CS248

Game Mechanics

INTRODUCTION

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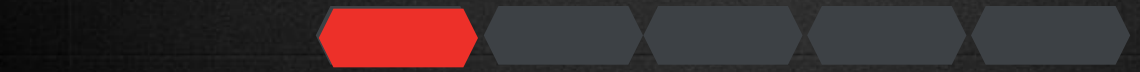
2007 BS/MS CS

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

- Teach players the rules of the world: concepts and interactions.

WORLD BUILDING

- Guide the player by defining playable space and boundaries.

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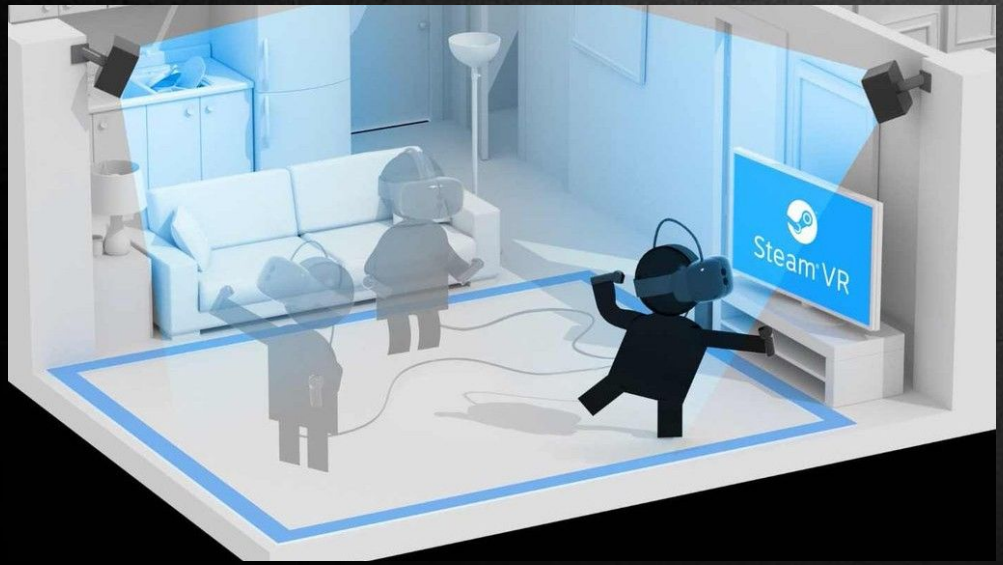
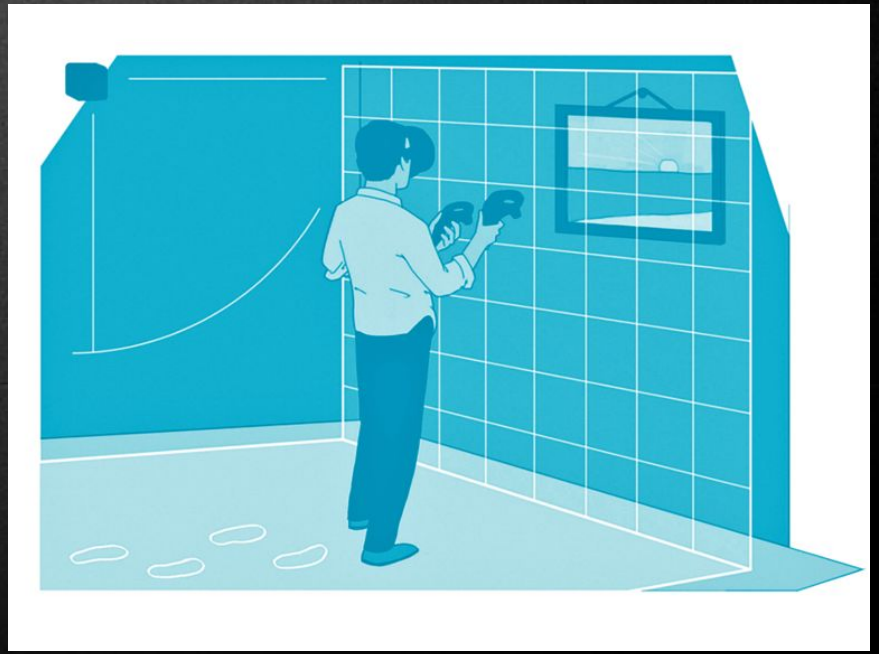
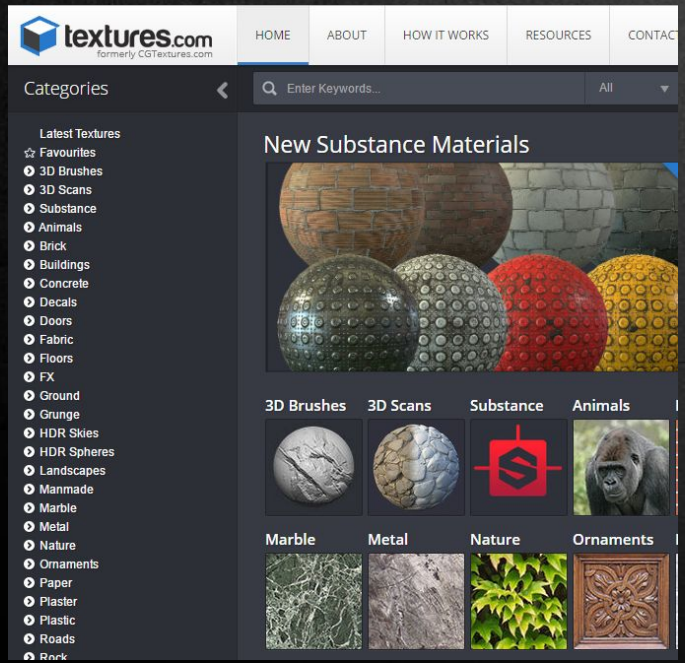
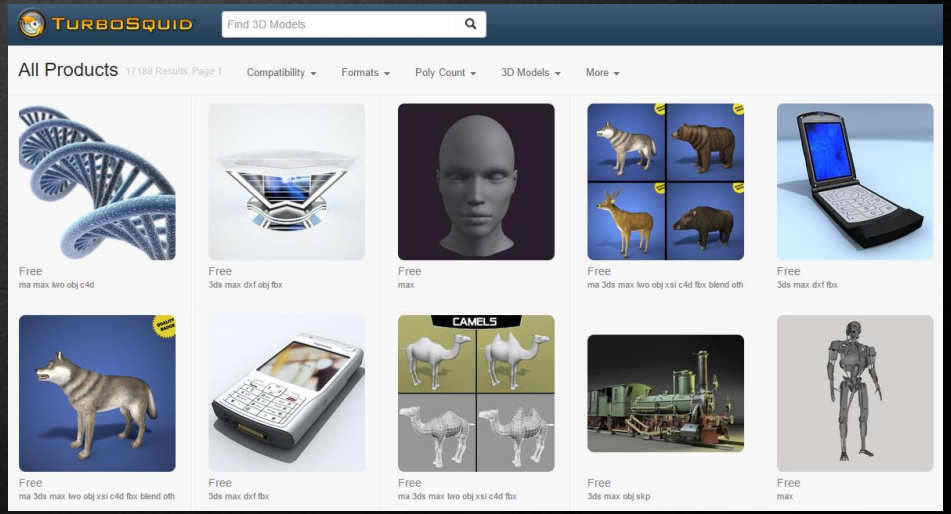




WORLD BUILDING

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





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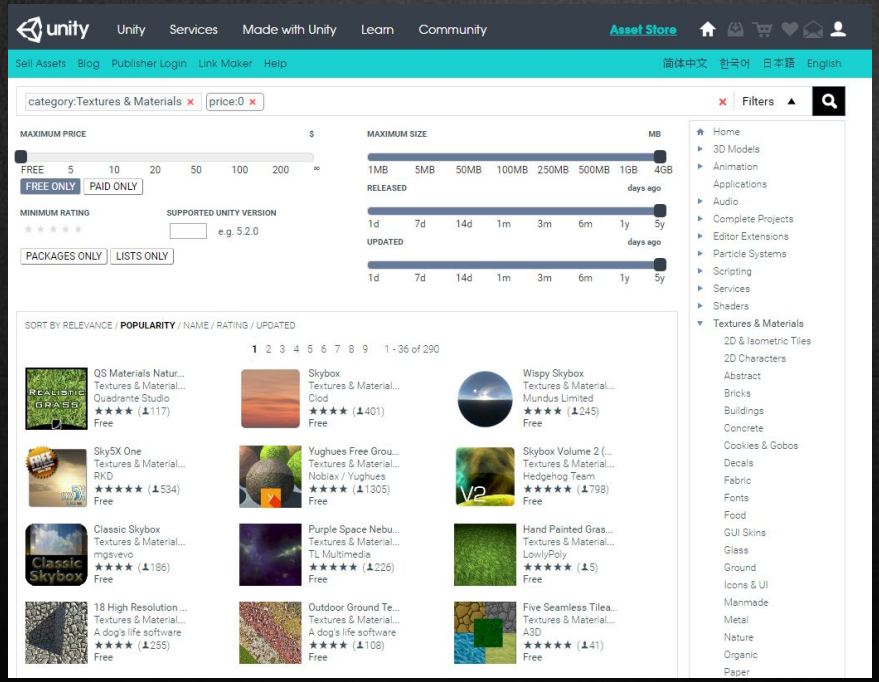
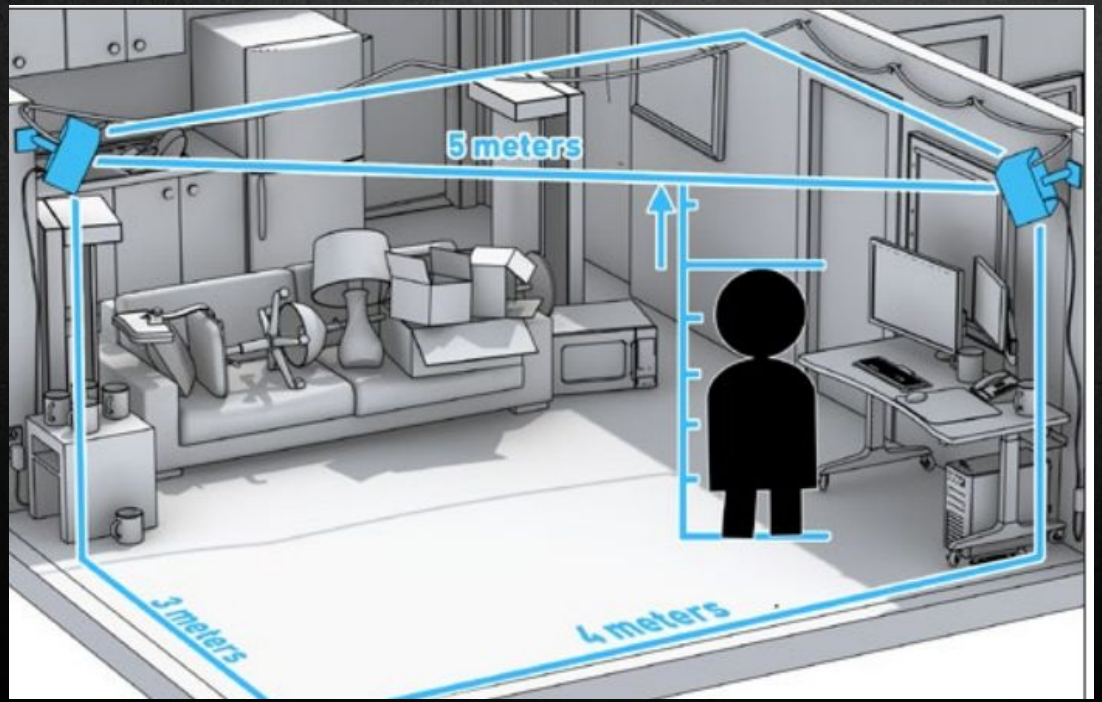


WORLD BUILDING

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



WORLD BUILDING

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

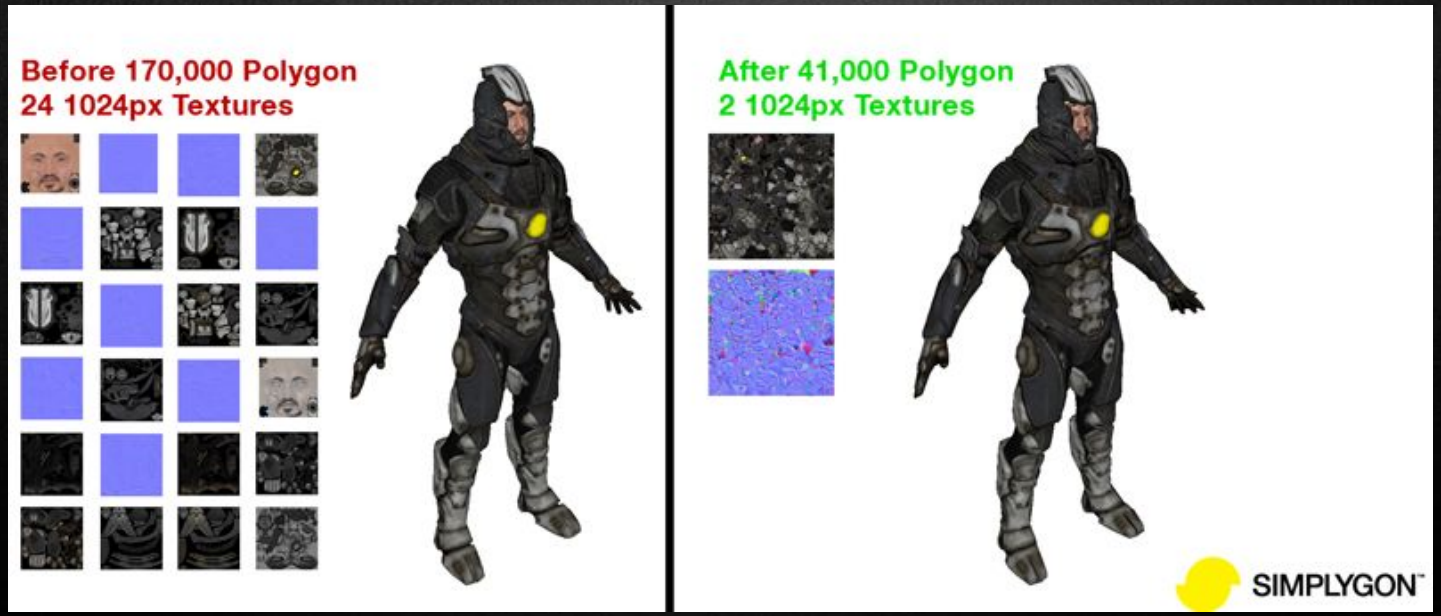
WORLD BUILDING

- 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

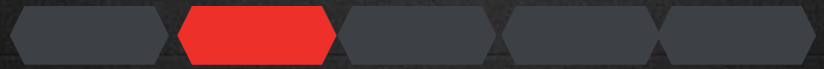
- For performance, utilize level of detail techniques



WORLD BUILDING

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

CAMERA

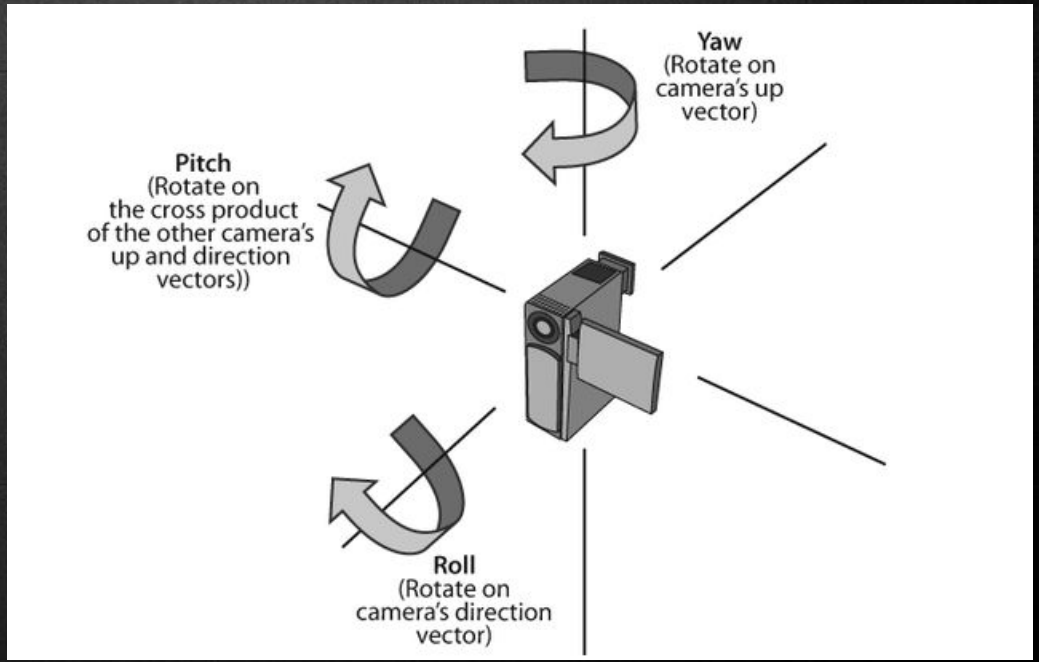


CAMERA

- 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]

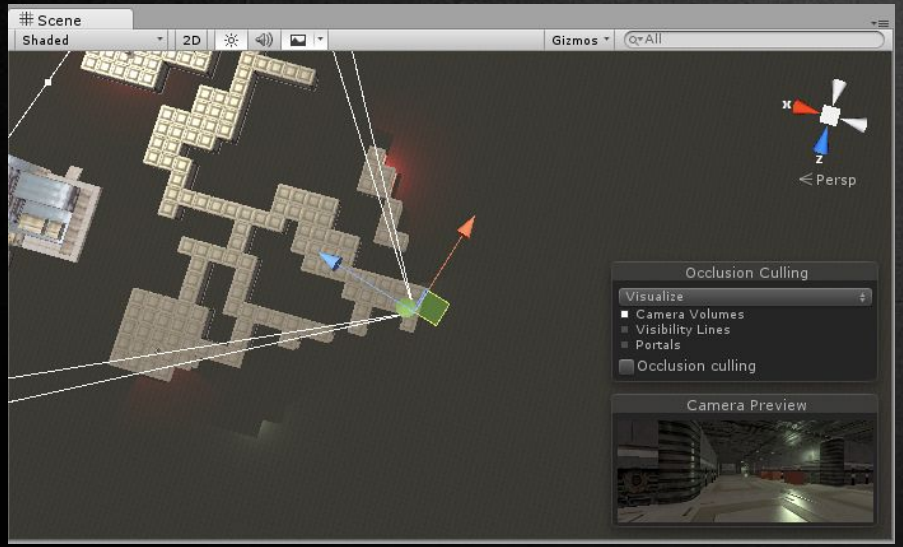
- Use human field of view at eye height
- Keep camera motion smooth & steady - don’t shake or bob the camera
- Avoid motion blur, depth of field, etc.
- Adjust for interpupillary distance and keep straps tight
- Stationary more accessible than room-scale

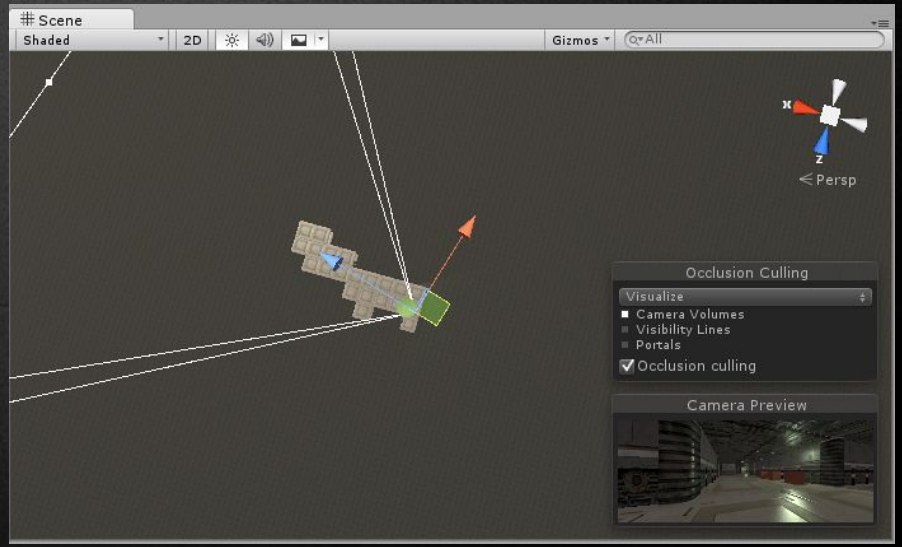
CAMERA

- 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

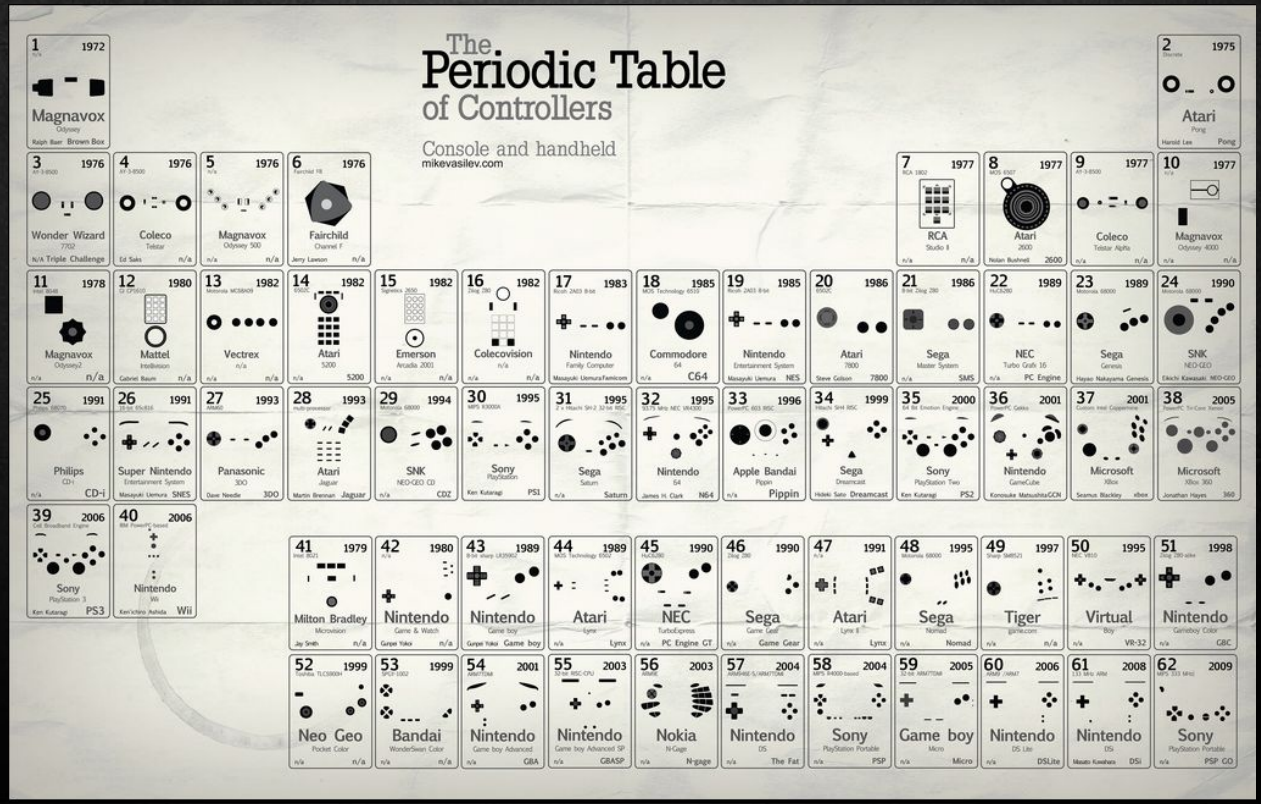




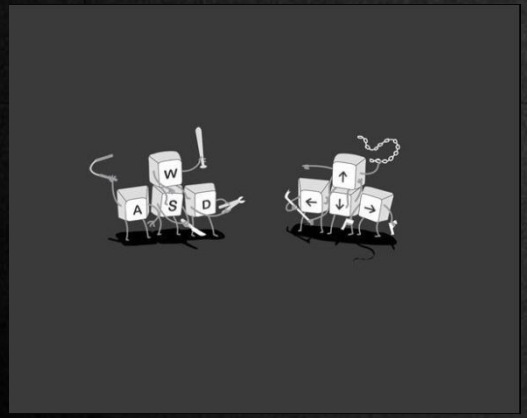
CONTROLS

CONTROLS

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



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

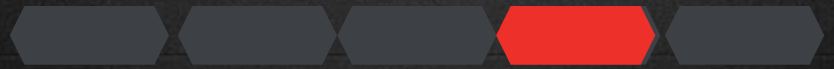
- Fitts's Law
  - Time required to rapidly move to a target area is a function of the distance to the target and the size of the target.

    - 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". *Quarterly Journal of Experimental Psychology* **4** (1): 11–26. doi: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

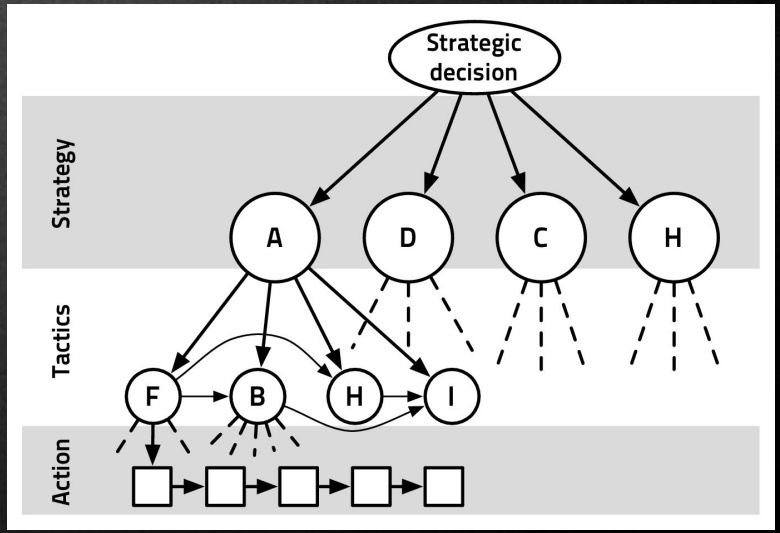
Decision Trees

- 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

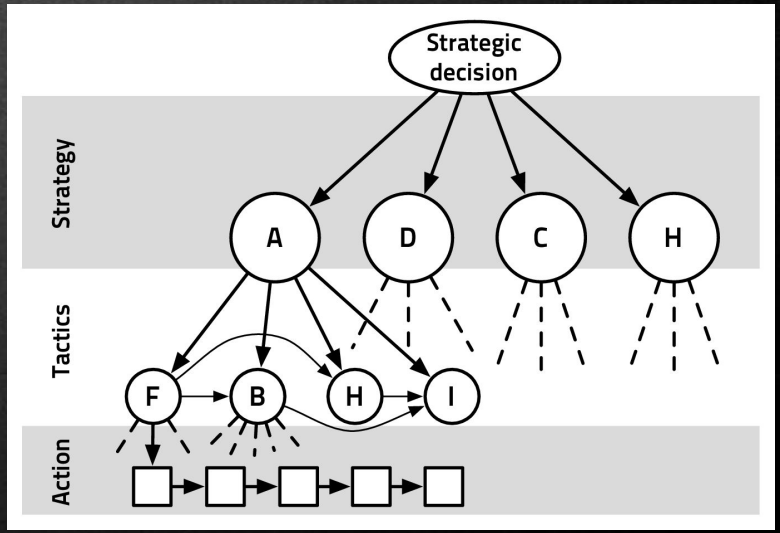
- Hierarchical State Machines are often used
  - Fewer states to evaluate vs decision tree
- Can use information from self or group
  - Squads can share data and ‘roles’
- Evaluates dynamic behaviors by priority
  - Maslow’s Hierarchy of Needs
  - Can introduce probability for randomness



AI

Behavior Trees

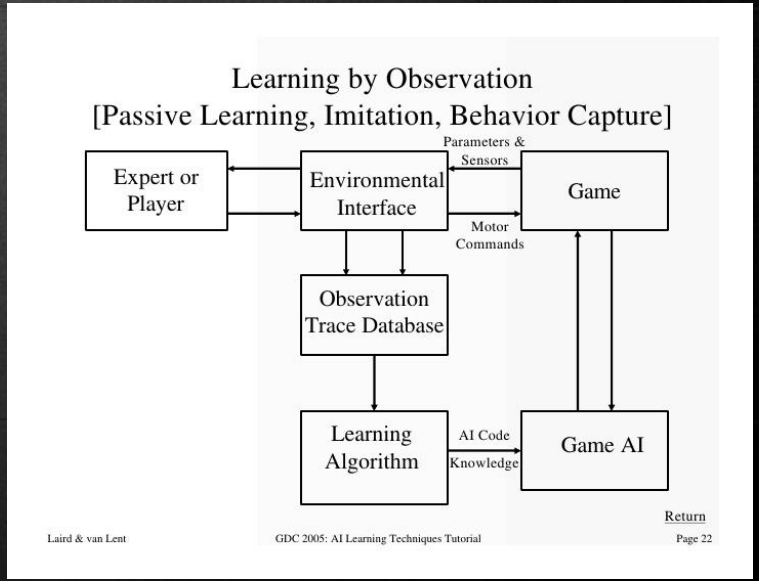
- Heuristic Tuning.
  - Requires constant re-balancing of priorities
- Indecision.
  - AIs rapidly change strategies with new data
  - Can be mitigated with hysteresis



AI

Neural Network

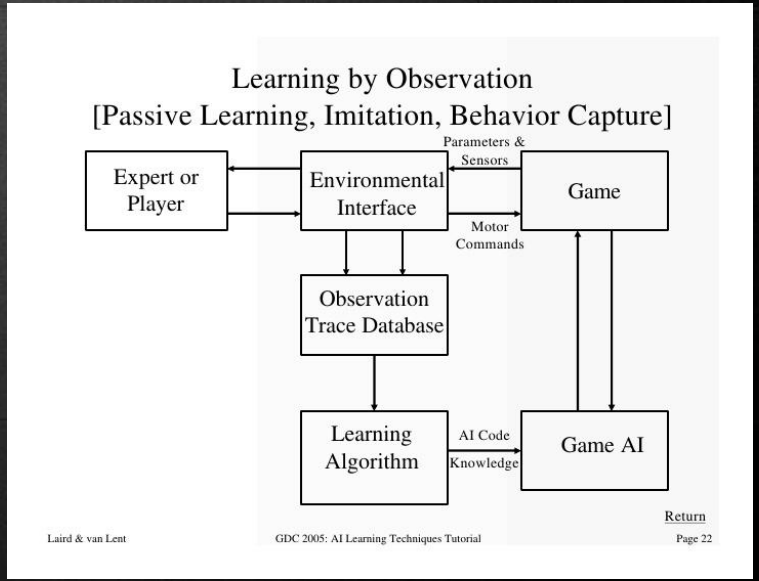
- Learned Data Set & Identify Nearest Behavior
  - Radial Basis Function / Nearest Neighbor
- Can learn information over AI or human trials
- Can leverage cloud Big Data platforms



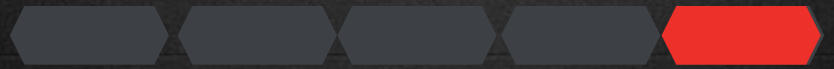
AI

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]



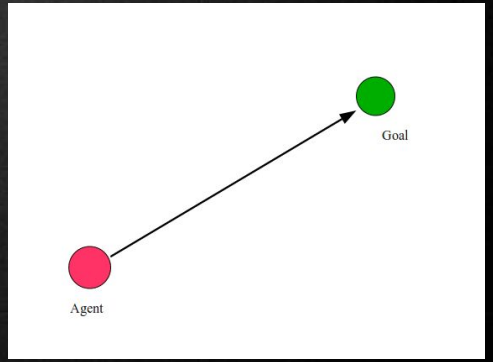
NAVIGATION



NAVIGATION

Straight Line with Local Avoidance

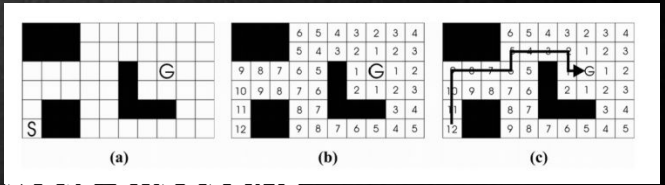
- Naïve and Simple - Plan a straight line from agent to goal
- If collision detected, select a random direction
- Paths are non-optimal and can get stuck in corners.



NAVIGATION

A* Gridmap

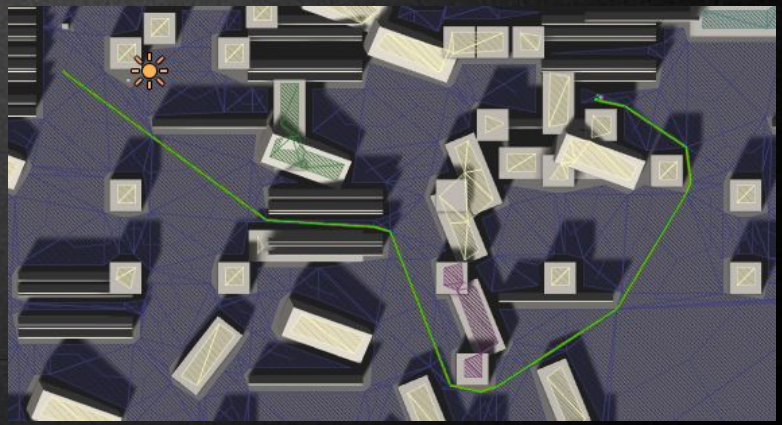
- Separate the world into grids and assign a travel cost to each grid.
- Keep an open set of each path, recursively search by adding neighbor grids and keep a running travel cost. Once a path found, cull other paths that are more expensive.



- 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

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