CSC 240 Computer Graphics
Video 20: Collision Detection & Game Design Basics

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Some slides & content courtesy Sara Mathieson

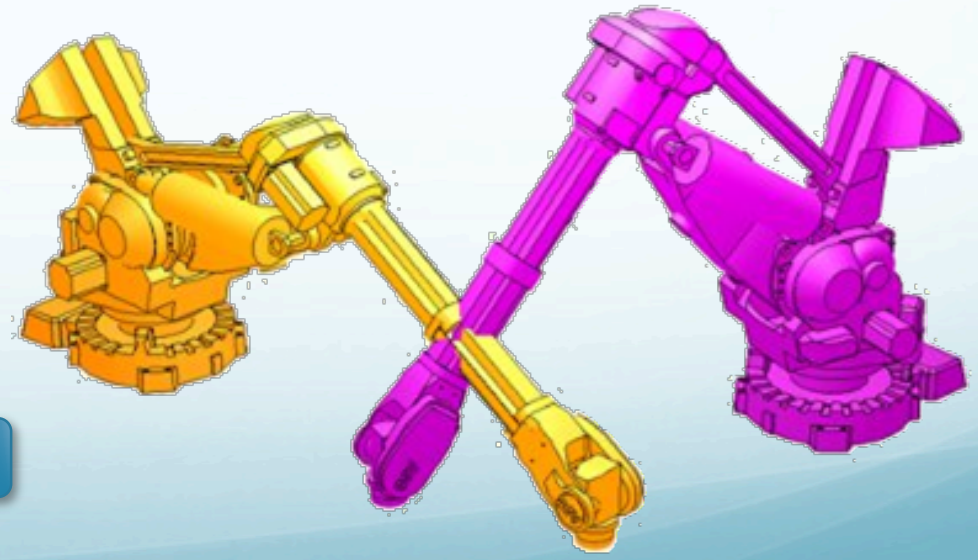
https://www.theverge.com/2016/9/12/12879766/moon-planetary-collision-theory-earth-impact

Collisions

What is meant by a **collision** in computer graphics?

- Two or more nominally solid objects occupying the same space
- Important in games and physical simulations
- May require action ➔ how to handle?
  - ➢ *A priori*
    - Predict in advance
    - Solve for time & place
  - ➢ *A posteriori*
    - Detect & react
    - Discrete timesteps

Easier for games!



http://www.coppeliarobotics.com/helpFiles/en/collisionDetection.htm

Collision Detection

Collision detection differs in **2D** and **3D**

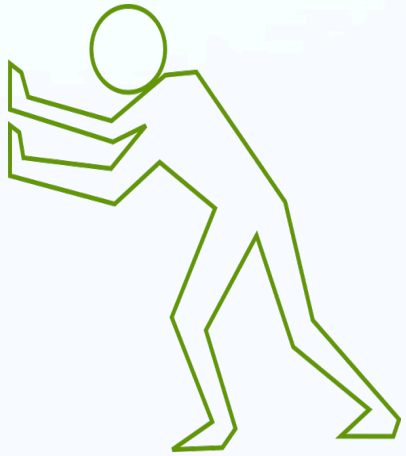
- 2D collision detection: may have hardware support
  - Sprite collisions
  - color overpainting
- 3D collision detection: handled in software
  - Object to object pairwise check: SLOOOOOW!
  - Partitioning & pruning schemes reduce work
  - Exploit temporal coherence

https://pixabay.com/en/fairy-sprite-elf-pixie-fantasy-2228449/
https://www.superherostuff.com/x-men/patches/nightcrawler-bamf-patch.html

Collision Response

How to respond when a collision occurs?

- Physics simulation: add countering force
  - Proportional to degree of collision
  - Situation corrects over time
- Game: change position to avoid collision
  - Correct situation immediately
  - "Good enough" is ok
  - May also have in-game effects

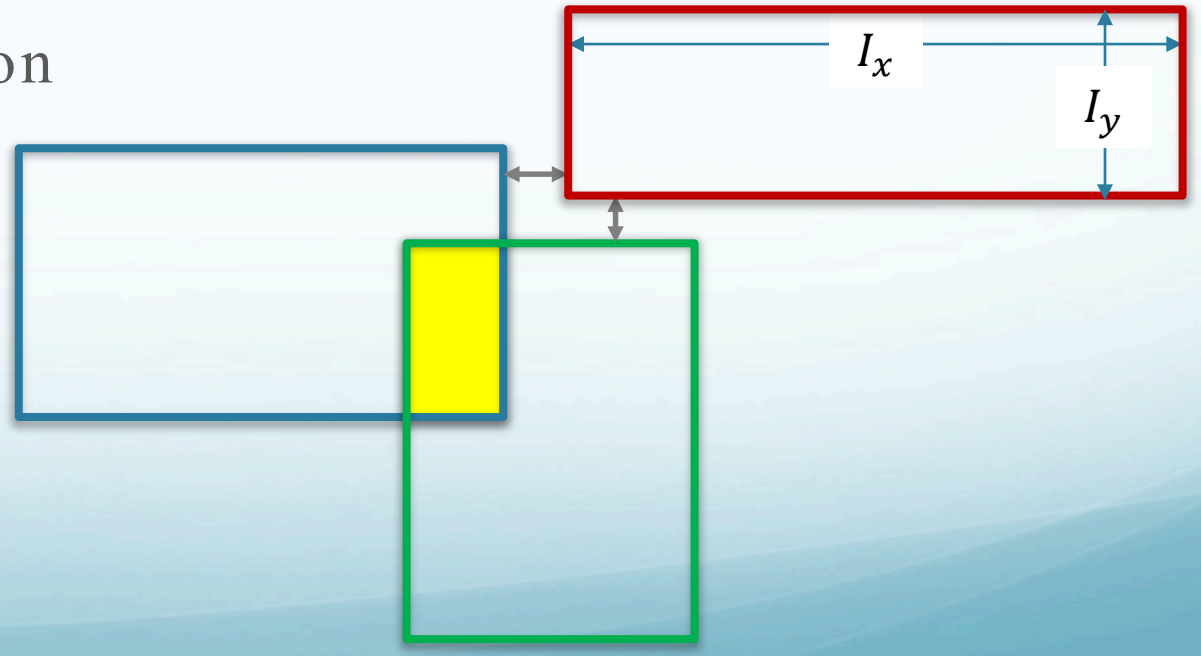


https://www.itembrowser.com/item.php?id=803 http://www.clker.com/clipart-push.html

Rough Collision Detection

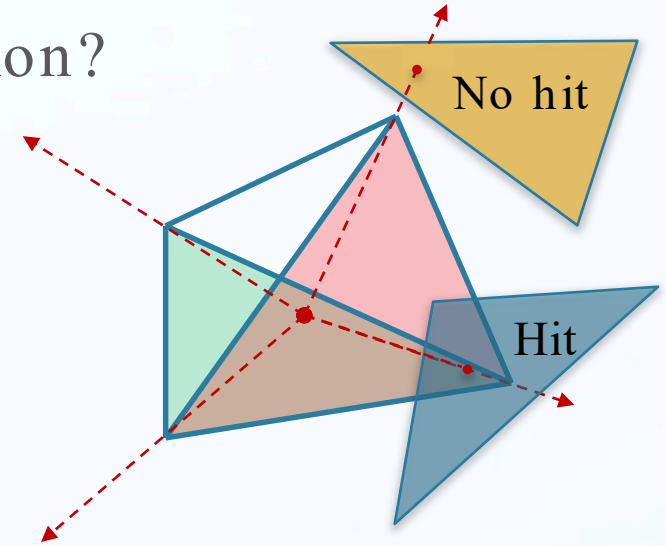
Simple bounding box scheme – prelude to detailed check

- Akin to computer window overlap problem, in 3D
- Each object described by 3 intervals: I_x, I_y, I_z
- All three must overlap for collision
- Use a sorted list of endpoints for efficient checking



Detailed Collision Detection

How do we carefully check two objects for a collision?



- Vertex method based on ray casting
  - Cast ray from object center to each vertex
  - Compute first external intersection
  - If closer to center than vertex, record a hit
  - Run for both objects in pair
- Slow and expensive – save for last resort
  - Simple proximity often will suffice (bounding boxes or spheres)

Setup up collidable objects

```
var movingCube;
var collidableMeshList = []; // objects the movingCube can collide with
```

```
// first purple box
var wall = new THREE.Mesh(wallGeometry, wallMaterial);
wall.position.set(100, 50, -100);
scene.add(wall);
collidableMeshList.push(wall);
var wall = new THREE.Mesh(wallGeometry, wireMaterial); // wireframe (not necessary)
wall.position.set(100, 50, -100);
scene.add(wall);
```

Create array of objects to check for collisions.

Modified from demo: http://stemkoski.github.io/Three.js/Collision-Detection.html

Collision Detection Code

```
var originPoint = movingCube.position.clone();

for (var vi = 0; vi < movingCube.geometry.vertices.length; vi++) {

    var localVertex = movingCube.geometry.vertices[vi].clone(); // get vertex coordinates relative to the object
    var globalVertex = movingCube.localToWorld( localVertex );  // convert to world coordinates
    var directionVector = globalVertex.sub( originPoint );      // vertex - origin (vector subtraction)

    // cast a ray from the center of the object through the vertex
    var ray = new THREE.Raycaster( originPoint, directionVector.clone().normalize() ); // normalize to unit vector
    var collisionResults = ray.intersectObjects( collidableMeshList );

    // if we have at least one collision result, and the collision vector is less than the direction vector, HIT
    // note: collisionResults[0].distance is like our "t" value
    if ( collisionResults.length > 0 && collisionResults[0].distance < directionVector.length() ) {
        console.log('HIT'); // or do something else like move the object back to where it was, or delete the collided object
    }
}
```

Loop over vertices of moving object

Send rays out from all the corners of the cube

Compute intersections with all objects of interest

Detect a collision if intersection point is closer than corner

Modified from demo: http://stemkoski.github.io/Three.js/Collision-Detection.html

Questions

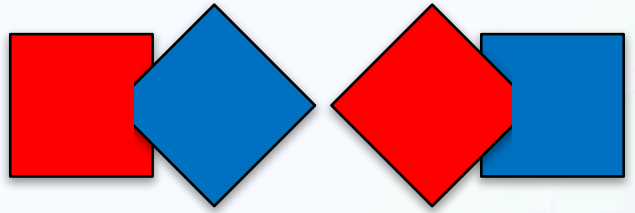
PAUSE NOW & ANSWER

1. Why are collisions easier to detect in 2D graphics?

   If objects occupy the same pixels, they have collided.

2. In 3D, why do you need to project rays from both objects to detect all collisions?

   A corner of one object may intersect with a face of the other.



3. Which boxes overlap?

   A. X: 2-7, Y: 10-12, Z: 0-4

   B. X: 6-9, Y: 6-9, Z: 3-10

   C. X: 4-8, Y: 8-11, Z: 2-5

   D. X: 7-10, Y: 3-7, Z: 0-4

A with C, B with C, and B with D.

Game Design

Game Design

A game is a tool designed for **meaningful play** .

- Meaning emerges from player actions within the game and the game's response to those actions
- Responses to actions should be both *discernable* & *integrated*

Discernable : Result of game actions is communicated in a perceivable way

Integrated : Player actions have immediate effects but also accumulate and affect the play experience in a continuing way

From Salen & Zimmerman, Rules of Play

https://b985.fm/introducing-the-dice-gift-exchange/

Considerations

Theme: What is the objective of the game?

- Can the player “win” or is it open-ended?
- How is progress perceived and recorded?

Gameplay: What is the primary mechanic of the game?

- What controls are available to the player?
- What sort of view is available?

Production: What ingredients will go into this game?

- What technical challenges must be solved?
- What digital resources are required & where will they come from?

Jay Kaslo, https://www.behance.net/

Review

After watching this video, you should be able to…

- Give two reasons for detecting collisions
- Describe two simple methods for checking possible collisions
- Describe and implement an algorithm for detailed 3D collision checks
- Identify important elements in any successful game

Music: https://www.bensound.com