

CS248

Game Mechanics

INTRODUCTION

TOM WANG

2007 BS/MS CS



KEY GAME MECHANICS

*

WORLD BUILDING



*

CONTROLS



*

CAMERA



*

AI

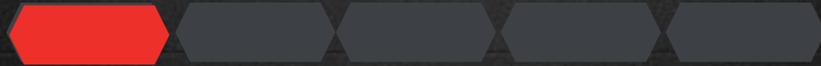


*

PERFORMANCE



WORLD BUILDING



WORLD BUILDING

- ▶ Set the **atmosphere** and tone of the game.



WORLD BUILDING

- ▶ Fill the world with engaging **characters** and **landmarks**.



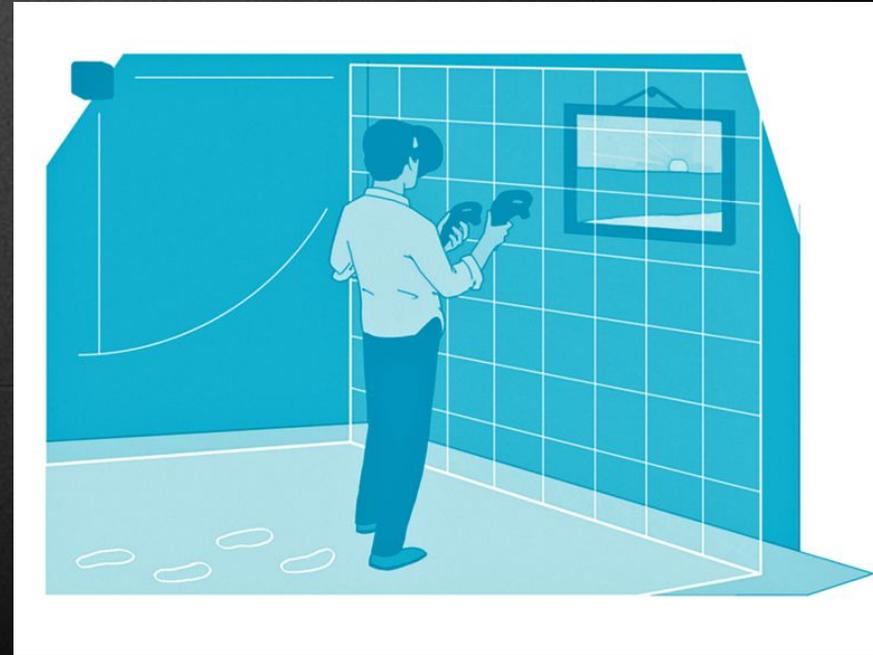
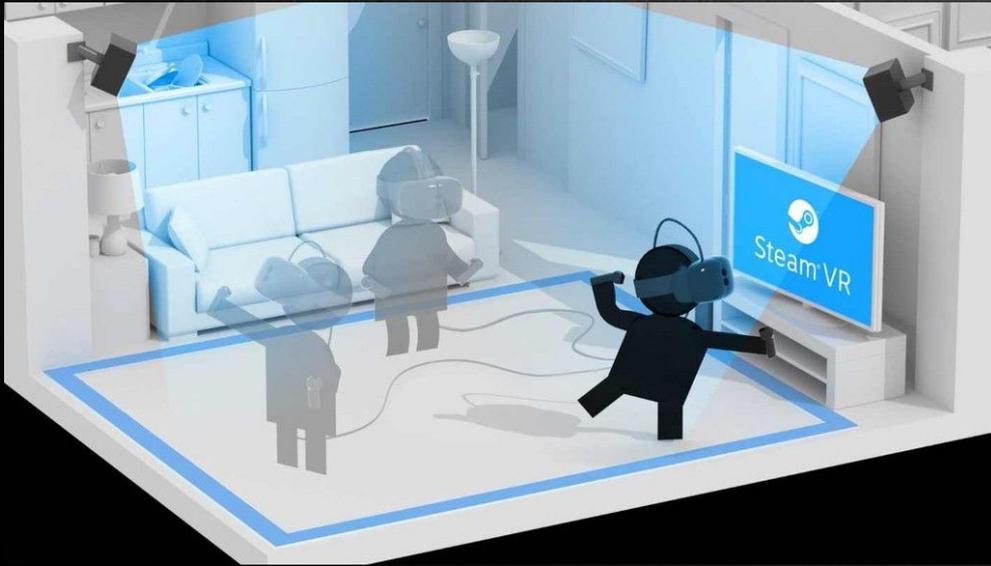
WORLD BUILDING

- ▶ Guide the player by defining **playable space** and boundaries.



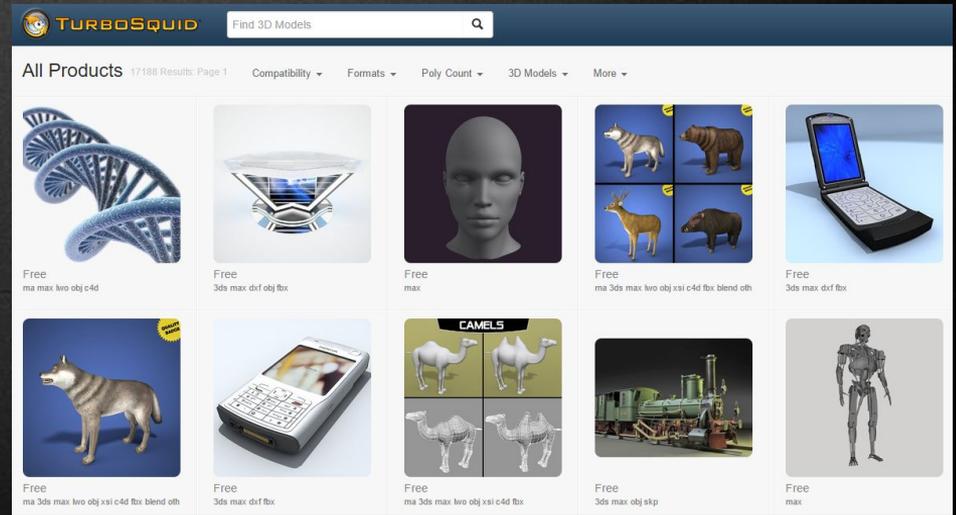
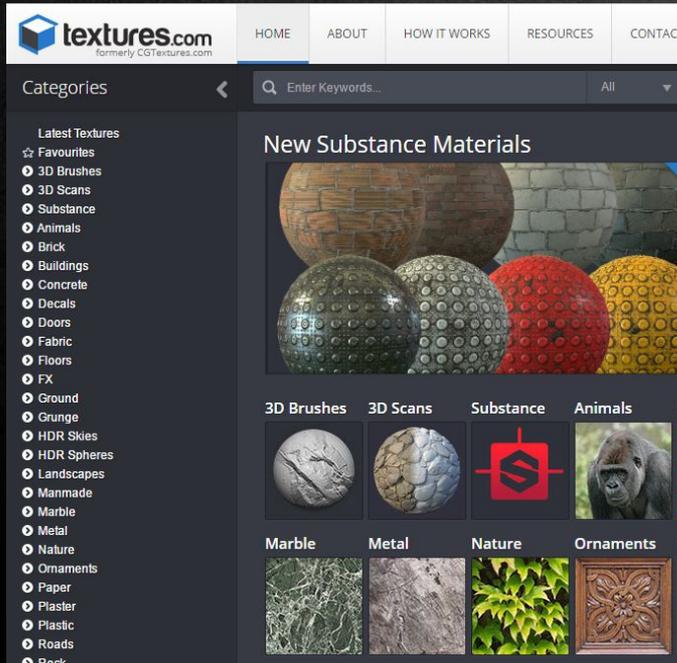
WORLD BUILDING

- ▶ Guide the player by defining **playable space** and boundaries.



WORLD BUILDING

- ▶ Look for **content** to accelerate your development and iteration speed.



WORLD BUILDING

- ▶ Look for **content** to accelerate your development and iteration speed.

The screenshot shows the Unity Asset Store interface. The top navigation bar includes the Unity logo, 'Unity', 'Services', 'Made with Unity', 'Learn', 'Community', and 'Asset Store'. Below this is a search bar with filters for 'category:Textures & Materials' and 'price:0'. The main content area displays a grid of asset listings, each with a thumbnail, title, author, rating, and price. The right sidebar shows a navigation menu with categories like 'Home', '3D Models', 'Animation', 'Applications', 'Audio', 'Complete Projects', 'Editor Extensions', 'Particle Systems', 'Scripting', 'Services', 'Shaders', and 'Textures & Materials' (expanded to show sub-categories like '2D & Isometric Tiles', '2D Characters', 'Abstract', etc.).

unity Unity Services Made with Unity Learn Community Asset Store

Sell Assets Blog Publisher Login Link Maker Help 简体中文 한국어 日本語 English

category:Textures & Materials price:0

MAXIMUM PRICE \$ MAXIMUM SIZE MB

FREE 5 10 20 50 100 200 ∞

1MB 5MB 50MB 100MB 250MB 500MB 1GB 4GB

RELEASED days ago

1d 7d 14d 1m 3m 6m 1y 5y

SUPPORTED UNITY VERSION

***** e.g. 5.2.0

UPDATED days ago

1d 7d 14d 1m 3m 6m 1y 5y

PACKAGES ONLY LISTS ONLY

Filters

- Home
- 3D Models
- Animation
- Applications
- Audio
- Complete Projects
- Editor Extensions
- Particle Systems
- Scripting
- Services
- Shaders
- Textures & Materials
 - 2D & Isometric Tiles
 - 2D Characters
 - Abstract
 - Bricks
 - Buildings
 - Concrete
 - Cookies & Gobos
 - Decals
 - Fabric
 - Fonts
 - Food
 - GUI Skins
 - Glass
 - Ground
 - Icons & UI
 - Manmade
 - Metal
 - Nature
 - Organic
 - Paper

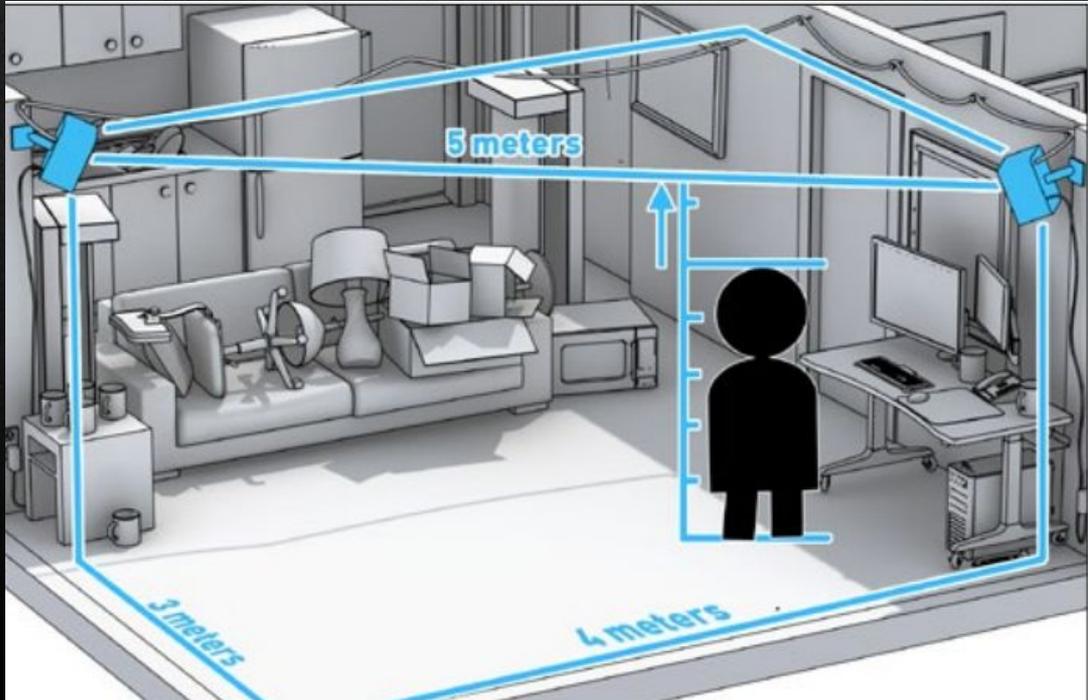
SORT BY RELEVANCE / POPULARITY / NAME / RATING / UPDATED

1 2 3 4 5 6 7 8 9 1 - 36 of 290

 <p>QS Materials Nature Pack Textures & Material... Quadrante Studio ★★★★ (1,117) Free</p>	 <p>Skybox Textures & Material... Clod ★★★★ (1,401) Free</p>	 <p>Wispy Skybox Textures & Material... Mundus Limited ★★★★ (1,245) Free</p>
 <p>Sky5X One Textures & Material... RKD ★★★★ (1,534) Free</p>	 <p>Yughues Free Ground Textures & Material... Noblix / Yughues ★★★★ (1,305) Free</p>	 <p>Skybox Volume 2 (...) Textures & Material... Hedgehog Team ★★★★ (1,798) Free</p>
 <p>Classic Skybox Textures & Material... mgsvevo ★★★★ (1,186) Free</p>	 <p>Purple Space Nebula Textures & Material... TL Multimedia ★★★★ (1,226) Free</p>	 <p>Hand Painted Grass Textures & Material... LowlyPoly ★★★★ (15) Free</p>
 <p>18 High Resolution Textures Textures & Material... A dog's life software ★★★★ (1,255) Free</p>	 <p>Outdoor Ground Textures Textures & Material... A dog's life software ★★★★ (1,108) Free</p>	 <p>Five Seamless Tiles Textures & Material... ASD ★★★★ (141) Free</p>

WORLD BUILDING

- ▶ Within VR, consider **human-accurate scale** to preserve world immersion



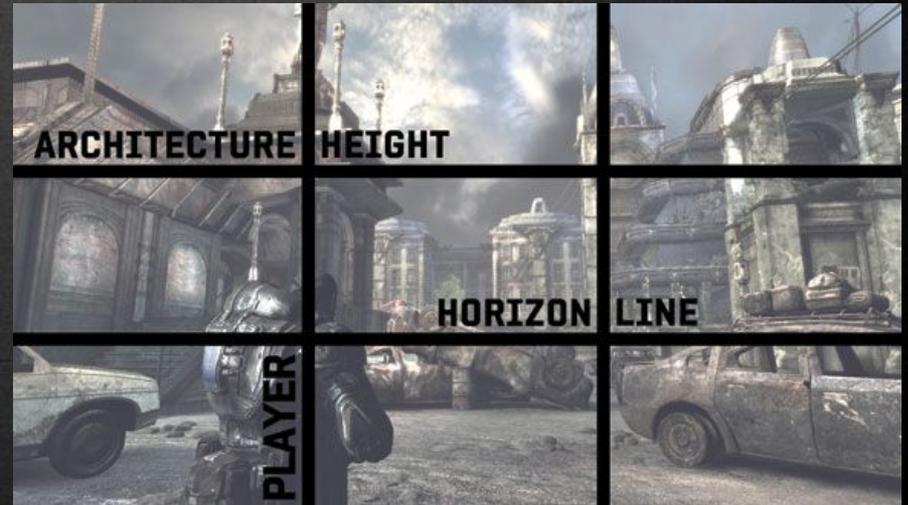
WORLD BUILDING

- ▶ Within VR, use **dimmer lighting & colors** to ensure highest comfort



WORLD BUILDING

- ▶ Take advantage of **level design** techniques
 - Sightlines
 - Landmarks
 - Composition [Rule of Thirds]
 - Symmetry

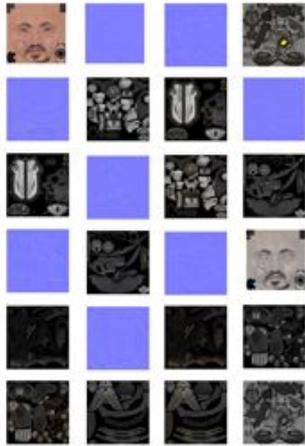


- ▶ <http://bobbyross.com/blog/2014/6/29/the-visual-guide-for-multiplayer-level-design>

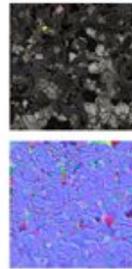
WORLD BUILDING

- ▶ For performance, utilize **level of detail** techniques

Before 170,000 Polygon
24 1024px Textures



After 41,000 Polygon
2 1024px Textures

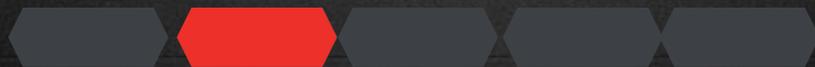


WORLD BUILDING

- ▶ Utilize **plug-ins** for specialized needs (sound engine, VR audio, physically based rendering, procedural trees, terrain generation)



CAMERA



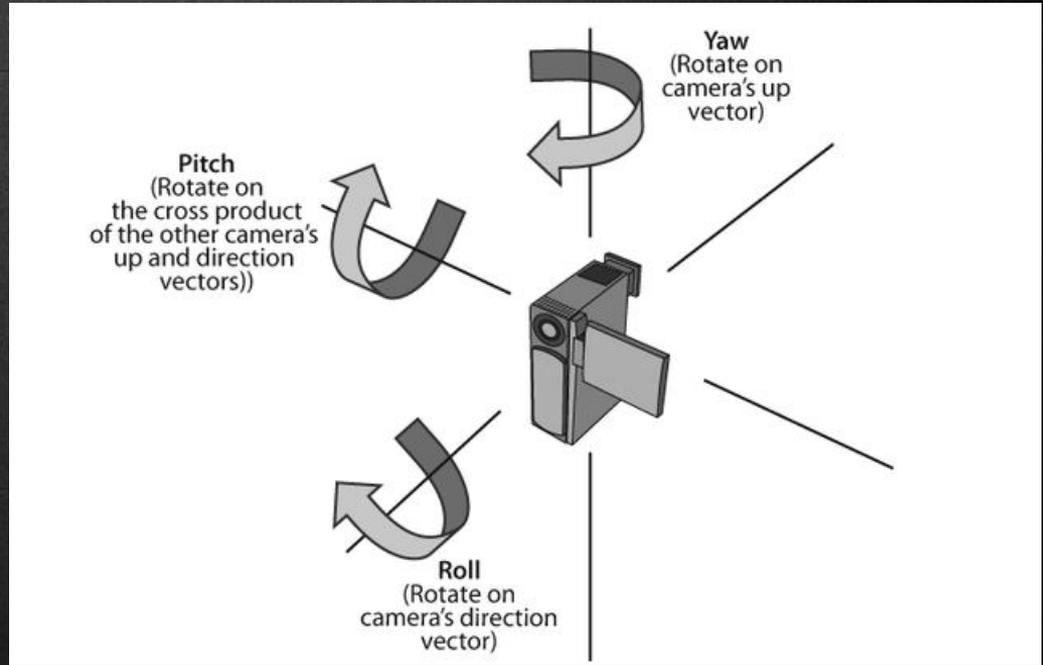
CAMERA

- ▶ Focus the attention in the world and **highlight** key areas and objectives.



CAMERA

- ▶ Position [x, y, z]
- ▶ Rotation
 - ▼ Pitch / Roll / Yaw
 - ▼ Rotation Matrix
 - Beware Gimbal Lock
 - ▼ Quaternion
- ▶ Direction Vector



CAMERA [SIDE-SCROLLER]

- ▶ Appears to have depth with background or parallax, usually 2D playable space.
- ▶ Natural fit for mobile applications



CAMERA [TOP-DOWN]

- ▶ Represents information with limited perspective, useful for maps, game boards, user interface
- ▶ Natural fit for mobile applications



CAMERA [FIRST-PERSON]

- ▶ View that builds immersion and tactile feel for the player.
- ▶ Field of View (70 to 110 degrees)
- ▶ Enables more precise motion & controls
- ▶ Natural fit for PC or VR applications



CAMERA [THIRD-PERSON]

- ▶ Field of View: 90 to 130 degrees
- ▶ Best for action adventure games
- ▶ More objects on screen vs. first-person
- ▶ Highlights environment and character actions well: climbing, jumping, cover



CAMERA [VR]

- ▶ Use human field of view at eye height
- ▶ Keep camera motion smooth & steady - don't shake or bob the camera
- ▶ Avoid motion blur, depth of field, etc.
- ▶ Adjust for interpupillary distance and keep straps tight
- ▶ Stationary more accessible than room-scale



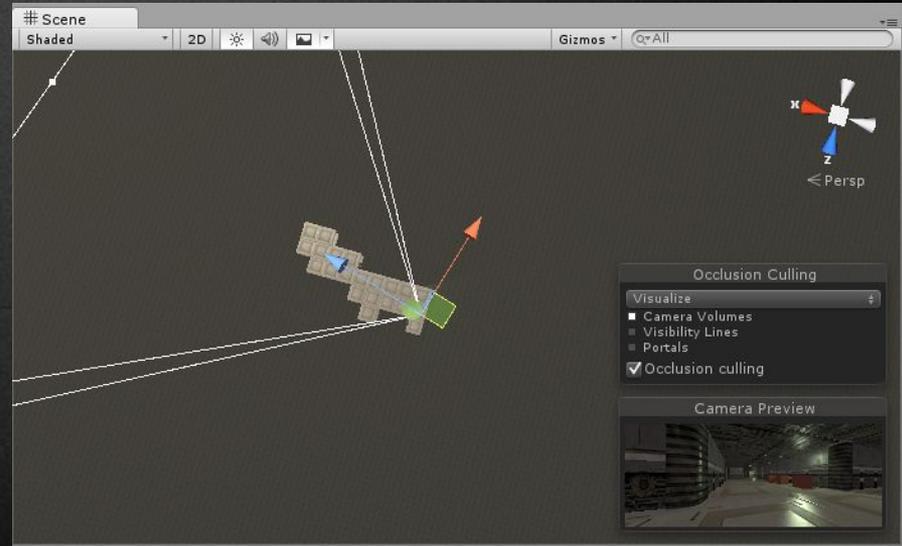
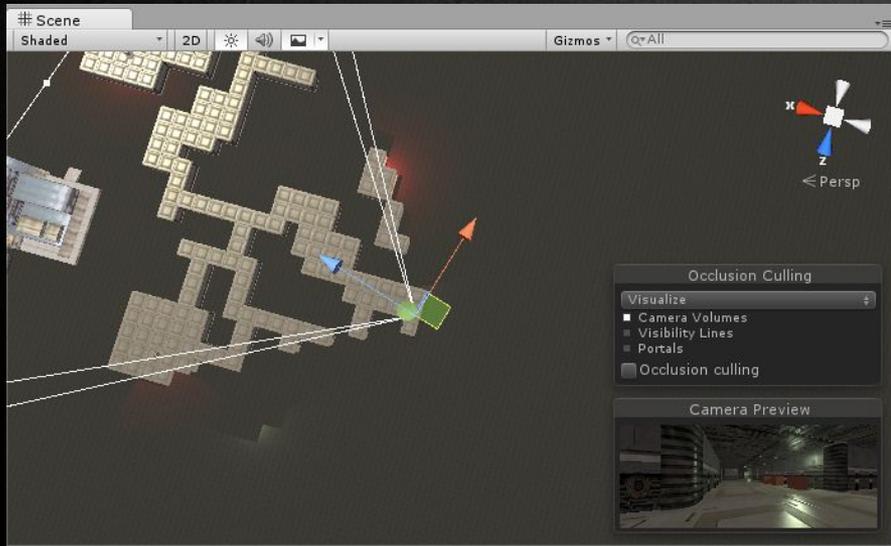
CAMERA

- ▶ Spherical interpolation for smooth motion
- ▶ Use transparency for objects in near and far clip planes
- ▶ 'Bump' the camera to safe spots
- ▶ Try Unity Plugin iTween for splines and motion paths

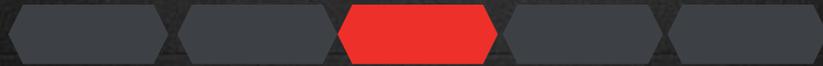


CAMERA

- ▶ For performance, enable **occlusion culling** to stop rendering occluded geometry



CONTROLS



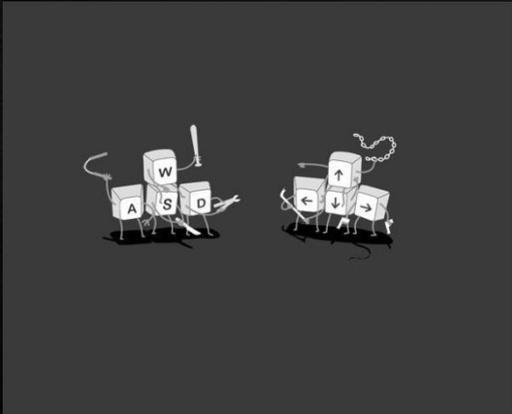
CONTROLS

- ▶ Help the player **interact** with the game world and characters.

The Periodic Table of Controllers
Console and handheld
mikevasilev.com

1 1972 Magnavox Odyssey Ralph Baer Brown Box	2 1975 Atari Pong Harris Lee Pong												
3 1976 Wonder Wizard 700 N/A Triple Challenge	4 1976 Coleco Telarc Ed Sals n/a	5 1976 Magnavox Odyssey 300 n/a	6 1976 Fairchild Channel F Amy Lawson n/a										
7 1977 RCA Studio II n/a	8 1977 Atari 2600 Nolan Bushnell 2600	9 1977 Coleco Telarc Alpha n/a	10 1977 Magnavox Odyssey 300 n/a										
11 1978 Magnavox Odyssey 2 n/a	12 1980 Mattel Intellivision n/a	13 1982 Vectrex n/a	14 1982 Atari 5200 n/a	15 1982 Emerson Arcadia 2001 n/a	16 1982 Colecovision n/a	17 1983 Nintendo Family Computer n/a	18 1985 Commodore 64 n/a	19 1985 Nintendo Entertainment System Masayuki Uemura NES	20 1986 Atari 7800 Steve Gelson 7800	21 1986 Sega Master System n/a	22 1989 NEC Turbo Grafx-16 n/a	23 1989 Sega Genesis Hajime Nakayama Genesis	24 1990 SNK Neo-Geo Etsch Kasparat NEO-Geo
25 1991 Philips CD-i n/a	26 1991 Super Nintendo Masayuki Uemura SNES	27 1993 Panasonic Game Boy Dove Needle 300	28 1993 Atari Jaguar Martin Brennan Jaguar	29 1994 SNK Neo-Geo CD n/a	30 1995 Sony PlayStation Ken Kutaragi PS1	31 1995 Sega Saturn n/a	32 1995 Nintendo 64 James H. Clark N64	33 1996 Apple Bandai Pipkin n/a	34 1999 Sega Dreamcast Hidemichi Sato Dreamcast	35 2000 Sony PlayStation 2 Ken Kutaragi PS2	36 2001 Nintendo GameCube Kooyoku Matsuhita GCN	37 2001 Microsoft Xbox Seamus Blackley xbox	38 2005 Microsoft Xbox 360 Jonathan Hayes 360
39 2006 Sony PlayStation 3 Ken Kutaragi PS3	40 2006 Nintendo Wii Kenichiro Ashida Wii												
41 1979 Milton Bradley Microvision Jay Sels n/a	42 1980 Nintendo Game & Watch Gunpei Yokoi n/a	43 1989 Nintendo Super Famicom Game Boy n/a	44 1989 Atari Lynx n/a	45 1990 NEC TurboGrafx-16 n/a	46 1990 Sega Game Gear n/a	47 1991 Atari Lynx II n/a	48 1995 Sega Nomad n/a	49 1997 Tiger VR-32 n/a	50 1995 Virtual Boy n/a	51 1998 Nintendo Game Boy Advance n/a			
52 1999 Neo Geo Pocket Color n/a	53 1999 Bandai WonderSwan Color n/a	54 2001 Nintendo Game Boy Advance n/a	55 2003 Nintendo Game Boy Advance SP n/a	56 2003 Nokia N-Gage n/a	57 2004 Nintendo DS n/a	58 2004 Sony PlayStation Portable n/a	59 2005 Game Boy Micro n/a	60 2006 Nintendo DS Lite n/a	61 2008 Nintendo DSi Masao Kamekura DSi	62 2009 Sony PlayStation Portable n/a			

CONTROLS [PC]



- ▶ Shooter



- ▶ Platformer



- ▶ Role Playing Game



CONTROLS [PC / WEB]



▶ Simulation



▶ Turn-Based Strategy



▶ Massively Multiplayer
Online [MMO]



CONTROLS [MOBILE]



▶ Swipe



▶ Tilt



▶ Touch



CONTROLS TIPS

- ▶ Design controls to feel **intuitive** and match expectations for the player.
- ▶ Design controls to allow **customization**.
- ▶ Design controls to be consistent and **responsive**.
- ▶ Design controls to allow the player to build mastery and **feel empowered**.

CONTROLS DESIGN

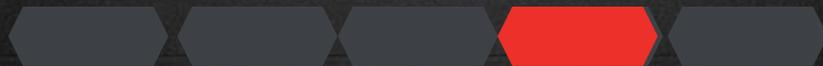
▶ Fitts's Law

- ▼ Time required to rapidly move to a target area is a function of the distance to the target and the size of the target.
 - Paul M. Fitts (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of Experimental Psychology*, volume 47, number 6, June 1954, pp. 381–391. (Reprinted in *Journal of Experimental Psychology: General*, 121(3):262–269, 1992)

▶ Hick's Law

- ▼ Time required to make a decision when given a set of possible choices. More choices will increase decision time logarithmically.
 - Hick, W. E. (1 March 1952). "[On the rate of gain of information](https://doi.org/10.1080/17470215208416600)". *Quarterly Journal of Experimental Psychology* 4 (1): 11–26. doi:[10.1080/17470215208416600](https://doi.org/10.1080/17470215208416600).

AI



AI

- ▶ Bring the game world to **life** with interesting NPCs and behaviors.



AI

Decision Trees

- ▶ Finite State Machines are commonly used
- ▶ Search all child nodes in tree to evaluate choices
- ▶ Consistent, deterministic behavior



AI

Decision Trees

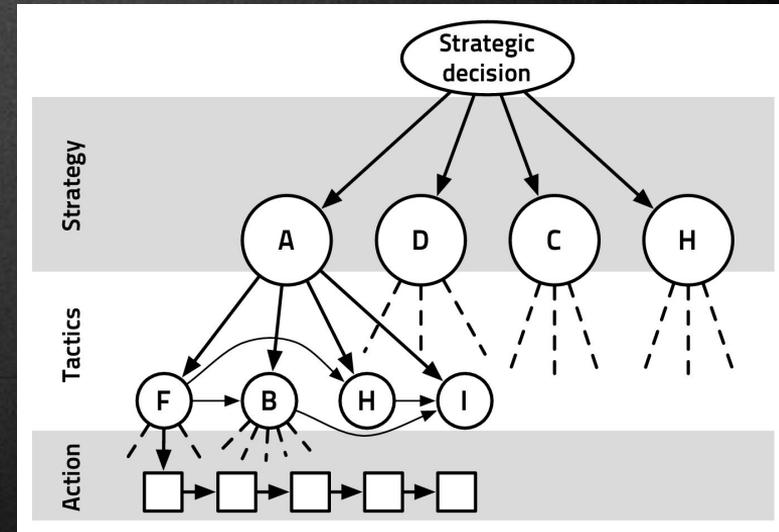
- ▶ Performance.
 - ▼ Evaluating nodes can get costly with limited CPU
 - ▼ Need to budget against scripts, sound, physics
 - ▼ Can be improved with cached info, pruning
- ▶ State Management.
 - ▼ Every new game feature requires new states
 - ▼ Connecting states requires $O(n^2)$ transitions



AI

Behavior Trees

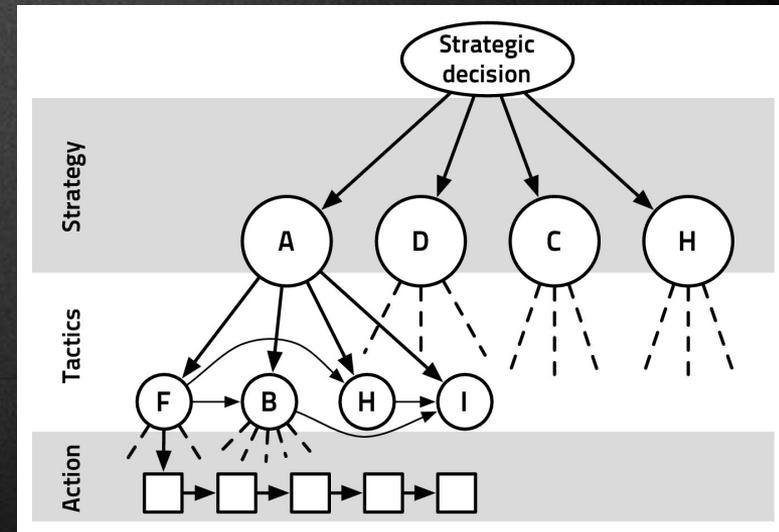
- ▶ Hierarchical State Machines are often used
 - ▼ Fewer states to evaluate vs decision tree
- ▶ Can use information from self or group
 - ▼ Squads can share data and 'roles'
- ▶ Evaluates dynamic behaviors by priority
 - ▼ Maslow's Hierarchy of Needs
 - ▼ Can introduce probability for randomness



AI

Behavior Trees

- ▶ Heuristic Tuning.
 - ▼ Requires constant re-balancing of priorities
- ▶ Indecision.
 - ▼ AIs rapidly change strategies with new data
 - ▼ Can be mitigated with hysteresis

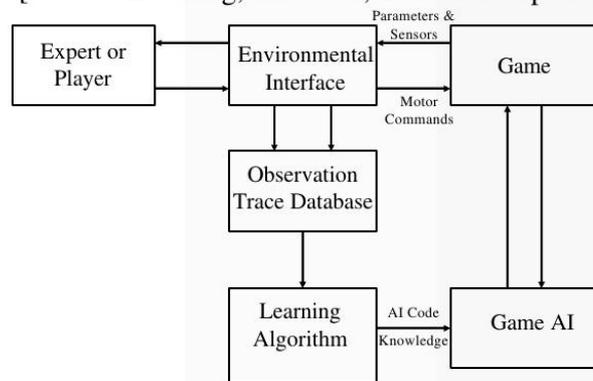


AI

Neural Network

- ▶ Learned Data Set & Identify Nearest Behavior
 - ▼ Radial Basis Function / Nearest Neighbor
- ▶ Can learn information over AI or human trials
- ▶ Can leverage cloud Big Data platforms

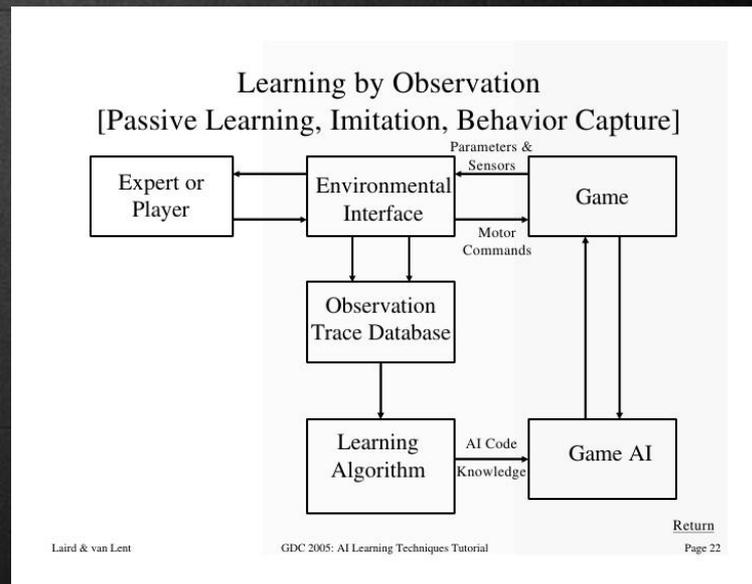
Learning by Observation [Passive Learning, Imitation, Behavior Capture]



AI

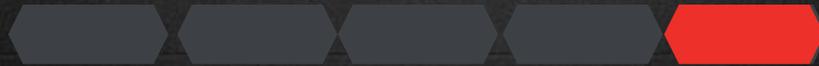
Neural Network

- ▶ **Data Size.**
 - ▼ Requires lots of experimentation for fitness
 - ▼ Selecting parameters can be tricky
 - ▼ May require a large amount of data storage
 - ▼ Data may invalidate as game changes
- ▶ **Implementation Complexity.**
 - ▼ Hard to debug with large # of parameters
 - ▼ Hard to reproduce poor behaviors



- ▶ <http://techblog.netflix.com/2014/02/distributed-neural-networks-with-gpus.html>

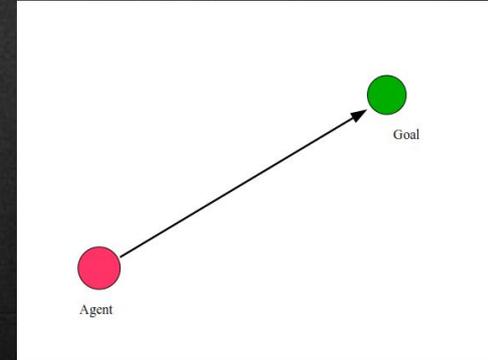
NAVIGATION



NAVIGATION

Straight Line with Local Avoidance

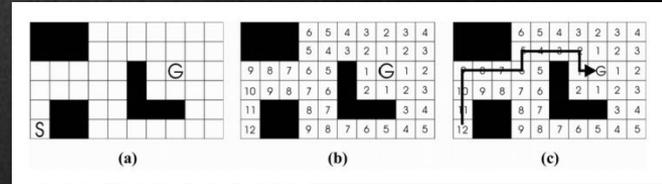
- ▶ Naïve and Simple - Plan a straight line from agent to goal
- ▶ If collision detected, select a random direction
- ▶ Paths are non-optimal and can get stuck in corners.



NAVIGATION

A* Gridmap

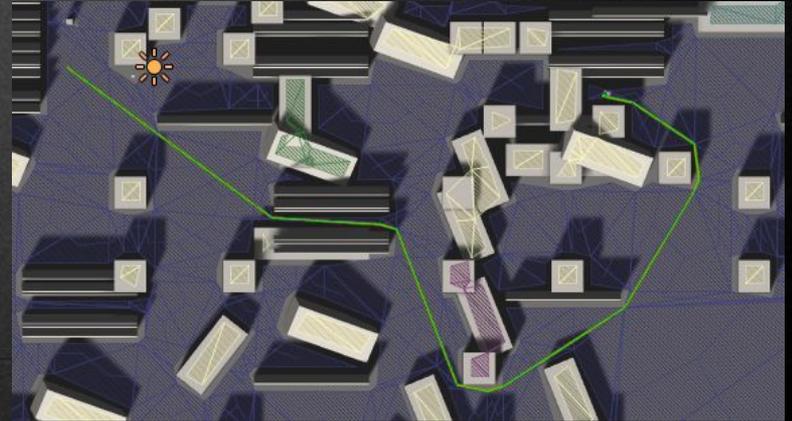
- ▶ Separate the world into grids and assign a travel cost to each grid.
- ▶ Keep an open set of each path, recursively search by adding neighbor grids and keep a running travel cost. Once a path found, cull other paths that are more expensive.
- ▶ Doesn't handle dynamic obstacles well or obstacles that don't fit neatly within a grid. Grid gets expensive to store in 3D with voxels



NAVIGATION

Navigation Mesh

- ▶ Process the world and separate into navigable nodes and polygons ('navmesh baking')
 - ▼ Watershed Partitioning
 - ▼ Monotone Partitioning
- ▶ Strategy - find shortest path of nodes to goal
- ▶ Tactics
 - ▼ Apply path smoothing for realistic turns
 - ▼ Add off-mesh links for jumps, one-way drops
 - ▼ Support a navmesh per navigation agent size
 - ▼ Repeller fields to avoid obstacles or attractor fields to encourage flocking
 - ▼ Clever partitioning to avoid sliver triangles



Q&A

twang@riotgames.com

