

# Game Notes

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Position within square stored as an odd signed integer in half-pixels, e.g.

101	011	001	011
-3	-1	1	3

Requires entities to have odd pixel dims to be centered

Edge/vertex states are not possible

Updating position requires doubling velocity first

Store position as  $x$  and  $y$  seen on screen or relative to a square's axes?

Screen position:

- Graphics and movement are easier
- Collision would be most convenient by loading the current square rotated

Relative position:

- Collision is easier, just check against stored square
- Need to ensure that rendering is done correctly

View splitting is decided by determinant sign: will always give edge to cell further (counter?)clockwise

Vertices/edges are on the border between pixels (even position): do not require a special case



Shaded pixel: camera

Lines: region boundaries

Inlined pixels: edge cases (given to clockwise region in this case)

Going through a singularity and back is a holonomy loop

Entity gravity is ambiguous when not in the same square as the player:

- Freeze when player leaves the square: unintuitive, esp for flat regions
- Based on last player interaction: better, but initial direction must be set: could be none

Have “naked” singularities or cover them up?

Naked is easier to implement if accounted for at the cost of real physics:

an object of finite size can’t actually pass through one

Not checking self-collisions would obviate this but may result in graphical glitches

Covering singularities would prevent glitches and restore accuracy but might hurt level design

Larger squares → fewer singularities → less harm in covering them

Also, must be regions accessible in only one orientation: side longer than 2x jump height

However, smaller squares → more convenient to travel/execute holonomy

Leaning towards covering, especially since multi- entity collisions near them can get hairy

Collisions near edges are inevitable, but behavior near edges is well-defined

Need to distinguish between singularities and non-singular vertices: 4 squares meeting at a point

To resolve collisions at edges/non-singular vertices, may need “intermediate” frame of reference

If these are necessary, may not need to bother with half-pixel positions: allow entities centered on edge/vertex

But if this is the case, need to ensure that behavior is the same regardless of if in one face or the other

Render method (pixel shader):

Build a tree of regions, starting from current square

Region info: left and right boundary points, square rendered, position, and orientation of square

Region is split if strictly contains singularity (i.e. not on edge)

4 quadrants constructed separately, contains current square 4x and squares in same row/col 2x

Build tree using an array/queue for BFS

Regions in the same position are contiguous in the queue

Store index of first region in array

Given a pixel, find position, access array for queue index, iterate through queue until pixel is in bounds

Apply orientation of region to find color

“Raycasting” each pixel is slower than this, but the function will be useful later for collision resolution

Art style between pixel and vector: each “pixel” is not a solid color but one of a few predefined shapes, e.g. solid color, 2 colors split diagonally, split by circular arc

## Physics

Single entity moving in static background: all collisions are with axis-aligned surfaces

Collision multiplies perpendicular velocity by integer  $\leq 0$ , keeps parallel velocity constant

Intersection point could be any rational number, so can’t store intermediate positions

Instead, reflect both beginning and end points across plane of collision (adjusted for size of player), recursively/iteratively resolve collision with “mask,” i.e. ignoring portion of trajectory “before” hitting wall

Collision state consists of beginning/end points and rectangle to check

Initialized to previous frame position and rectangle encompassing path

E.g. moving up+right: rectangle starts at lower left corner of starting position, extends to top right of ending position

Collision with vertical surface changes only x-coordinates of beginning, end, and quadrant

But this can cause bugs with large players and irregular walls: maybe rational coords are the easiest

45 degree slopes are possible as well, as long as coefficient of restitution (bounciness) is odd

Doesn’t work with pixel buffer for collisions: need to add “static” entity

## Game loop

Build region tree

Take player input

Update velocity accordingly (also gravity here?)  
Resolve collisions  
Render

#### Types of entities

Environmental: either stationary or on a fixed path (e.g. bouncy walls, moving platforms)

Collision resolution should not affect their velocities under any(?) circumstances

Environmental entities may intersect each other

Interactive: can be moved by the player (e.g. boxes)

Player

All entities are 135 degree octagons

8 numbers representing taxicab distance from center to sides in half-pixels

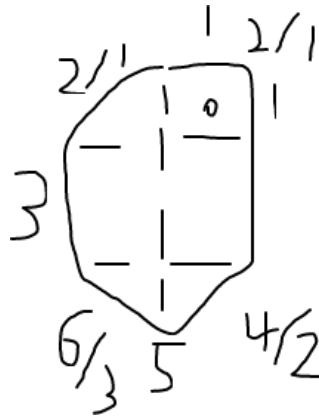
Ex:  $3 \times 5$  rectangle has horizontal distances 3, vertical 5, diagonal 8

Orthogonal distances must be odd, diagonal must be even

Spec:  $NE \leq N+E$ ,  $2N \leq NE+NW$  (equality implies side length 0)

Alternatively, could measure diagonal distance in pixels

Spec in this case:  $2NE \leq N+E$ ,  $N \leq NE+NW$



Sides are marked as collidable or not

Collisions are only checked between opposing sides of entities: makes one-way platforms possible

Simplest case: only need to check player vs. environment

Create “virtual” entities in adjacent faces to allow for collisions across boundaries

How to handle sub-pixel movement for fluidity?

Store sub-pixel position: more “correct,” but may not look good

Also would require additional programming for collisions to avoid resetting sub-pixel position

Round sub-pixel velocity before adding: more consistent jumps between frames, position is always an integer

Simple collision: 2 entities (A, B), same tile

Check each pair of opposite sides (e.g. A left, B right)

Use adjacent sides to determine vertex locations

Edges of A and B trace out a parallelogram as they move

Need to check whether these intersect using Minkowski difference, which is itself another parallelogram

Difference intersects origin  $\rightarrow$  edges collide

Need to ensure that origin is “passed over” in the right direction to allow for one-way platforms

Ex checking A left, B right: A side must be non-strictly to right of B at beginning, strictly left at end

Find (rational) time where distance is 0:  $0 \leq t < 1$

Use bounciness to compute new “starting point” (image) and velocity

Ex player vs. environment: use frame of reference of environment

Entity passes through multiple tiles: include “virtual” entities  
Virtual entity should be created for all tiles which any part of the entity non-strictly touches  
How to find all of these (easily?) Assurances on entity size, etc  
Not just all tiles, but all “regions:” can pass through same tile in multiple ways e.g. Mobius strip

Collision resolution loop has current positions (rationals), ending positions (integers), velocities (integers)  
Only consider collisions which occur between this number (incl) and 1 (non-incl)  
Collision location (edge) must also be (non-strictly) within bounds of tile  
May happen on tile boundary: should not matter which one is resolved before end of loop

Could heavily emphasize integer-based physics:  
discrete position in large “cells,” movement updates occur slowly (turn-based or on visible timer)  
Could have interesting interplay with gravity  
Pool-type game? Does not work in general with equal masses  
Golf is much better: environment does not respond to ball  
Octagolf!

Ways that physics could break  
Object crushed between two others of higher priority: detect by overflow of denominator of time/position  
Object sandwiched between two bouncy walls: detect by returning perfectly(?) to previous state  
Object bouncing between superelastic walls: also overflow(?)  
Easy catchall fix: limit on number of iterations  
Cleaner fix: no interactive entities (besides player), no squeezing/crushing, speed cap  
Player may hit multiple entities on the same edge at the same time: use the bounciest one  
Speed cap would also ensure that one of the following is true about player trajectory:

- Remains within 1 tile
- Crosses an edge: 2 tiles
- Crosses two adjacent right-angled edges: 3 tiles
- Passes through a non-singular vertex: 4 tiles

Could potentially allow crushing with other constraints: only player can be crushed, triggers on overflow  
After collision, need to trace path from intermediate (rational) point: tile of end position is not yet known

All collisions need to be handled as edges, including entities (edges on outside) and tile boundaries  
Tile boundary edges create a new virtual entity on other side when collided  
Need to avoid infinite loop (how?)  
Potential properties of edges:

- Location (tile and coordinates) and orientation
- Whether it is collidable, and if so, its bounciness
- Whether it is a portal, and if so, where it leads
- Whether it is deadly to the player
- Whether it is opaque (only affects rendering)

Rendering method/finding geodesics should also be a mechanic, e.g. shine a directional light at a source  
Light may need to pass through filters to become the right color  
Mirrors would be interesting but difficult to visualize  
Virtual entities must be removed when they exit their square to prevent holonomy bug:  
bouncing around a singularity may lead to extra collisions otherwise