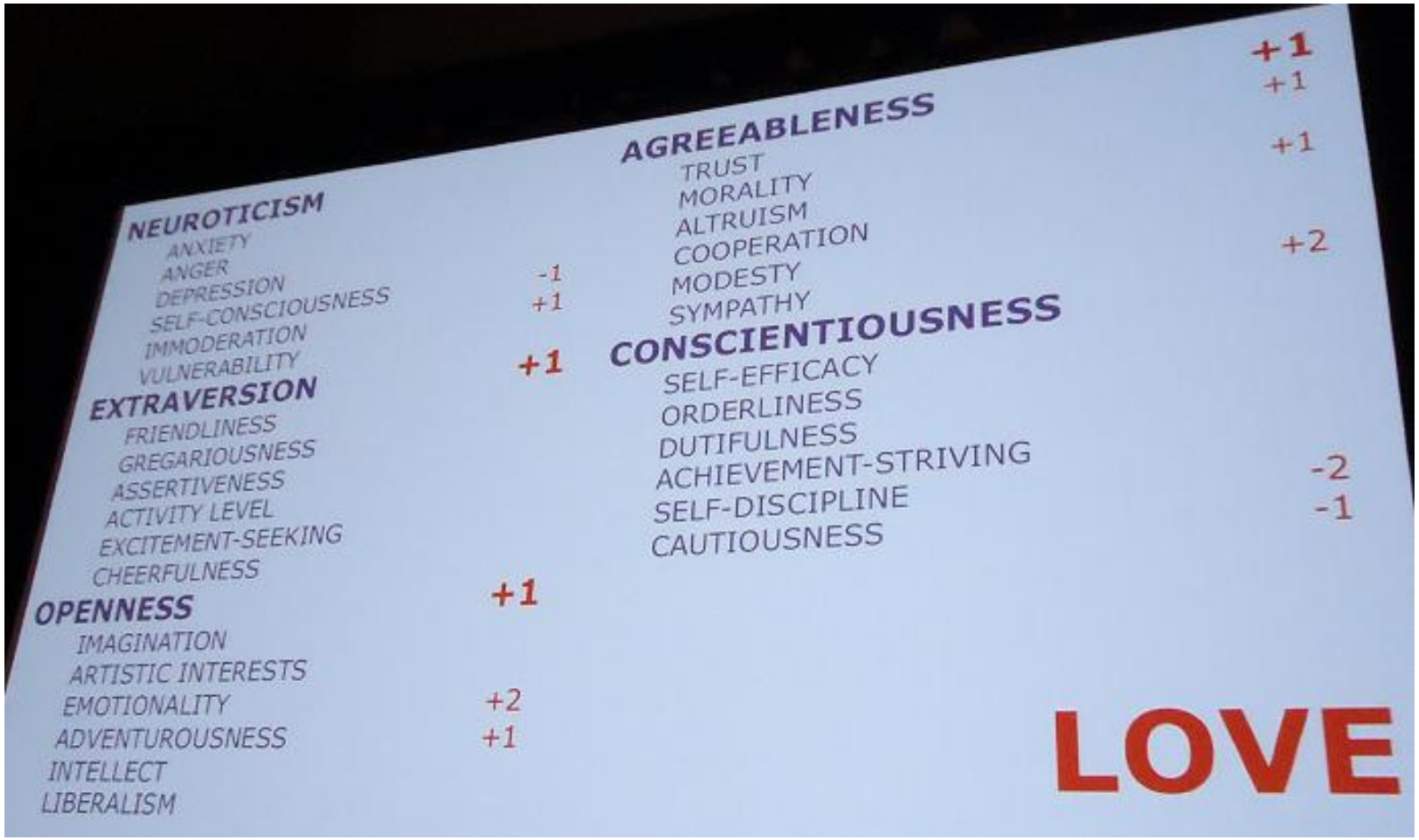
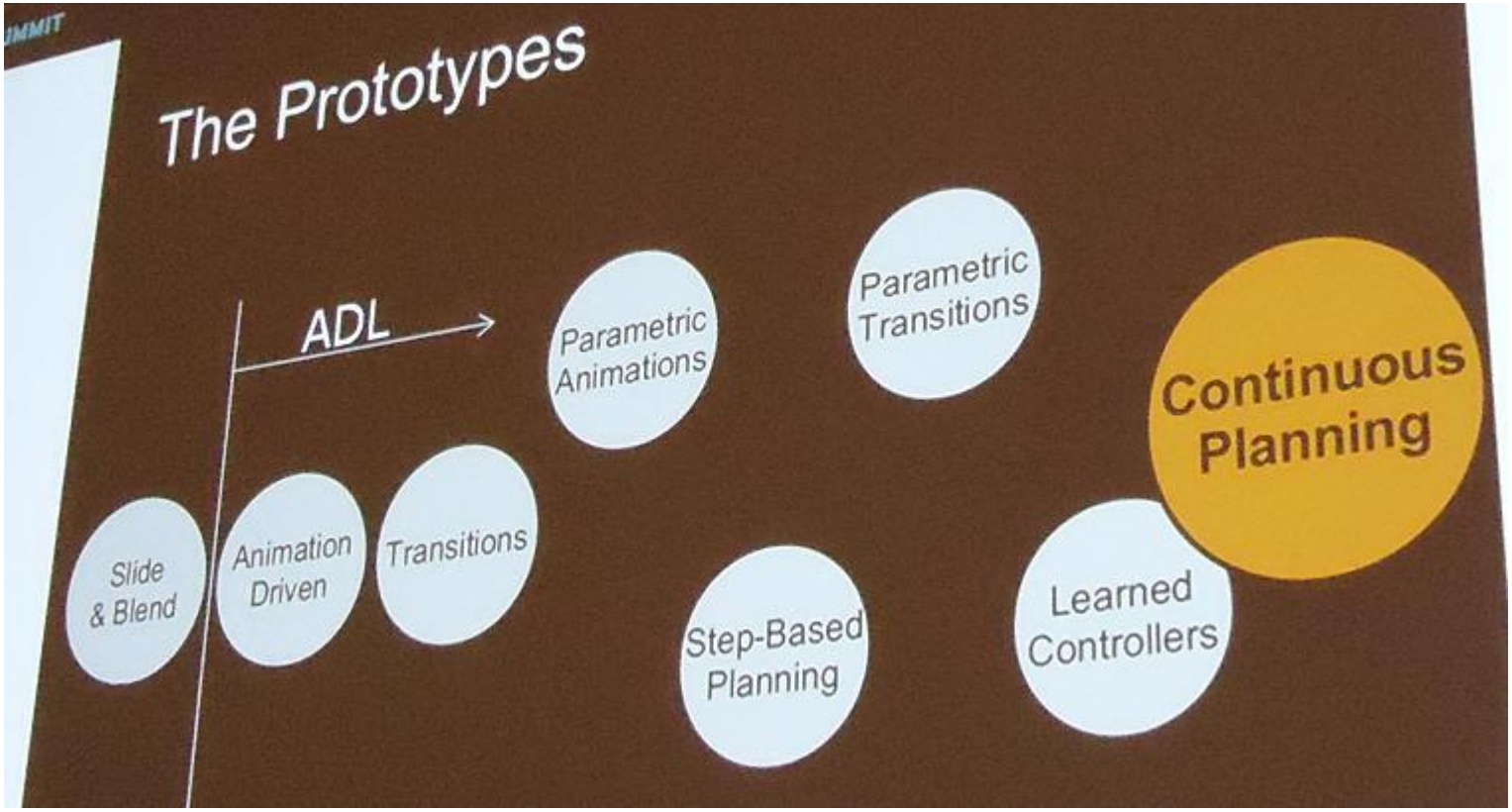


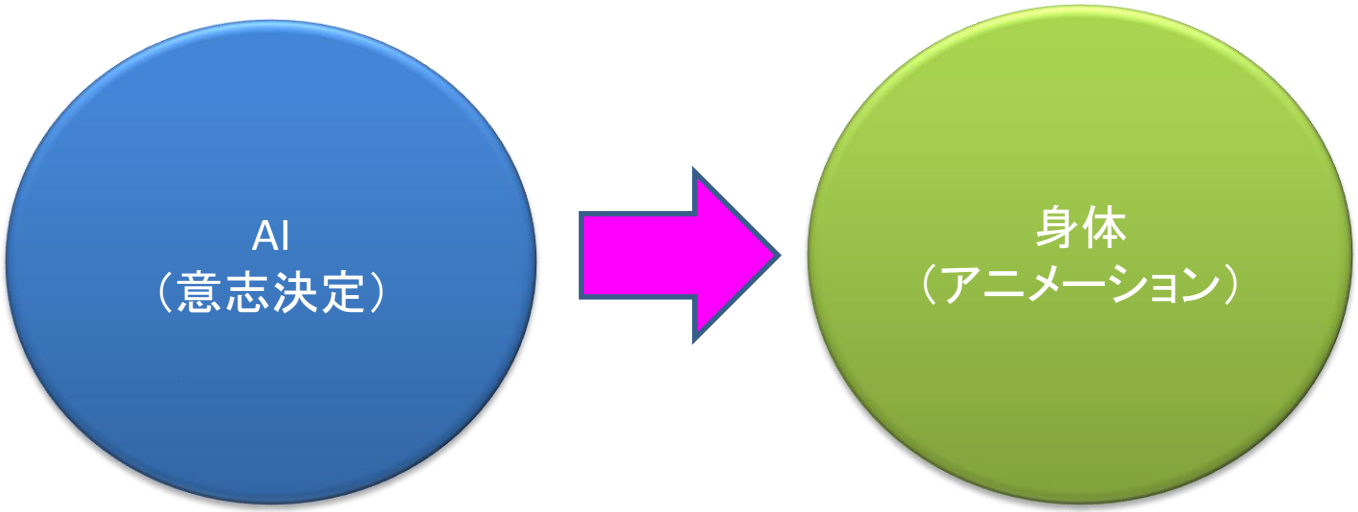
Animation Driven Locomotion for Smoother Navigation

SPEAKER/S: Bobby Anguelov (IO Interactive), Gabriel Leblanc (Eidos Montreal) and Shawn Harris (Big Huge Games/38 Studios)

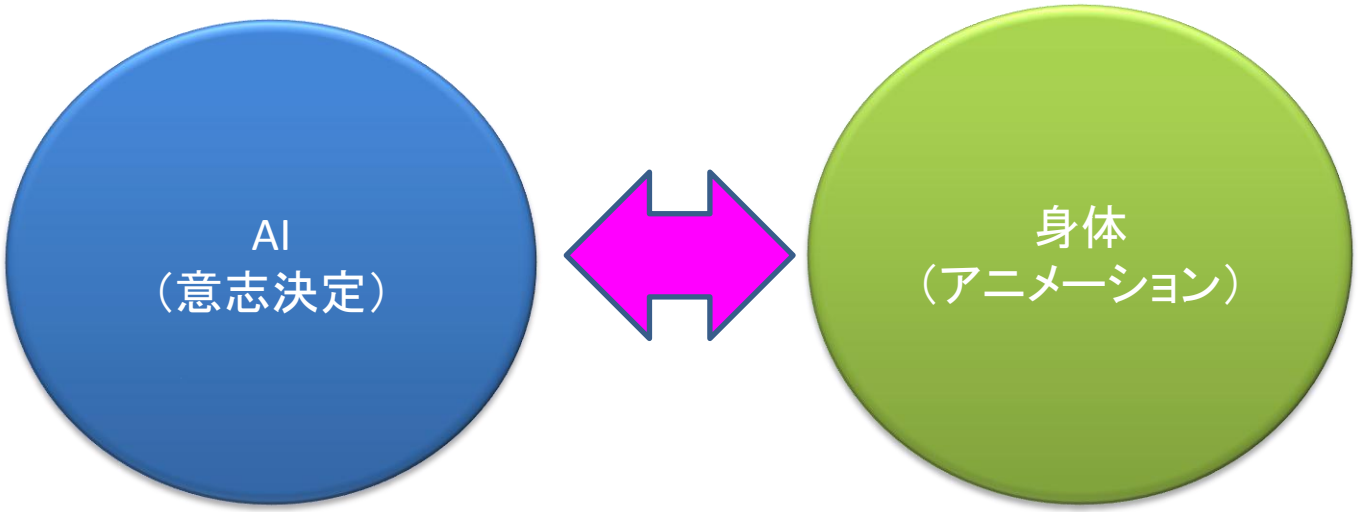


ADL = Animation Driven Locomotion System

AIとアニメーションの関係



AIとアニメーションの関係



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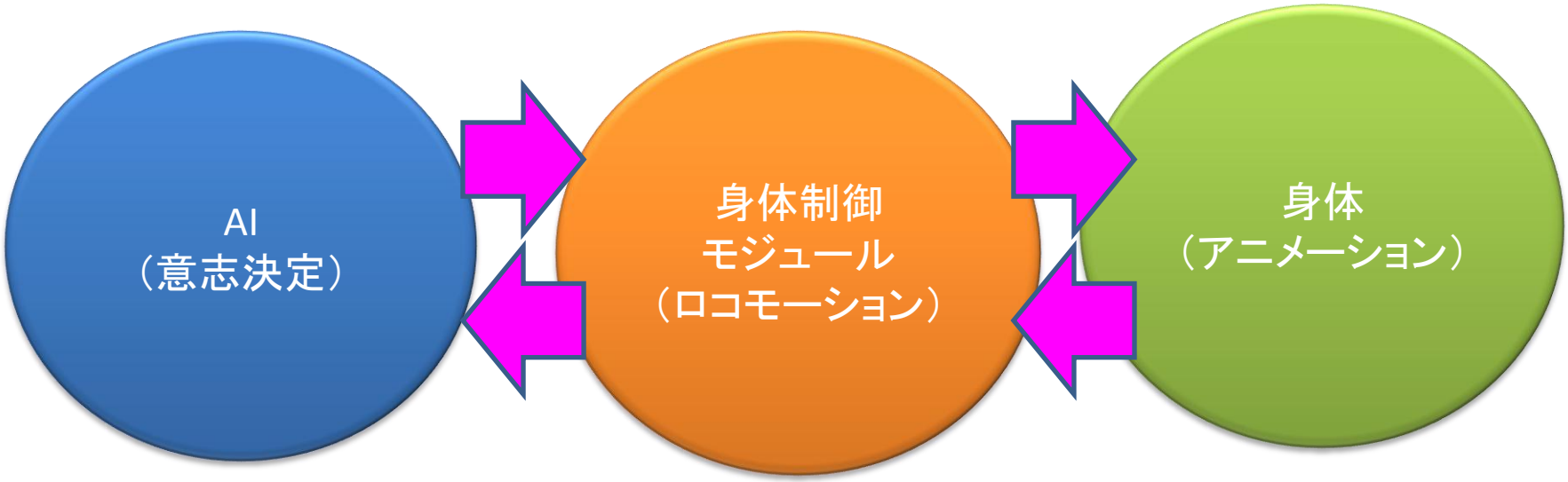

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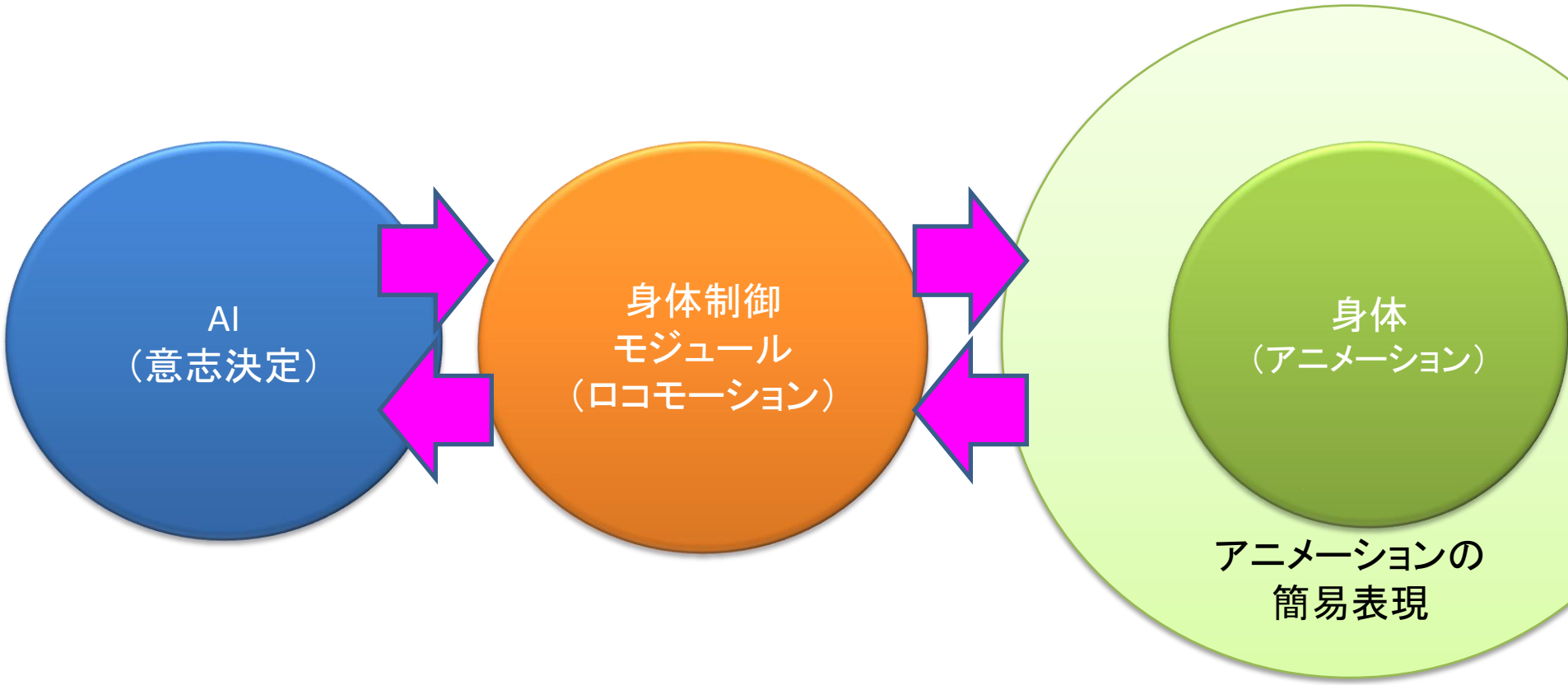
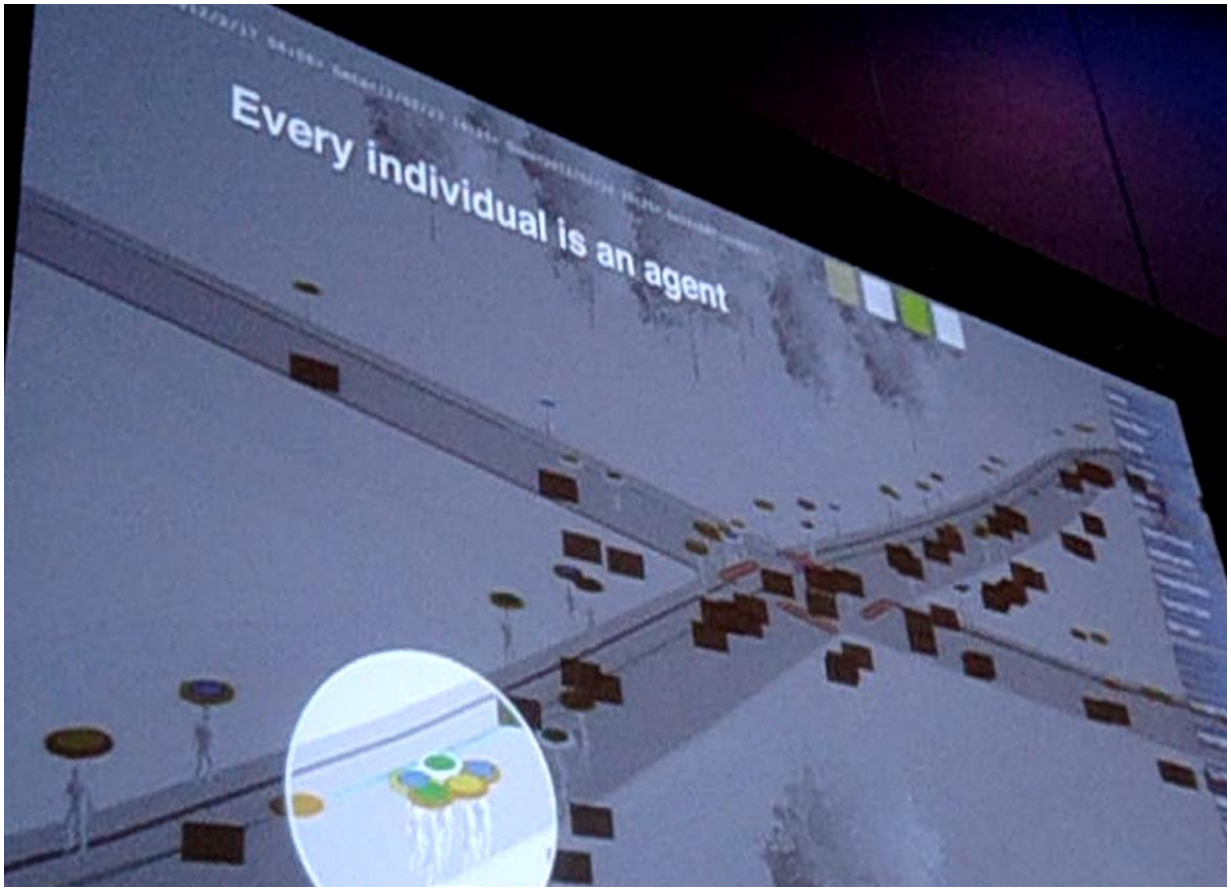


アニメーションの簡易表現＝特徴データ
→　ロコモーション

Inside the GlassBox (Presented by EA)

SPEAKER/S: Ocean Quigley (EA), Andrew Willmott (EA) and Dan Moskowitz (EA)



EA Maxis のシミュレーション・ゲームエンジン （SimCity 4へ向けて）
あらゆるものをシミュレーションしようとする思想。
- あらゆる動く単体はエージェント
- 発展シミュレーション　- 経済シミュレーション
- 輸送シミュレーション　- 災害シミュレーション
- 歩行シミュレーション

Inside GlassBox - Andrew Willmott
http://www.andrewwillmott.com/talks/inside-glassbox

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- 歩行シミュレーション

Inside GlassBox - Andrew Willmott
http://www.andrewwillmott.com/talks/inside-glassbox

確かにシミュレーション技術の蓄積は次世代エンジンでは課題かもしれない。

Inside the GlassBox (Presented by EA)

SPEAKER/S: Ocean Quigley (EA), Andrew Willmott (EA) and Dan Moskowitz (EA)

動画

http://www.ea.com/jp/sim-city/videos/0e249b3e68736310VgnVCM2000001165140aRCRD

Inside the GlassBox (Presented by EA)

SPEAKER/S: Ocean Quigley (EA), Andrew Willmott (EA) and Dan Moskowitz (EA)

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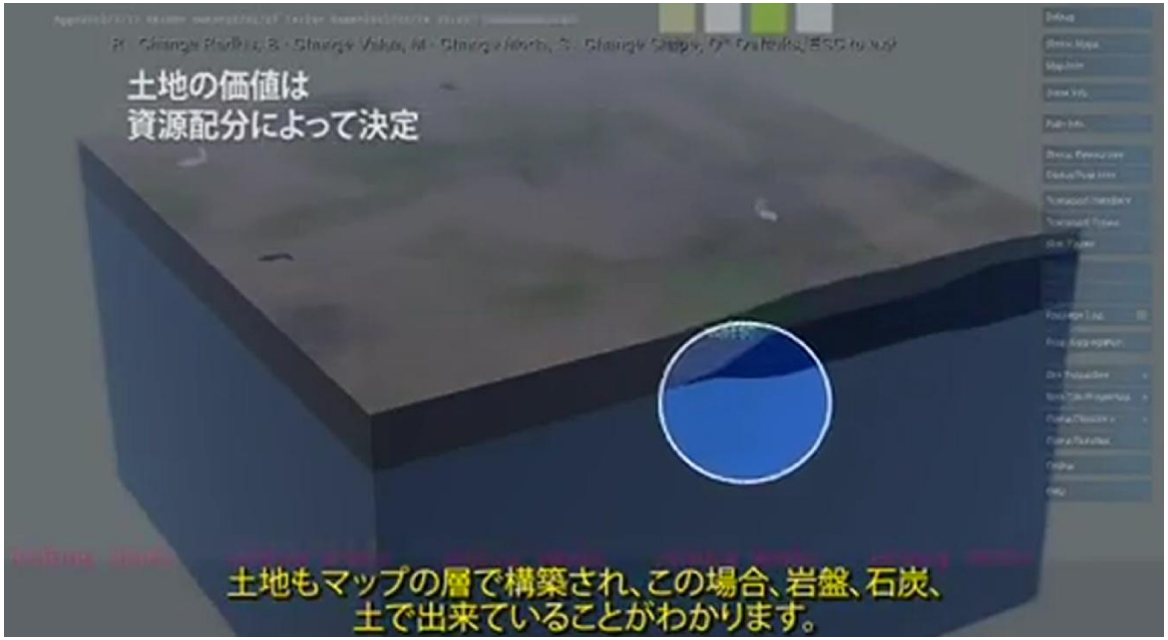


- シミュレーション技術はゲームエンジンのコンテンツ部分への上乗せだけで終わらない部分がある。
- そもそもデータの作り方からして違う。

Inside GlassBox - Andrew Willmott
http://www.andrewwillmott.com/talks/inside-glassbox

Inside the GlassBox (Presented by EA)

SPEAKER/S: Ocean Quigley (EA), Andrew Willmott (EA) and Dan Moskowitz (EA)

Distance Field (後述)

D*-Lite
= 動的な環境におけるA* 検索
- メモリを動的に多く取る。
- 逐次的計算する。

Inside GlassBox - Andrew Willmott
http://www.andrewwillmott.com/talks/inside-glassbox

http://idm-lab.org/bib/abstracts/papers/aaai02b.pdf

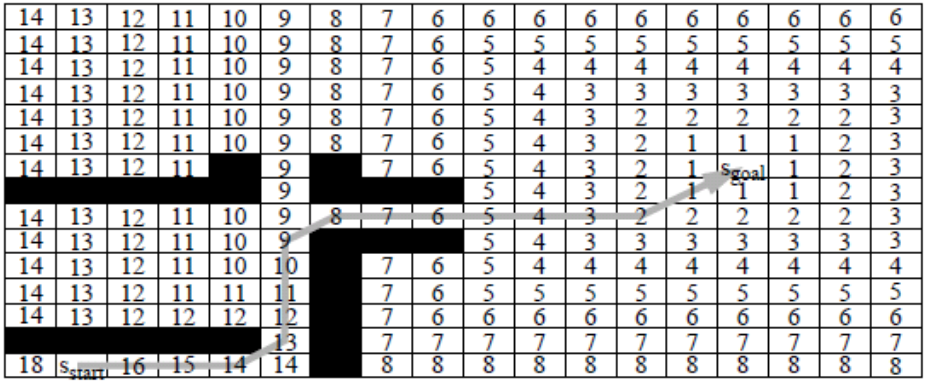
D* Lite

A* < LPA (Lifelong A*) < D* lite

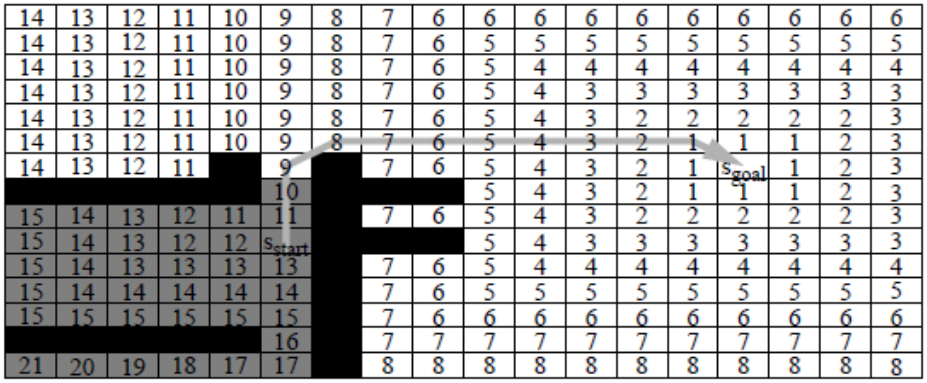
```
procedure CalcKey(s)
{01'} return [min(g(s), rhs(s)) + h(s_start, s); min(g(s), rhs(s))];
procedure Initialize()
{02'} U = ∅;
{03'} for all s ∈ S rhs(s) = g(s) = ∞;
{04'} rhs(s_goal) = 0;
{05'} U.Insert(s_goal, CalcKey(s_goal));
procedure UpdateVertex(u)
{06'} if (u ≠ s_goal) rhs(u) = min_{s'∈Succ(u)}(c(u, s') + g(s'));
{07'} if (u ∈ U) U.Remove(u);
{08'} if (g(u) ≠ rhs(u)) U.Insert(u, CalcKey(u));
procedure ComputeShortestPath()
{09'} while (U.TopKey() < CalcKey(s_start) OR rhs(s_start) ≠ g(s_start))
{10'}   u = U.Pop();
{11'}   if (g(u) > rhs(u))
{12'}     g(u) = rhs(u);
{13'}     for all s ∈ Pred(u) UpdateVertex(s);
{14'}   else
{15'}     g(u) = ∞;
{16'}     for all s ∈ Pred(u) ∪ {u} UpdateVertex(s);
procedure Main()
{17'} Initialize();
{18'} ComputeShortestPath();
{19'} while (s_start ≠ s_goal)
{20'}   /* if (g(s_start) = ∞) then there is no known path */
{21'}   s_start = arg min_{s'∈Succ(s_start)}(c(s_start, s') + g(s'));
{22'}   Move to s_start;
{23'}   Scan graph for changed edge costs;
{24'}   if any edge costs changed
{25'}     for all directed edges (u, v) with changed edge costs
{26'}       Update the edge cost c(u, v);
{27'}       UpdateVertex(u);
{28'}     for all s ∈ U
{29'}       U.Update(s, CalcKey(s));
{30'}     ComputeShortestPath();
```

Fig. 4. D* Lite: First Version.

Knowledge Before the First Move of the Robot



Knowledge After the First Move of the Robot



知識を含む探索。

S. Koenig and M. Likhachev. Fast Replanning for Navigation in Unknown Terrain. Transactions on Robotics, 21, (3), 354-363, 2005
http://idm-lab.org/publications.html

S. Koenig and M. Likhachev. Improved Fast Replanning for Robot Navigation in Unknown Terrain. Technical Report, GIT-COGSCI-2002/3, College of Computing, Georgia Institute of Technology, Atlanta (Georgia), 2002
http://idm-lab.org/bib/abstracts/papers/tr-dstarlite.pdf

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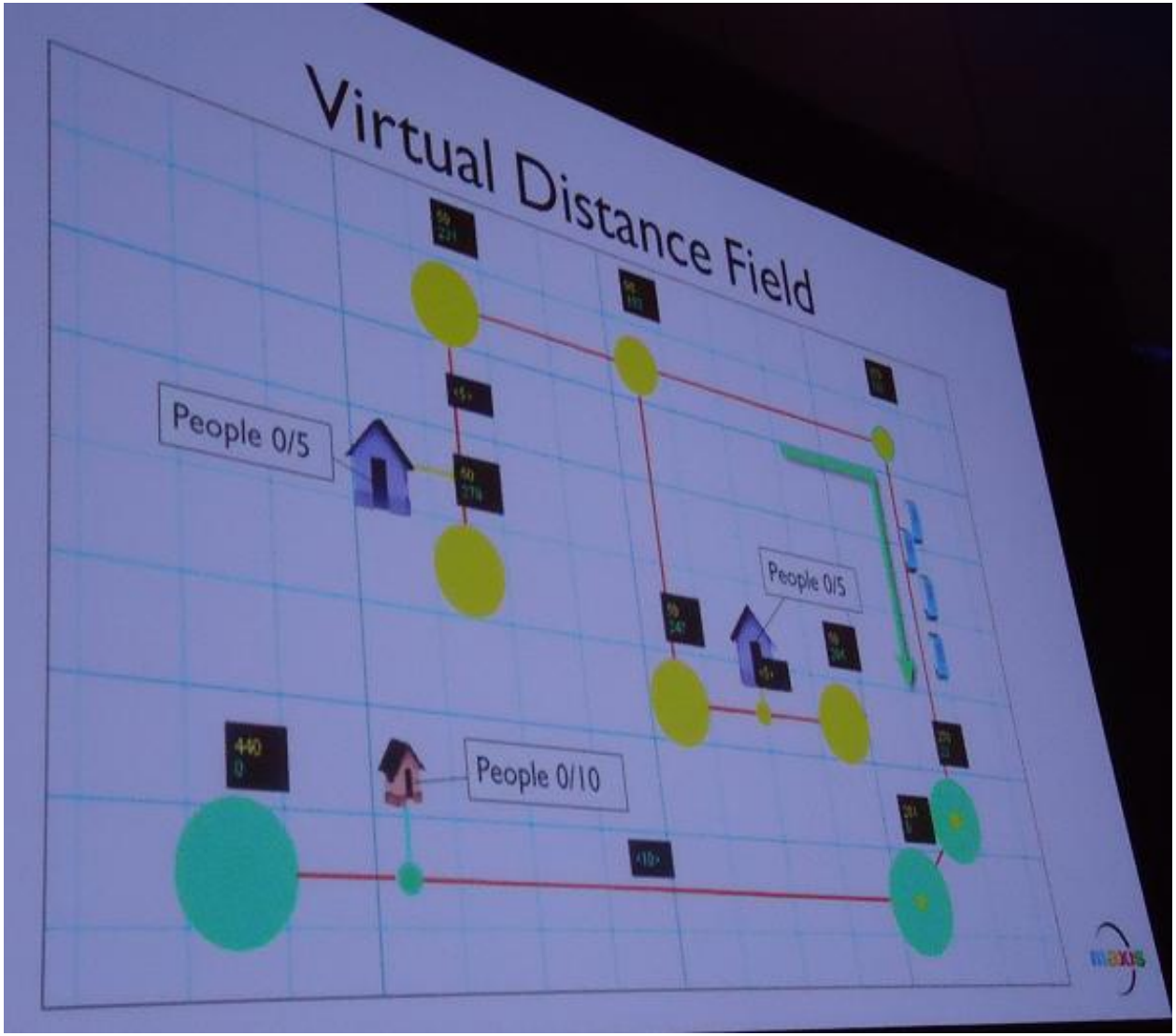

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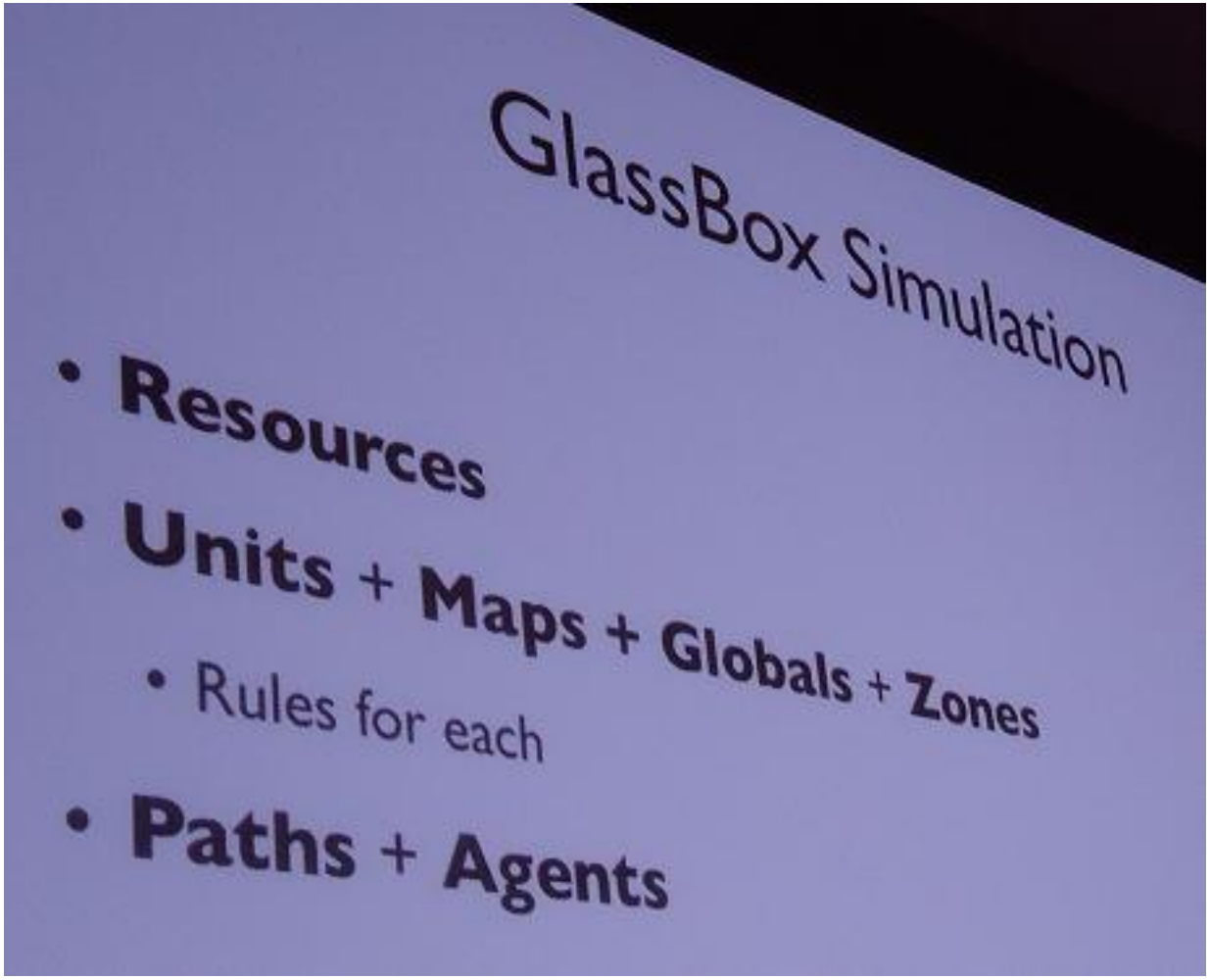
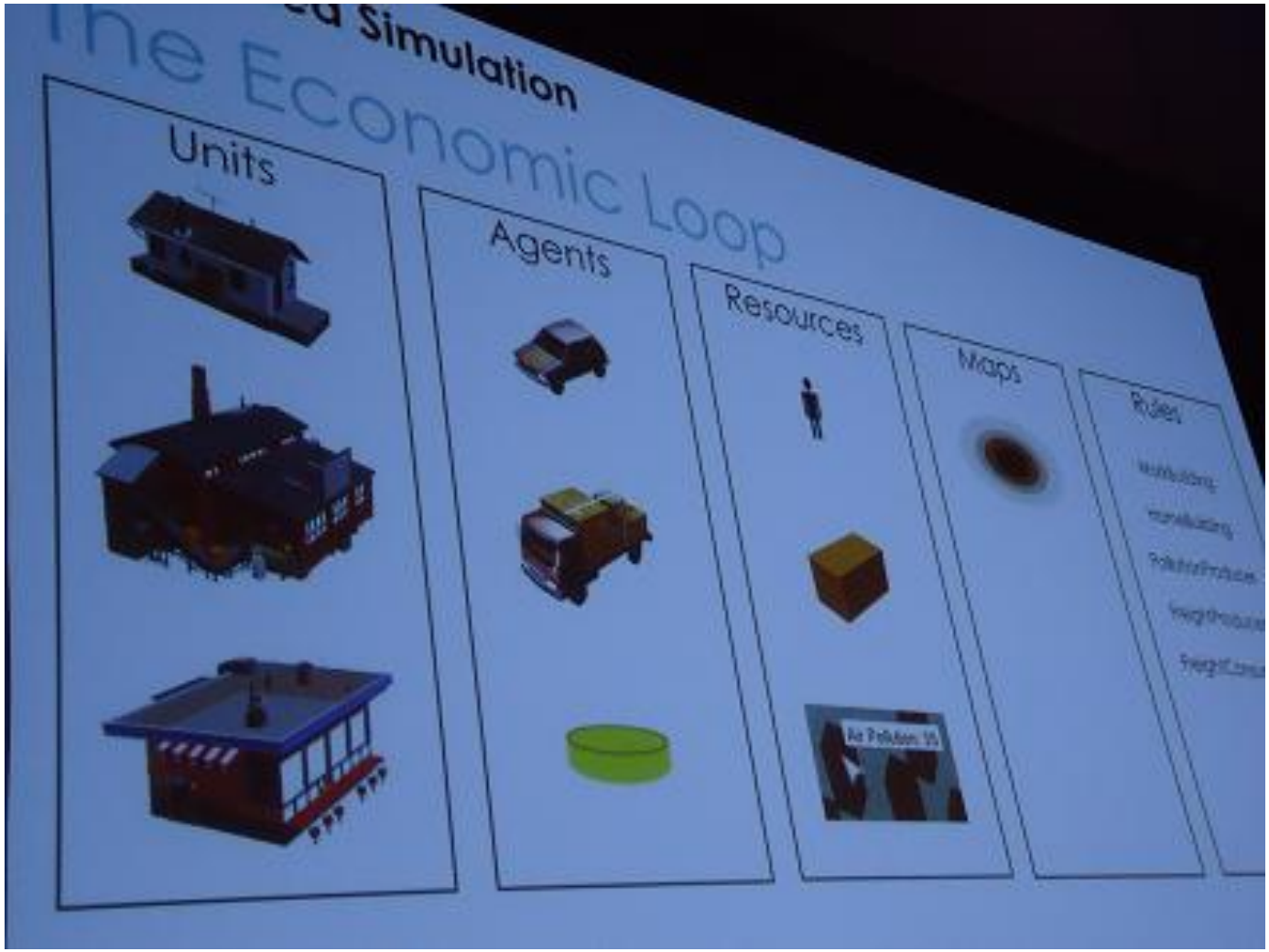


階層化されたルール

Inside GlassBox - Andrew Willmott
http://www.andrewwillmott.com/talks/inside-glassbox

Inside the GlassBox (Presented by EA)

SPEAKER/S: Ocean Quigley (EA), Andrew Willmott (EA) and Dan Moskowitz (EA)

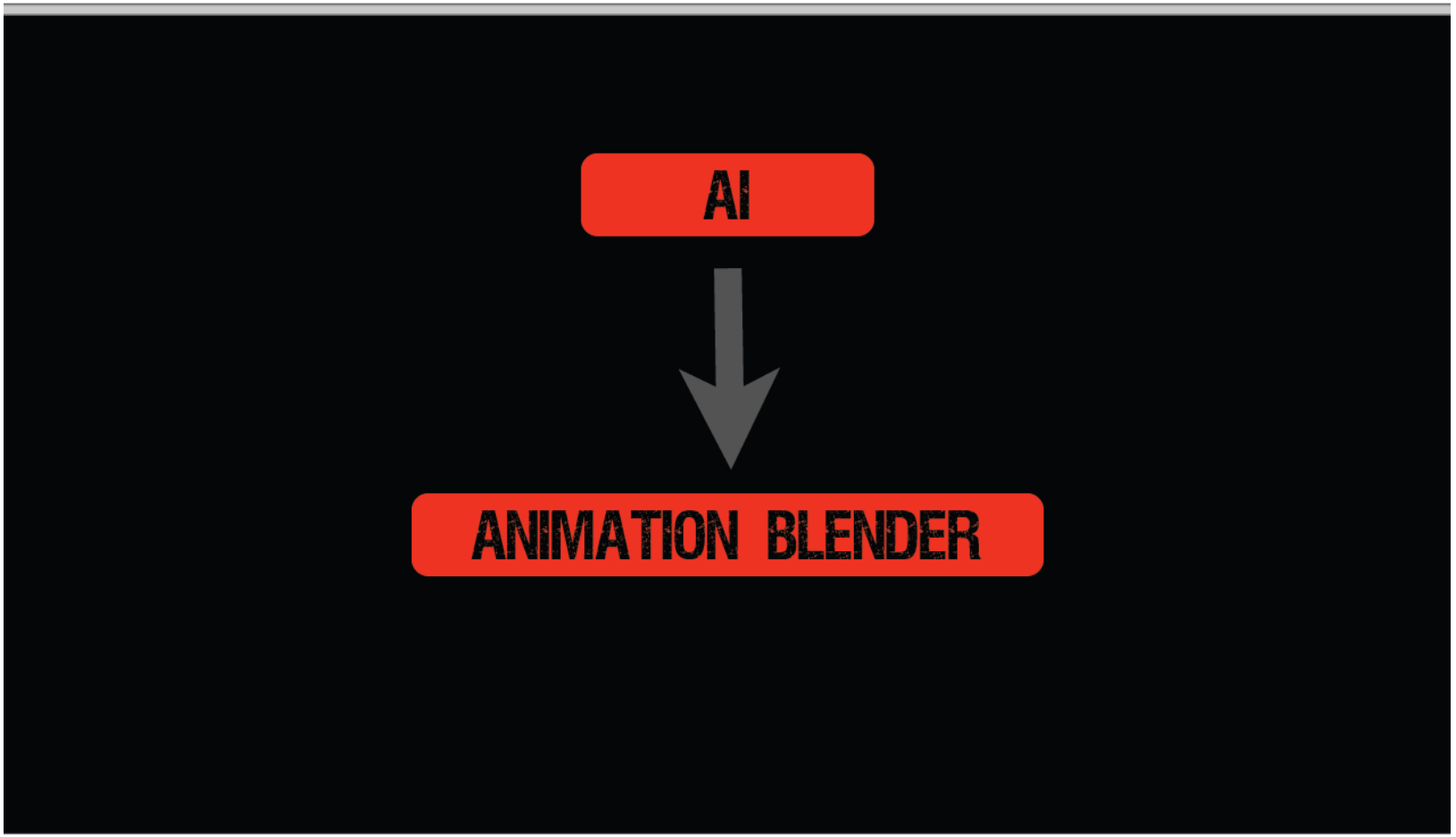


いろいろな「イベント」は幾つかのレベルに分けて表現される。

Inside GlassBox - Andrew Willmott
http://www.andrewwillmott.com/talks/inside-glassbox

The Creation of Killzone 3

Jan-Bart van Beek, Michal Valient, Marijn Giesbertz, Paulus Bannink | Siggraph 2011,Vancouver, August 2011



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Next I'll briefly explain how our AI system works and how this is triggering the animations on the characters... after that I'll go into more detail on our Animation blender tool.

The Creation of Killzone 3
Jan-Bart van Beek, Michal Valient, Marijn Giesbertz, Paulus Bannink | Siggraph 2011, Vancouver, August 2011
http://www.guerrilla-games.com/publications/

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In this image you can see typical encounter situation, where we have one of our **enemies** taking cover behind a large concrete block while being attacked by one of the **good guys**.

Our AI Agents obtain knowledge about the world through a sensory system. This sensory system tries to mimic human perception.

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Jan-Bart van Beek, Michal Valient, Marijn Giesbertz, Paulus Bannink | Siggraph 2011, Vancouver, August 2011
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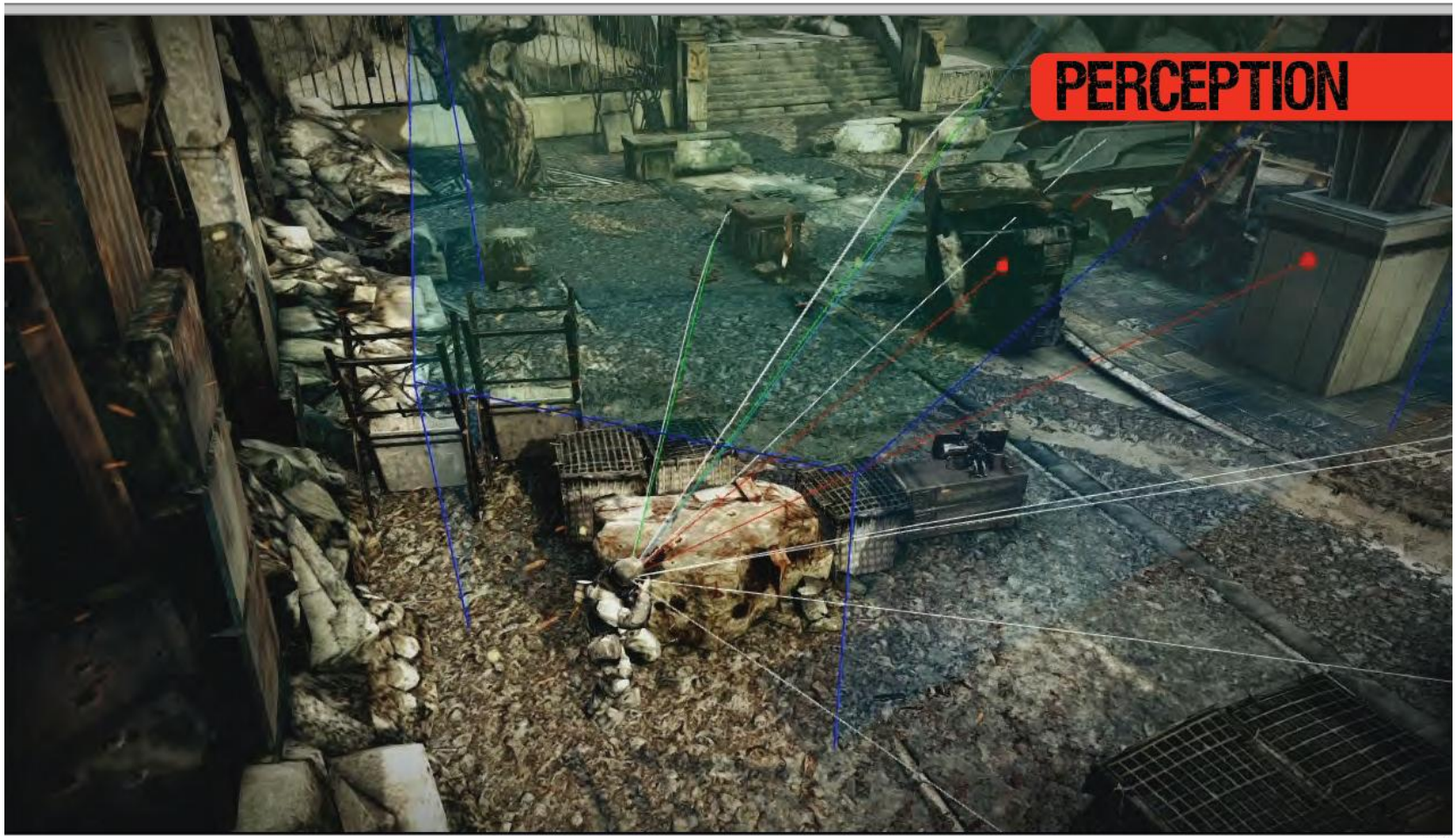

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The **vision part** of the sensory system consists of a cone (represented by the blue lines in this image), in which the agent can directly see things and a **hemisphere** which represents the peripheral vision of the agent. How well an agent can see is affected by distance... velocity... and atmosphere (like for example fog and smoke). In its peripheral vision an agent can only perceive motion.
The **hearing** part of the sensory system perceives sounds such as footsteps, explosions, bullet impacts and bullets whizzing by.

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Jan-Bart van Beek, Michal Valient, Marijn Giesbertz, Paulus Bannink | Siggraph 2011, Vancouver, August 2011
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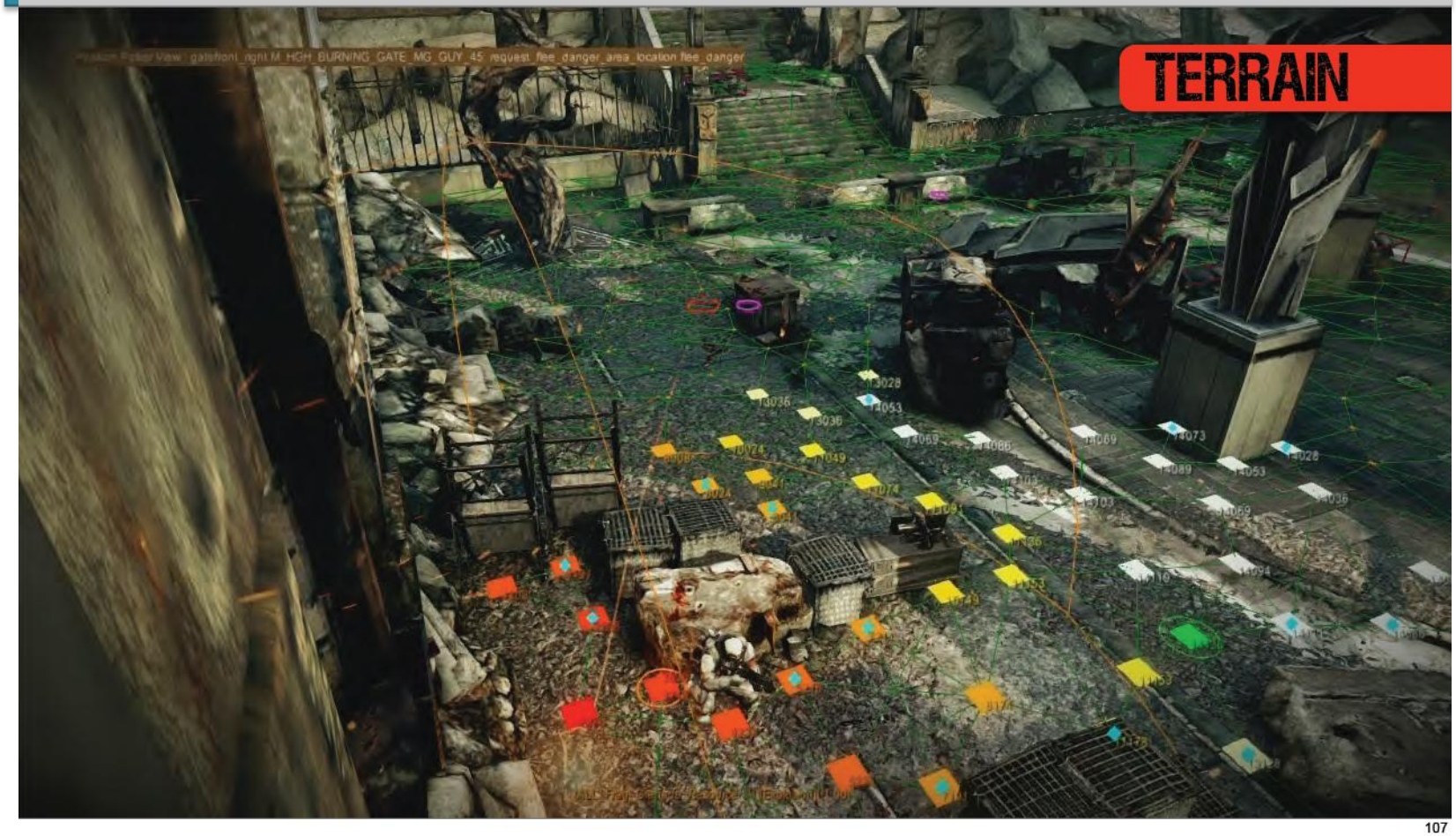

Terrain information

In order to navigate around the world agents need to know where they can walk and what areas are reachable. We use a graph of nodes called waypoints to describe the walkable areas of a level, represented by the green grid in this image.
The agents use these waypoints to decide where to move and how to get there.

The waypoints themselves contain information about cover. Determining whether or not a position provides cover is expensive to do at run-time. In order to be in cover you need your entire body to be obscured. It would require a huge amount of raycasts to check this.

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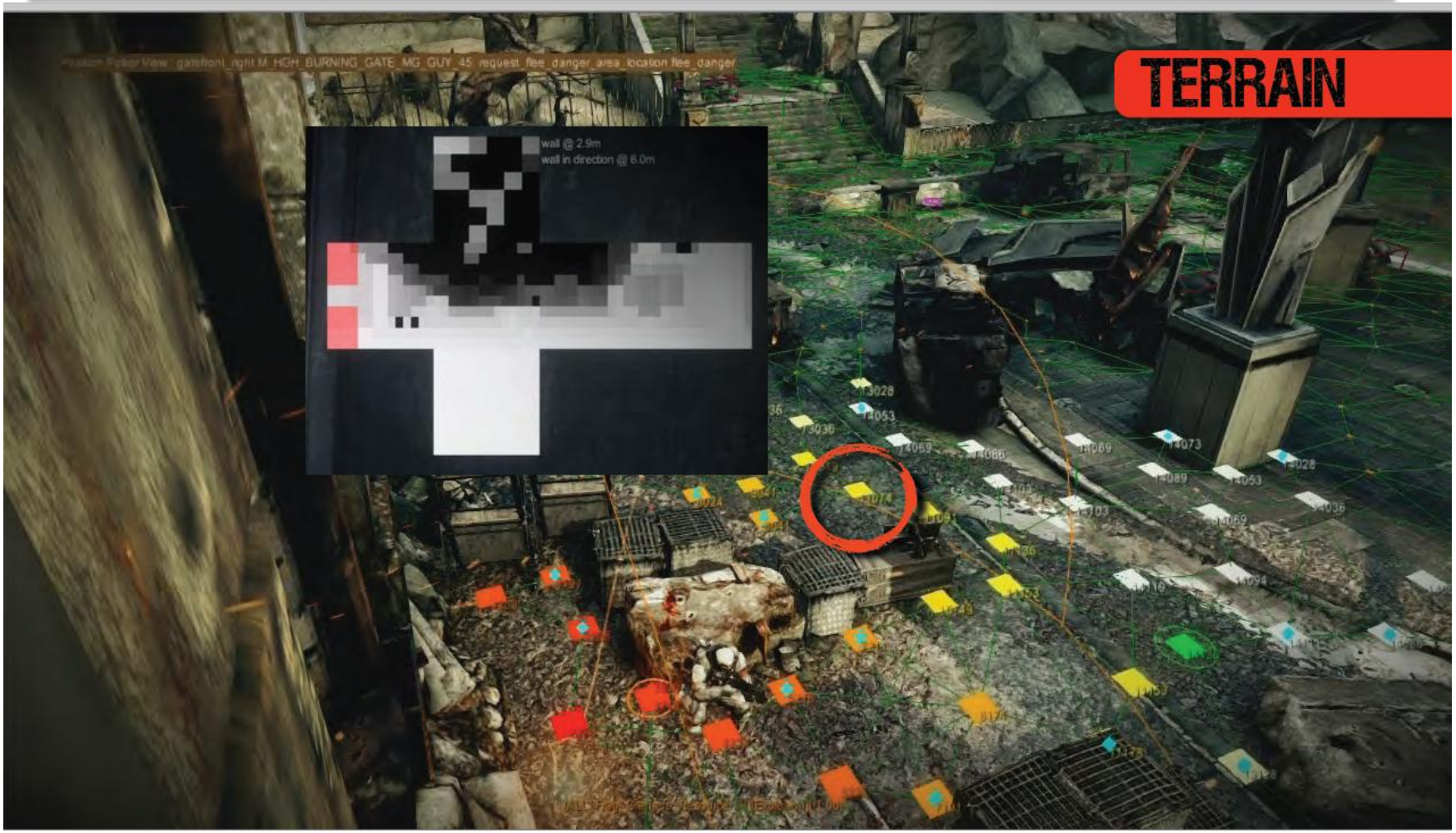

We solve this problem by precalculating a cover map for each waypoint. A cover map is a **cube map** containing depth values. The cover maps are generated in such a way that we can guarantee the entire body is in cover with a single check.

The waypoint graph and especially the cover information are expensive to generate and therefore are created offline. The calculation of the cover maps is distributed over multiple machines.

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execute plan

After the perceived data has been processed the agent forms a plan of action .

In the process of creating a plan we search for good positions in the **vicinity** of the agent. We **score** positions based on cover and attack opportunities....
distance to walls and enemies ....and many more.

The cover maps provided by the waypoints are essential to this process. In this image you can see the lowest scoring points in red and highest in green.

The executed plan is a sequence of actions the agent will perform, let's take a look at a example:

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Here you can see a grenade getting thrown near our agent.

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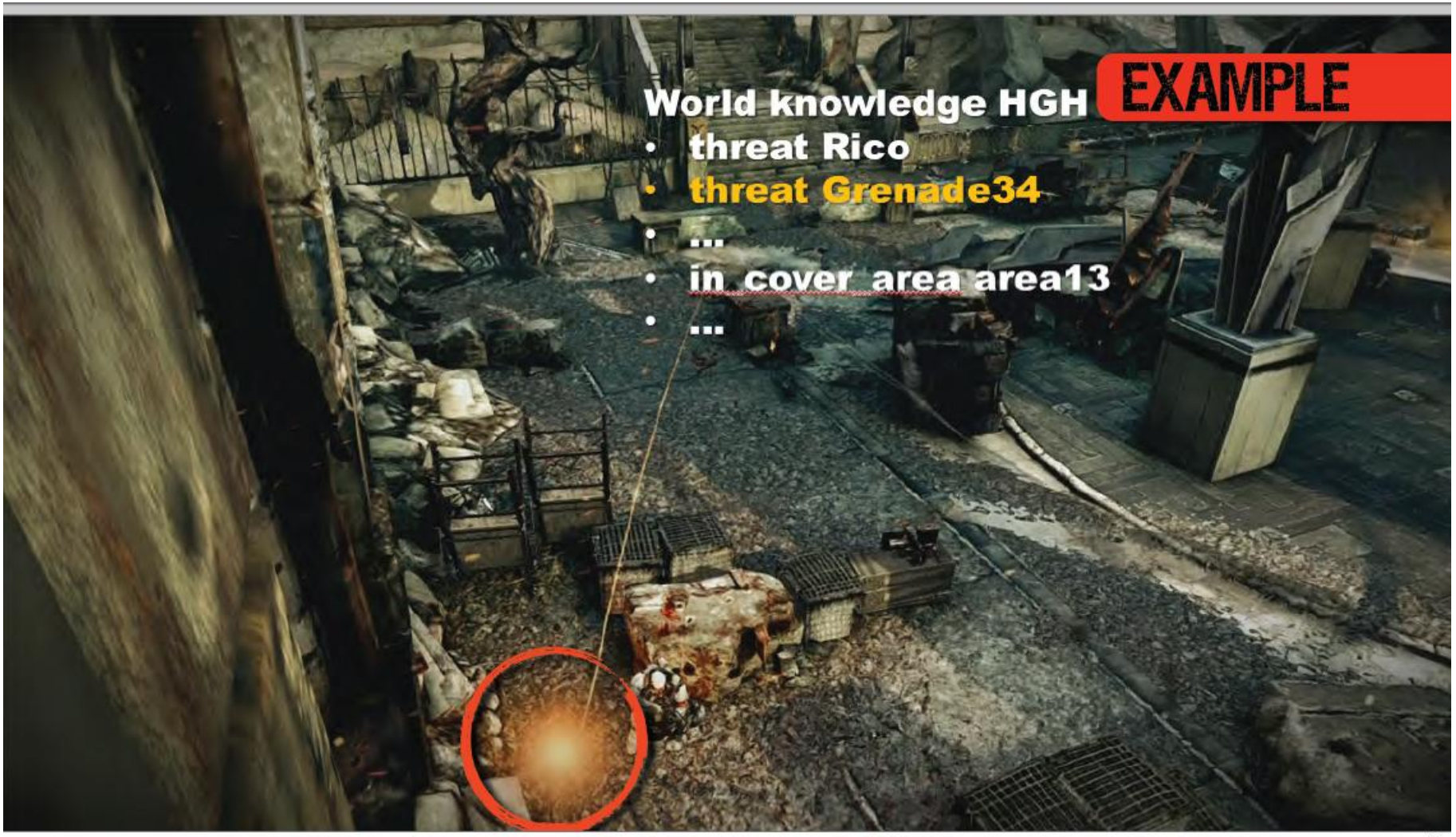

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our agent is aware of the new threat.

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http://www.guerrilla-games.com/publications/

The Creation of Killzone 3

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Based on this plus the terrain knowledge a decision is made to go out of cover and flee to a safer spot, represented by the green waypoint.

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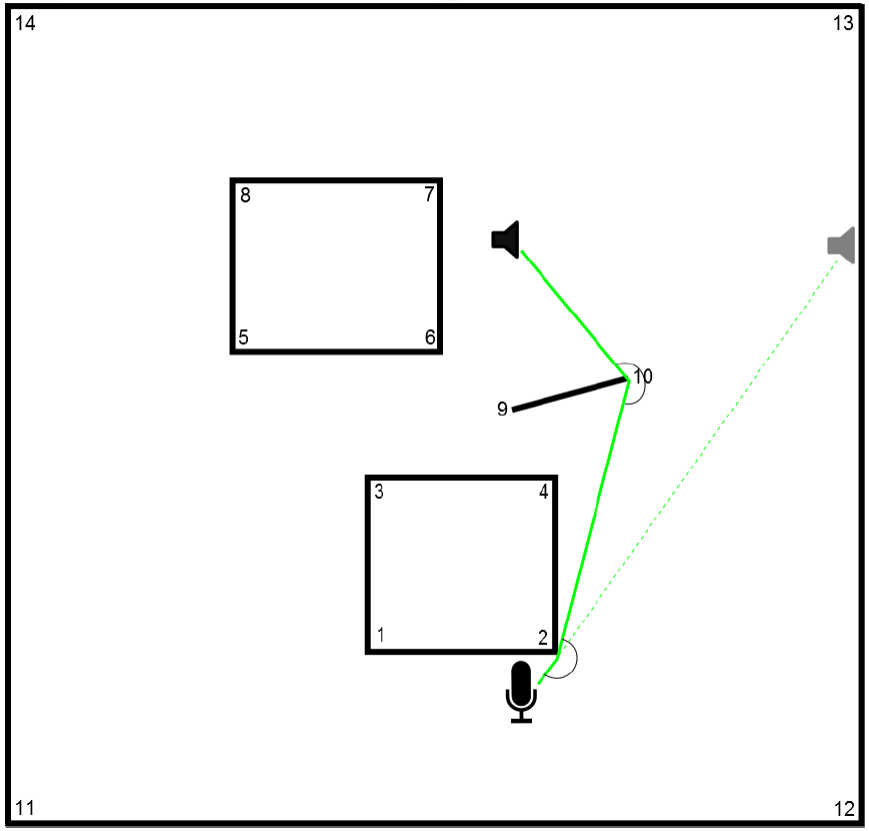
here you can see this in progress..

The plan executed contains the following series of actions :

- run from cover
- run to safe position and ....attack threat.

These actions are then sent and executed by our animation system.

Our way of doing it

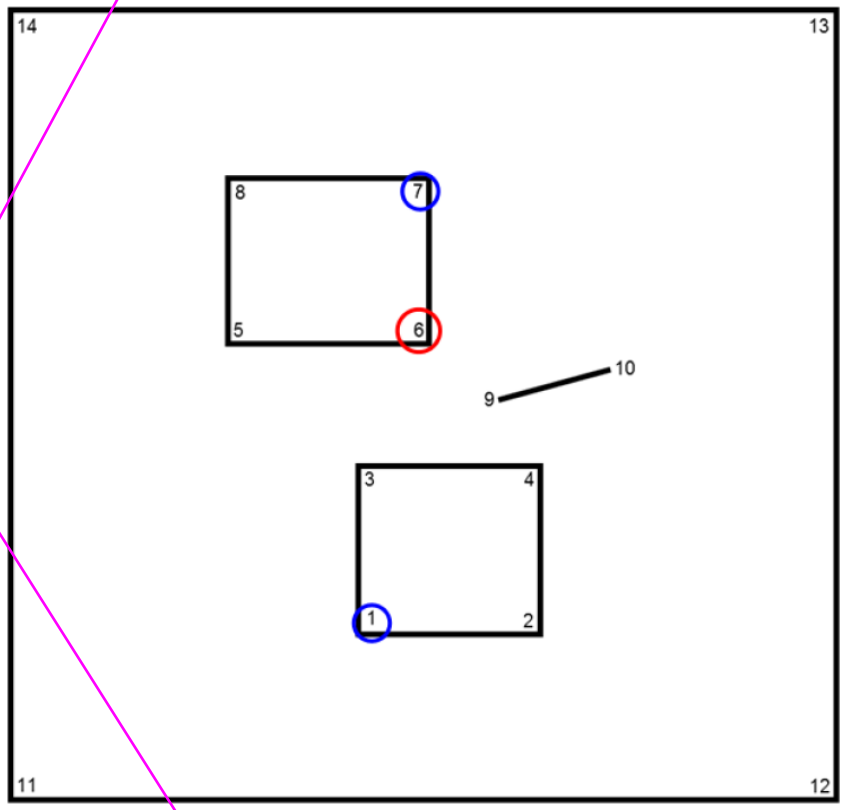


音の伝播をシミュレーション

Real-time Sound Propagation in Video Games
Jean-Francois Guay (Ubisoft)
http://gdcvault.com/play/1015492/Real-time-Sound-Propagation-in

Our way of doing it

Edge dist	1	2	3	4	5	6	7
1	-- -	2 10	3 10	2 20	5 23	3 17	3 27
2		--	1 20	4 10	1 35	4 21	4 36
3			--	4 10	5 13	6 7	6 17
4				--	5 17	6 11	9 3
5					--	6 10	6 20
6						--	7 10
7							--



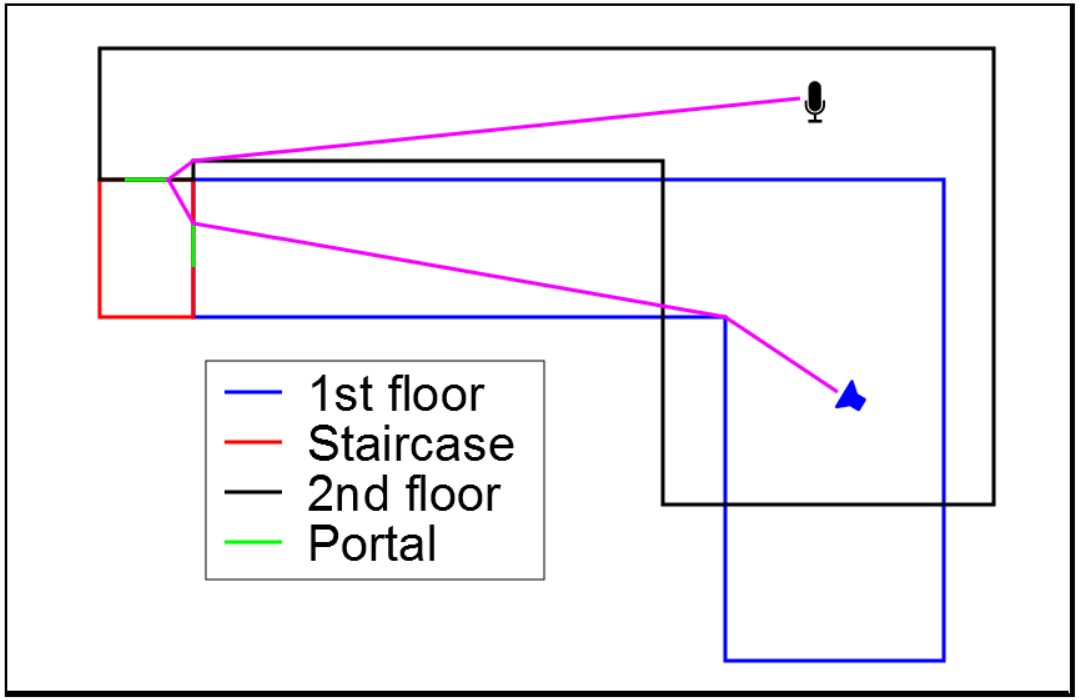
経由点

テーブルを用いる

総合距離

Optimization

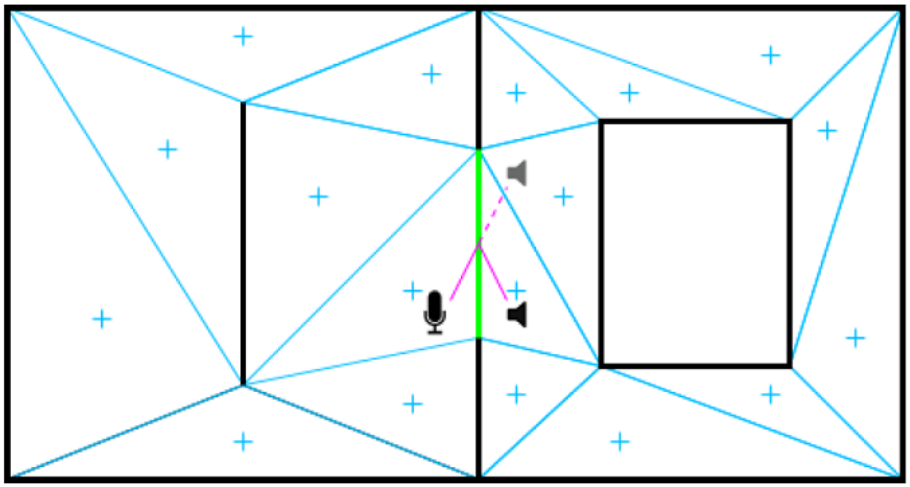
- Zoning to remove irrelevant geometric data
- Computation done in 2D + height

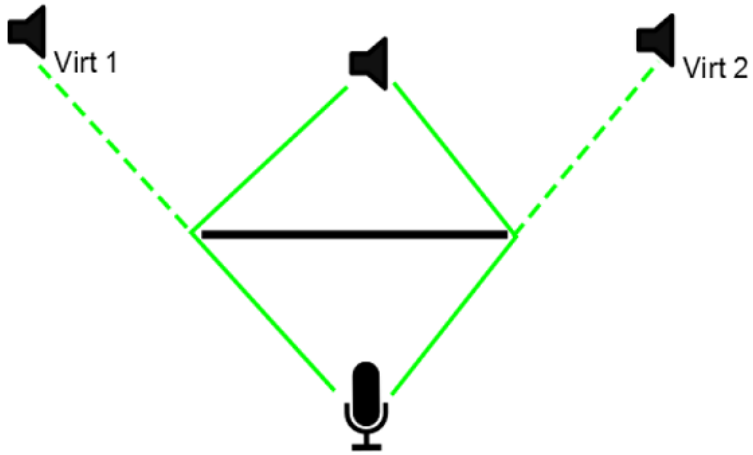


Problems we faced

Not the same as AI Path finding

Discontinuity





Problems we faced

Dynamic loading

Had to reorganize data structure for pre-computed shortest paths

Problems we faced

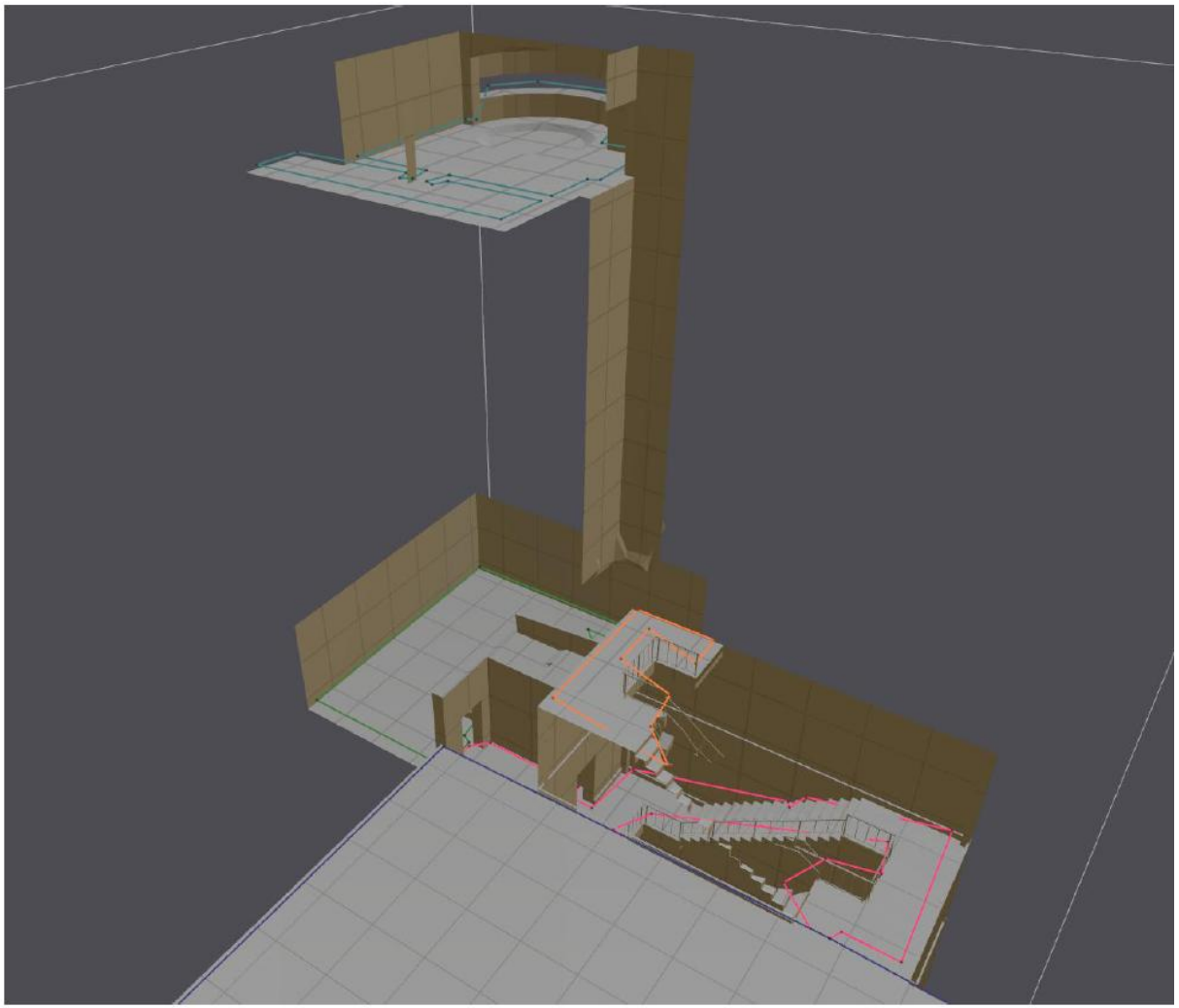
内装のデータ自働生成

Data creation

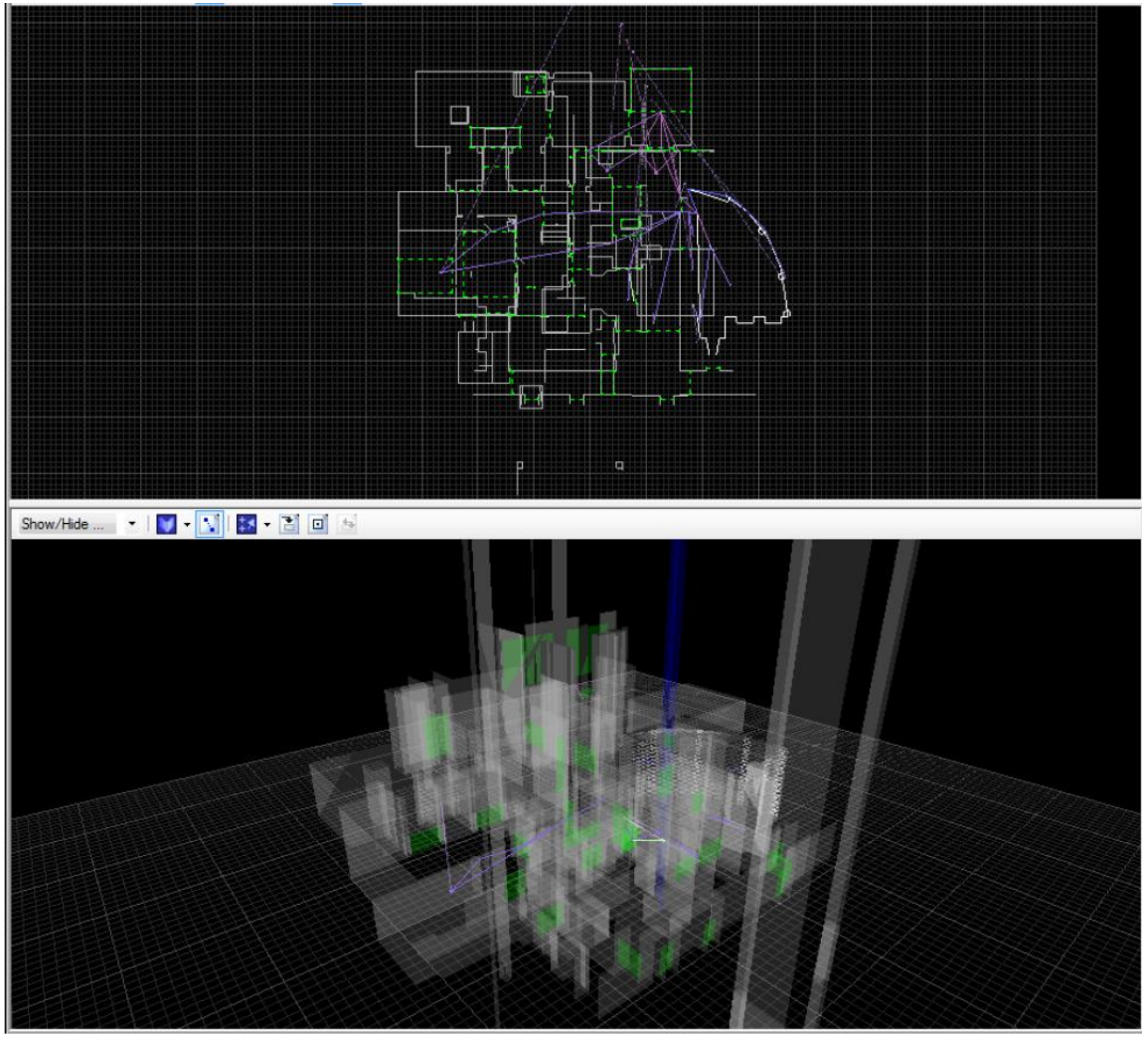
- First version needed to flag walls individually
- Was hard to have a comprehensive, 100% automatic solution
- Ended up with 2 automatic generation algorithms
  - One optimized for complex interiors
  - One optimized for exteriors with small buildings

小さなブロックごとのデータ自働生成

Data creation



Data creation

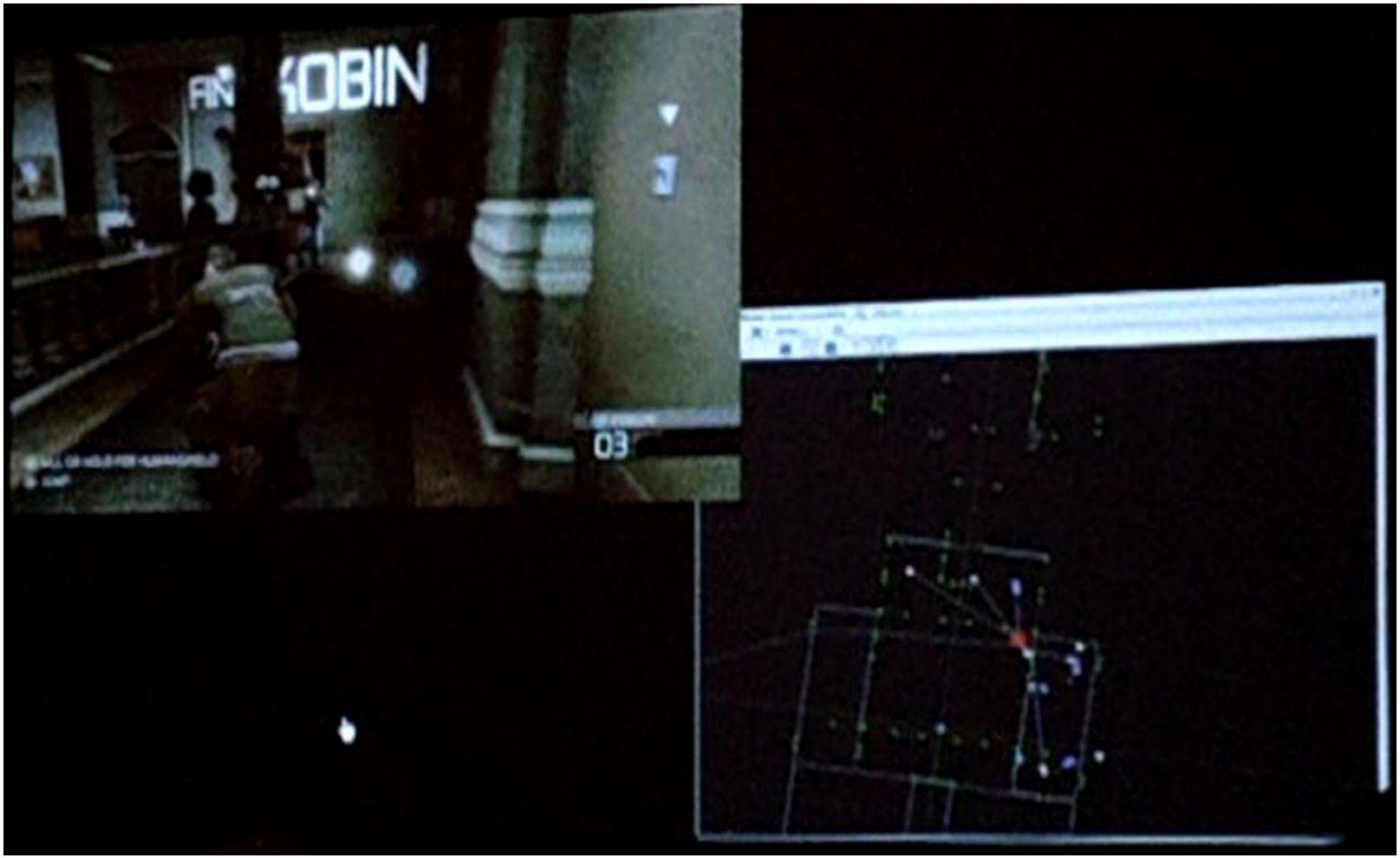


Data creation

Real-time Sound Propagation in Video Games Jean-Francois Guay (Ubisoft)
http://gdcvault.com/play/1015492/Real-time-Sound-Propagation-in

Real-time Sound Propagation in Video Games

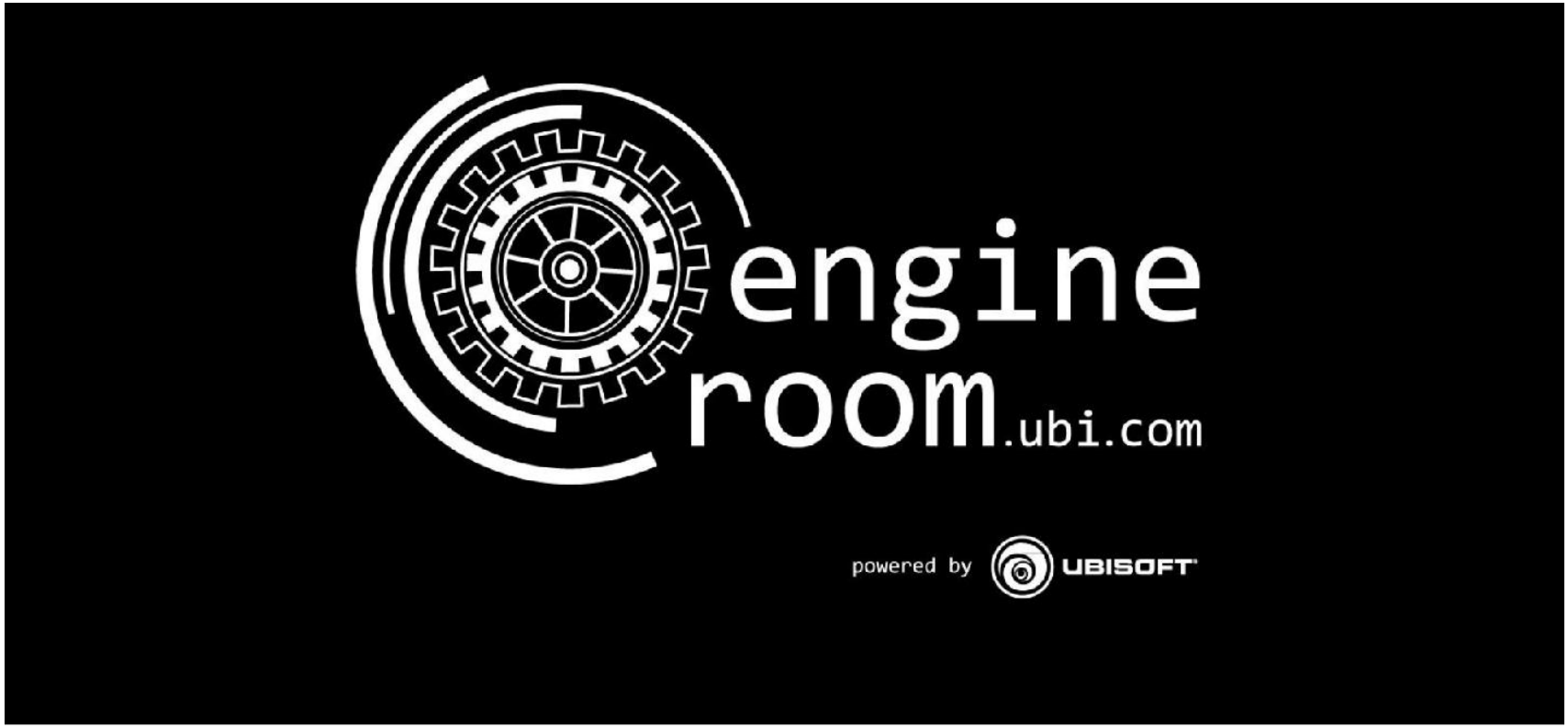
Jean-Francois Guay (Ubisoft)



SPRINTER CELL: CONVICTION

Real-time Sound Propagation in Video Games

Jean-Francois Guay (Ubisoft)



YOUR ONE-STOP IN-DEPTH TECH BLOG

Ubi 及び他社の技術情報

Off the Beaten Path: Non-Traditional Uses of AI
Michael Robbins (Gas Powered Games)
http://www.gdcvault.com/play/1015667/Off-the-Beaten-Path-Non

Off the Beaten Path: Non-Traditional Uses of AI

Ben Sunshine-Hill (Havok), Michael Robbins (Gas Powered Games)

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Fight or Flight

- Platoon encounters enemies.
  - Platoon decides to engage.
- Platoon encounters point defenses.
  - Losses start adding up.
  - Platoon decides to back off.
  - Continues engaging enemy units.
- Enemy reinforcements arrive.
  - Time to cut losses and run.

Off the Beaten Path: Non-Traditional Uses of AI

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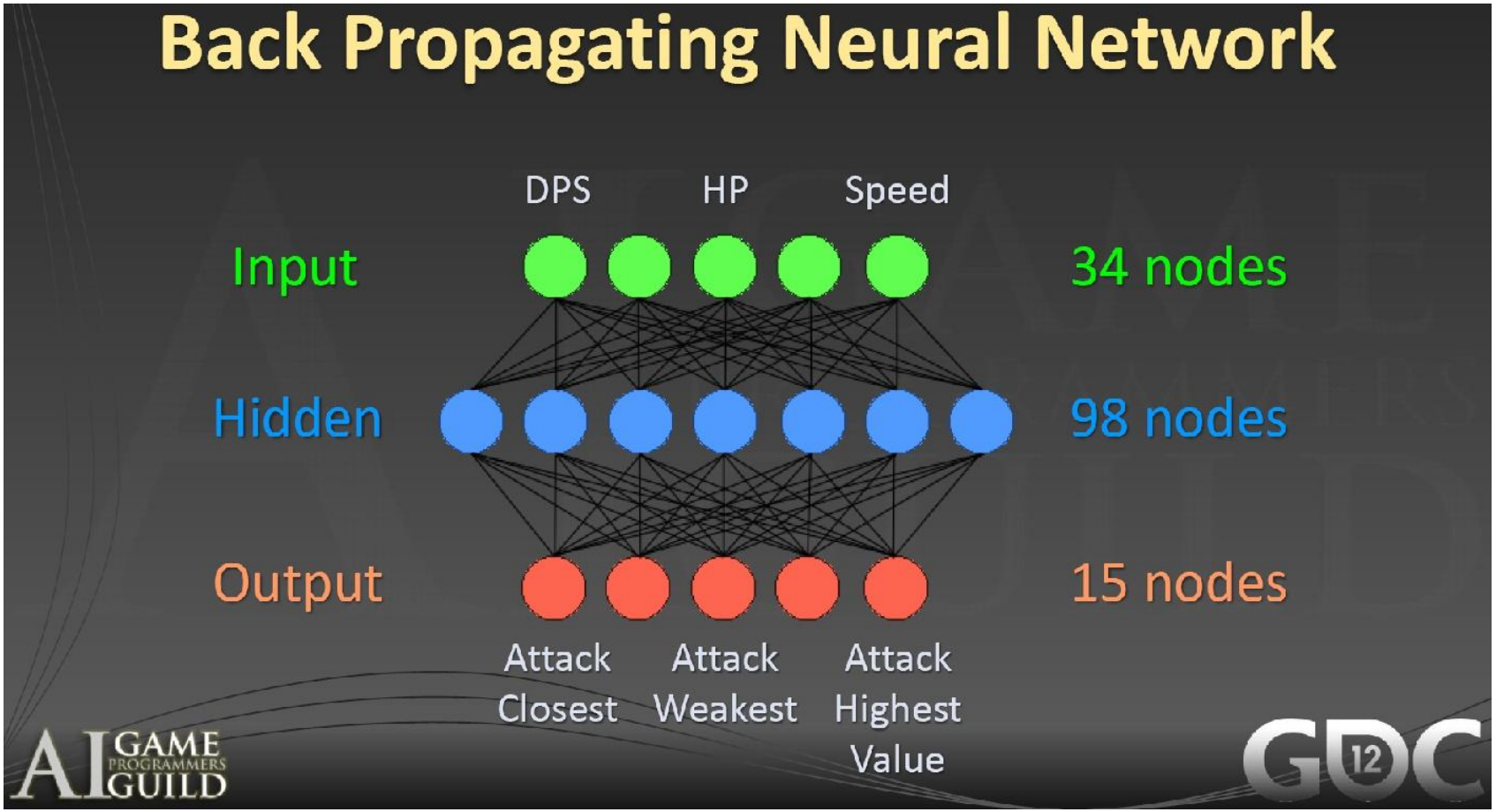

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入力

Evaluate Platoon and Enemies

Evaluate 17 data points for each

- # of Units
- HP
- Overall DPS
- Speed
- Mass Value
- Shields
- # of ACUs
- Repair Rate
- Short Range Static DPS
- Mid Range Static DPS
- Long Range Static DPS
- Short Range Mobile DPS
- Mid Range Mobile DPS
- Long Range Mobile DPS
- Alternate DPS

Two Different Threat Values Based on Platoon Type

(DPS=Damage per second)

出力

React Based on Output

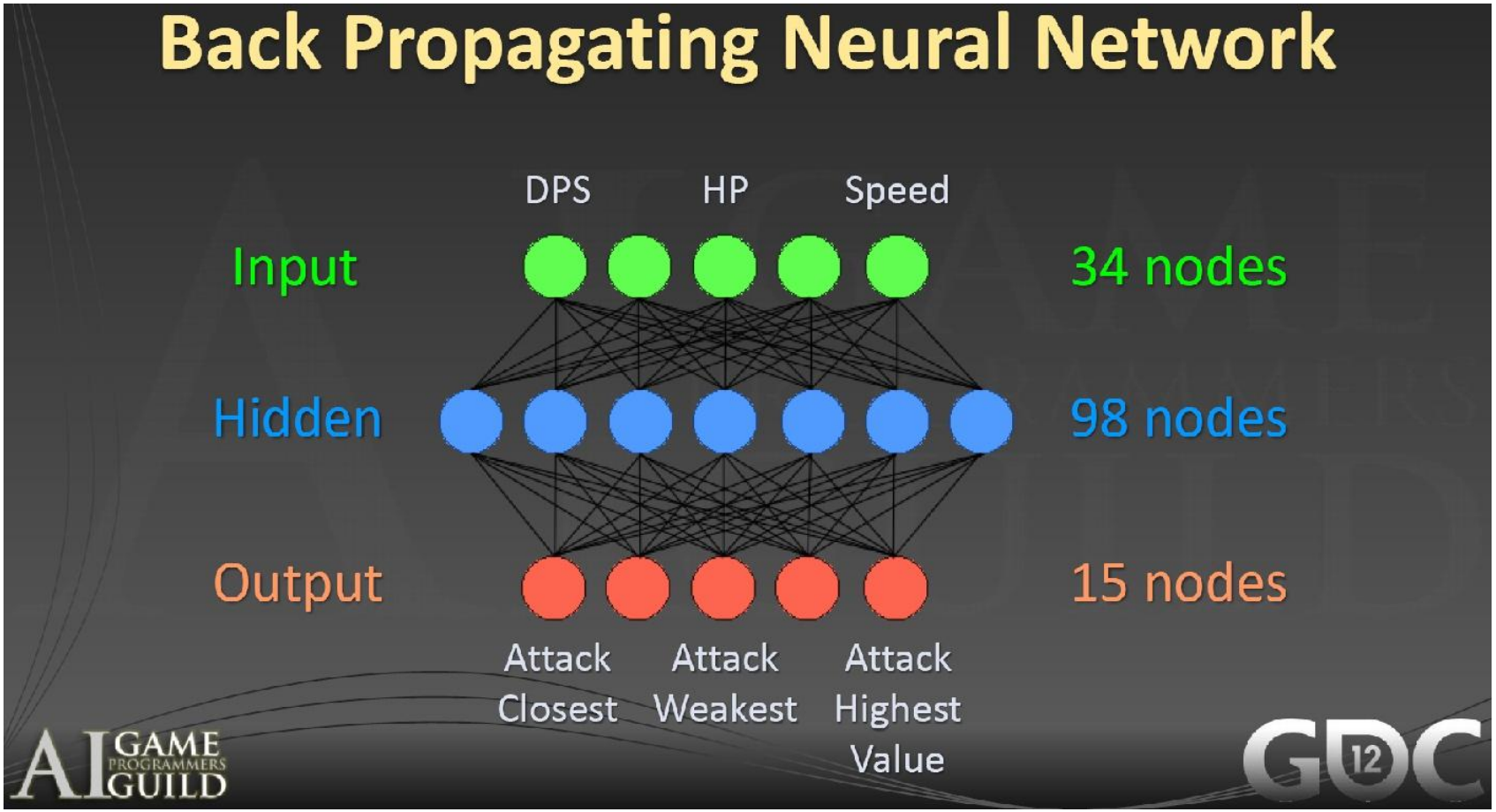
- Attack Weakest
- Attack Closest
- Attack Highest Value
- Attack Highest Range
- Attack Mobile
- Attack Engineer
- Attack Resource
- Attack Shield
- Attack Defense
- Attack the above from Range
- Attack ACU

Feed Input Into the Neural Network

- Data points are turned into two sets of deltas.
  - Platoon vs Enemies.
  - Enemies vs Platoon.
- Neural network is fed forward.
  - Pushes input through hidden layer and out to output layer.
- Output corresponds to platoon actions.

Off the Beaten Path: Non-Traditional Uses of AI

Ben Sunshine-Hill (Havok), Michael Robbins (Gas Powered Games)



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Training Time

- 1 hour per network + test time.
- Completely hands off training.
- Any behavior/neural network changes starts training over!
- Neural networks handle balance changes well.

展望

- 次世代へ向けて全方位の準備
- 各企業の次世代エンジン＋ツール開発統合環境の準備
- ミドルウェアの全開発ライン化（Havok、Autodesk、Unity…）
- ミドルウェアを組み込んだエンジン

- 情報環境整備 （サイト、書籍、カンファレンス）
-
- 学術との落ち着いた関係性

- 日本は大丈夫か？
- 学術
- 手先でなく芯の入った技術
- ミドルウェアを組み込んだパイプライン

各企業の講演資料サイト (GDC, SIGGRAPH,etc…)

- DICE
http://publications.dice.se/

- Ubisoft
http://engineroom.ubi.com/

- Insomniac
http://www.insomniacgames.com/category/research-development/

- Autodesk
http://area.autodesk.com/gdc2012

- Naughty Dog
http://www.slideshare.net/naughty_dog/presentations

- Guerrilla の資料サイト
http://www.guerrilla-games.com/publications/

- Crytek presentation
http://www.crytek.com/cryengine/presentations

ご清聴ありがとうございました。

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- Facebook: http://www.facebook.com/youichiro.miyake

- 講演資料・論文集:
  http://blogai.igda.jp/article/46500782.html

IGDA日本 SIG-AI メイリングリスト会員募集中！僕まで連絡！（ @miyayou スパムとも言う！）
月一でゲームAIラウンドテーブル開催中。With @hudepen