lssx, LÖVE Space Shooter X

Artifact

Extended Project Qualification

2018

ttxi - JLC

What *is* lssx?

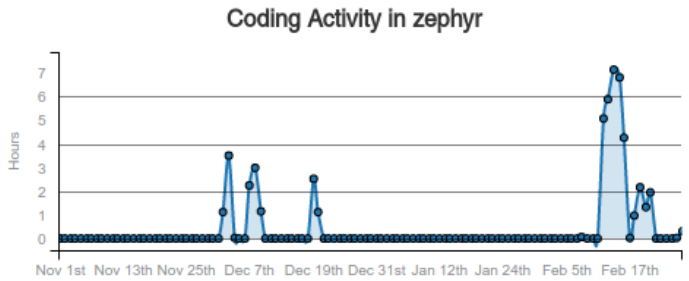
An archaic piece of software ripped from a fusty floppy disk is in-fact a US space-pilot training simulator from the Cold War.

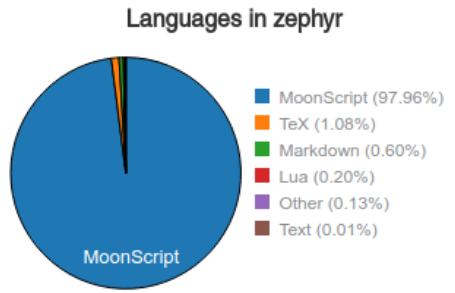
`https://youtu.be/VVLTaXaBqdw`

Statistics

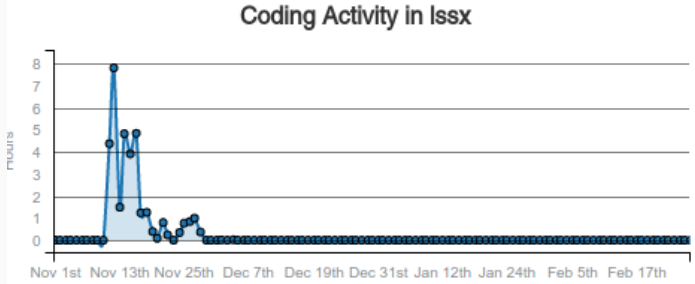
- ~4000 lines of code, 8000 including libs.
- ~120 hours spent
- ~140 commits

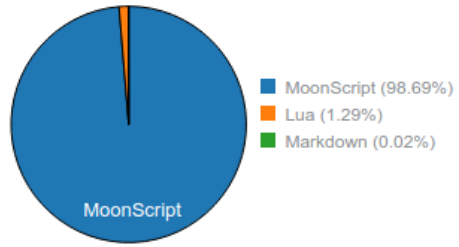
50 hrs 33 mins 50 secs from Wed Nov 1st until Today in zephyr under all branches.





34 hrs 31 mins 49 secs from Wed Nov 1st until Today in lssx under all branches.





Why lssx?

Several years experience in programming.

Never actually finished a game before.

Diverse skill-set required: geometry, trigonometry, design, sound-editing, art etc.

Fun (it was not).

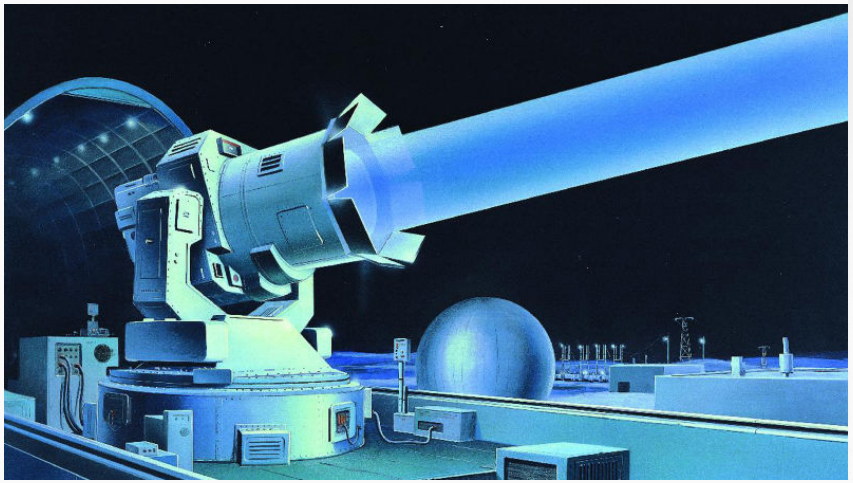
Project aims

Aims were to create a small-scoped, space-esque, shoot-em-up with semi-realistic physics and retro graphics, akin to **Asteroids** or **Space Invaders**.

- Finish it
- Enjoyable, *re-playable* and simple experience
- Release onto itch.io

Inspiration & Research

Cold war paranoia, fantasy systems (Star Wars ICBM defence) - Training simulator for cold-war pilots. Cold war computing, Apollo Guidance Computer (AGC)



Looked into: **BYTEPATH**, **Reassembly** and **Data Wing**

BYTEPATH

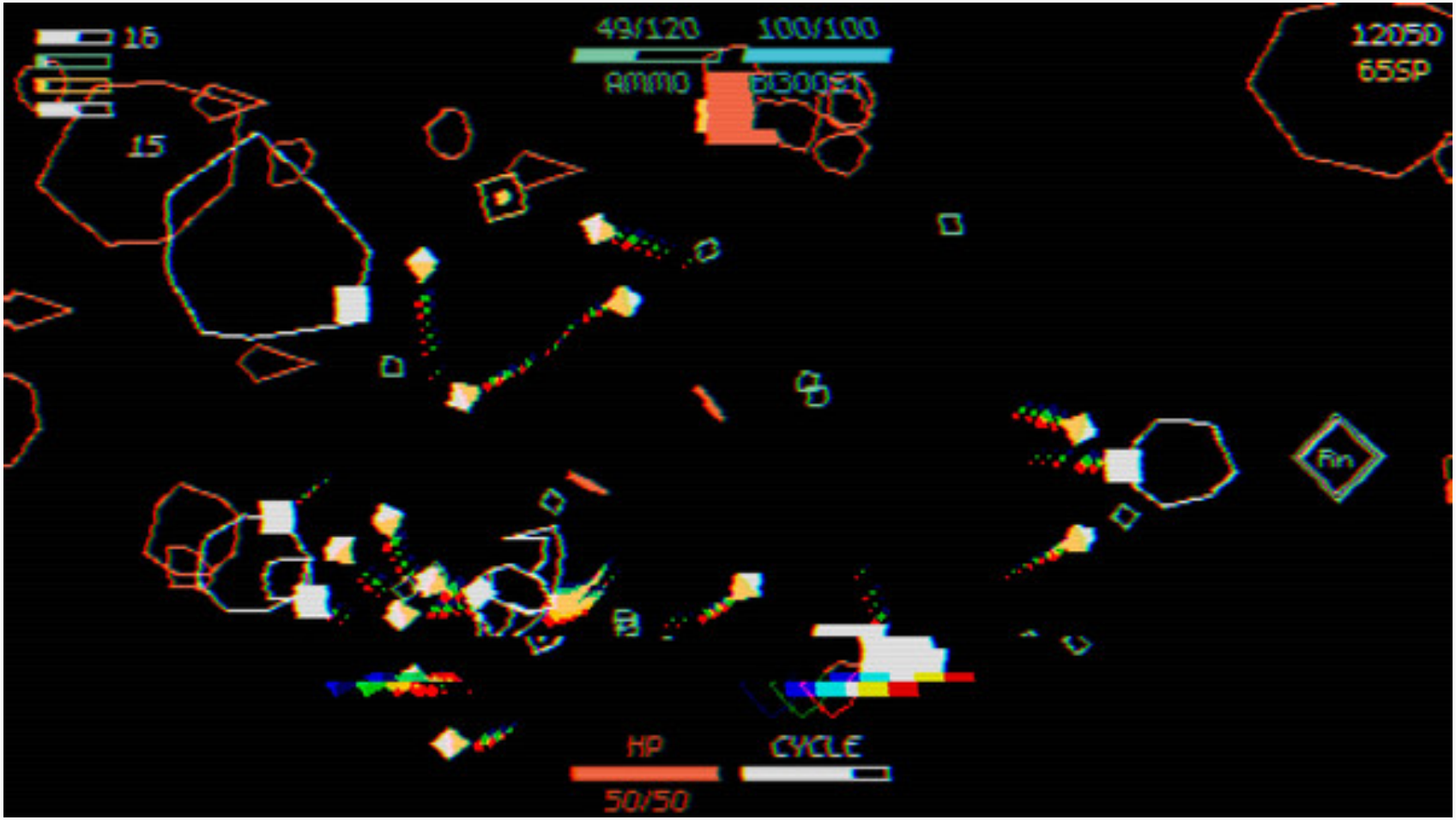


Figure 1: BYTEPATH

Simple yet diverse gameplay, no camera, limited movement (a la. Asteroids)

Reassembly

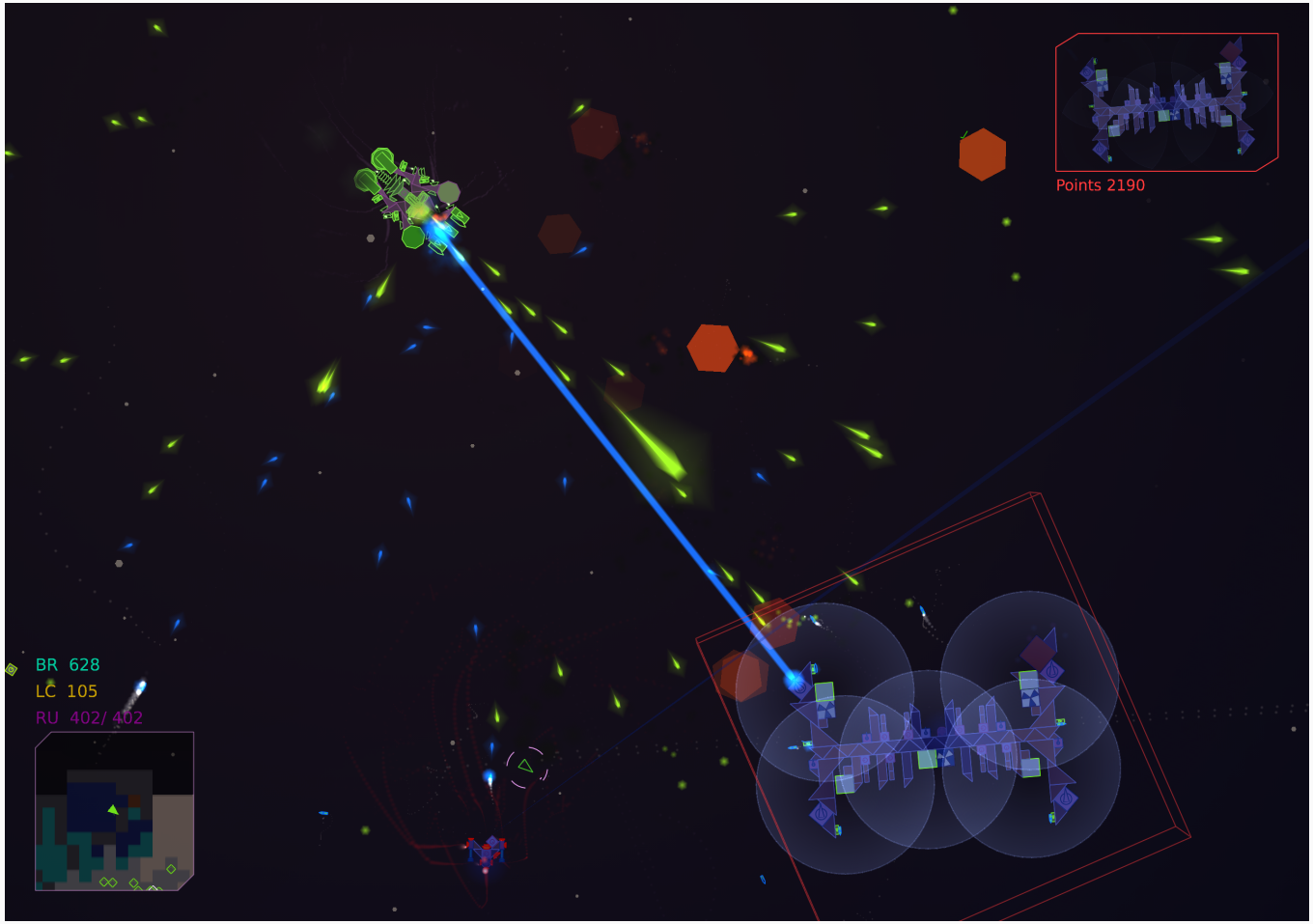


Figure 2: Reassembly

Vector graphics, heavy use of lighting and shaders, minimal UI

DATA WING

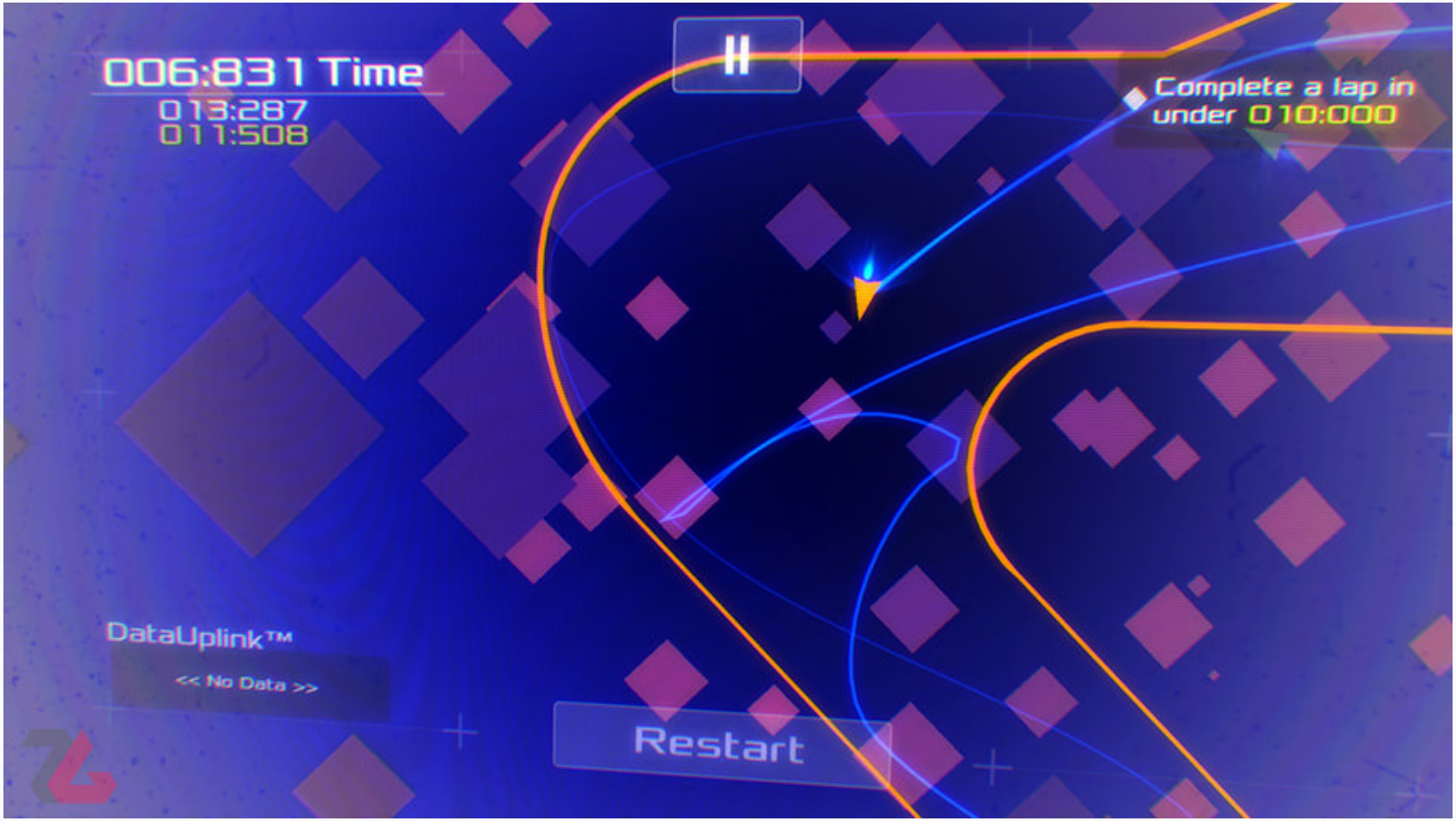


Figure 3: DATA WING

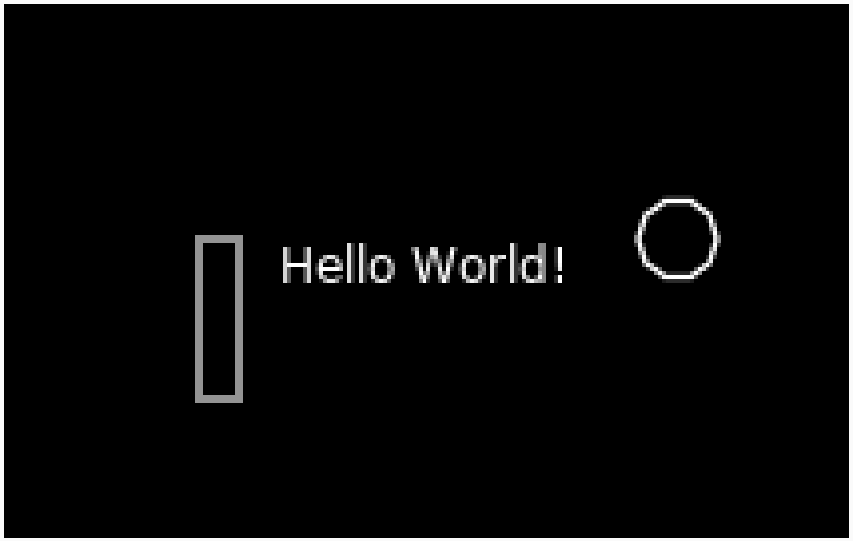
Basic yet enjoyable movement mechanics, camera parallax.

Architecture

- **Lua**, a powerful, efficient, lightweight, embeddable scripting language, used in programs such as *Adobe Lightroom* and *Civ5*.
- **LÖVE**, 2D game development framework, used in commercial games such as "*Move or Die*".
- **Box2D**, 2D physics engine used to realistically simulate interaction between rigid bodies, in development for over 10 years.

Lua and LÖVE

```lua
function love.draw()
  love.graphics.print("Hello World!", 400, 300)
  love.graphics.circle("line", 500, 300, 10)
  love.graphics.rectangle("line", 380, 300, 10, 40)
end
```



Box2D

Box2D powers almost all physics interactions within the game, it's proven to be reliable and fast and also has plenty documentation to learn from.

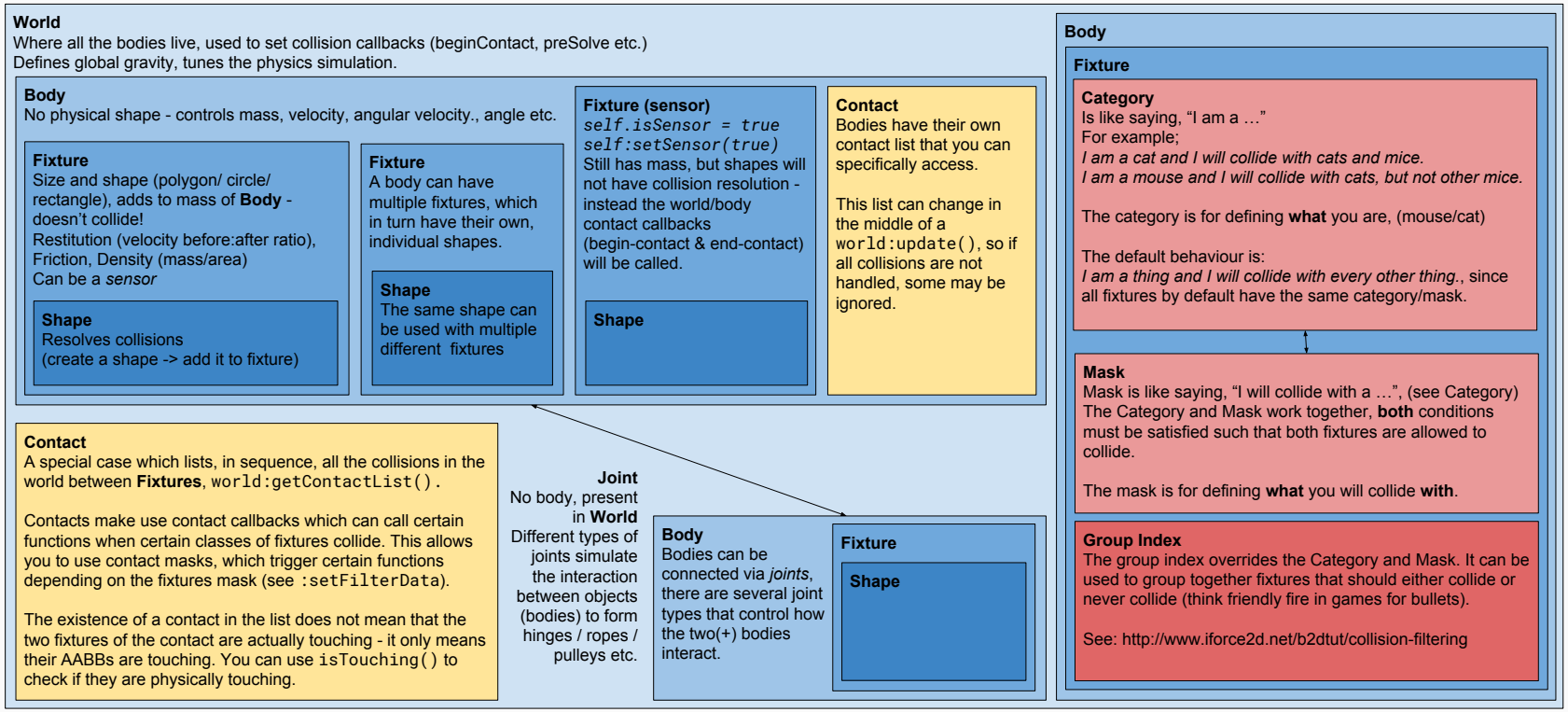


Figure 4: Anatomy of Box2D

Important Box2D concepts

- **Body**, defines properties of an object you cannot see, density, location, rotational inertia and others.
- **Fixture**, used to define material properties of an object, e.g. friction, restitution.
- **Shape**, defines the actual physical shape for collisions.

Multiple **fixtures** can be added to a **Body** to create different forms.

Shapes inside **Fixtures**, **Fixtures** inside **Bodies**.

How do you even write a game?

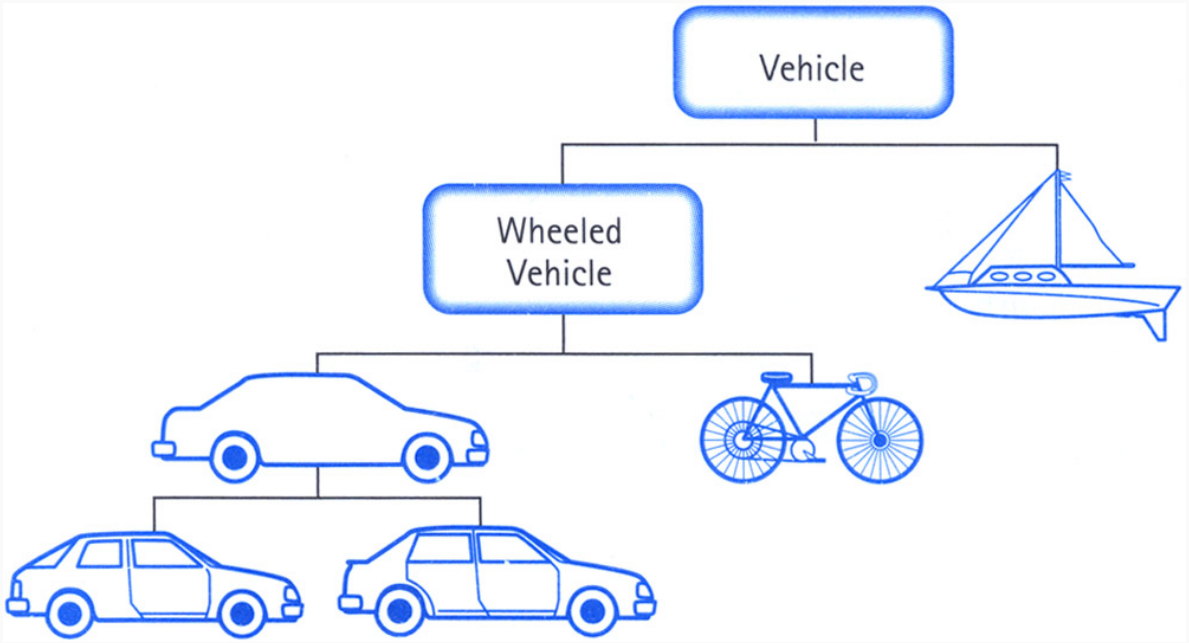
Idea → Program idea → Test → Debug / improve → Repeat

Organization is **paramount**, but not *that* much.

Most popular ways of developing bigger-than-small projects is either with an **Entity Component System** or via **Object Oriented Programming**.

Object Oriented Programming

Object Oriented Programming is a paradigm which attempts to define the behaviour of real world objects via inheriting behaviours.

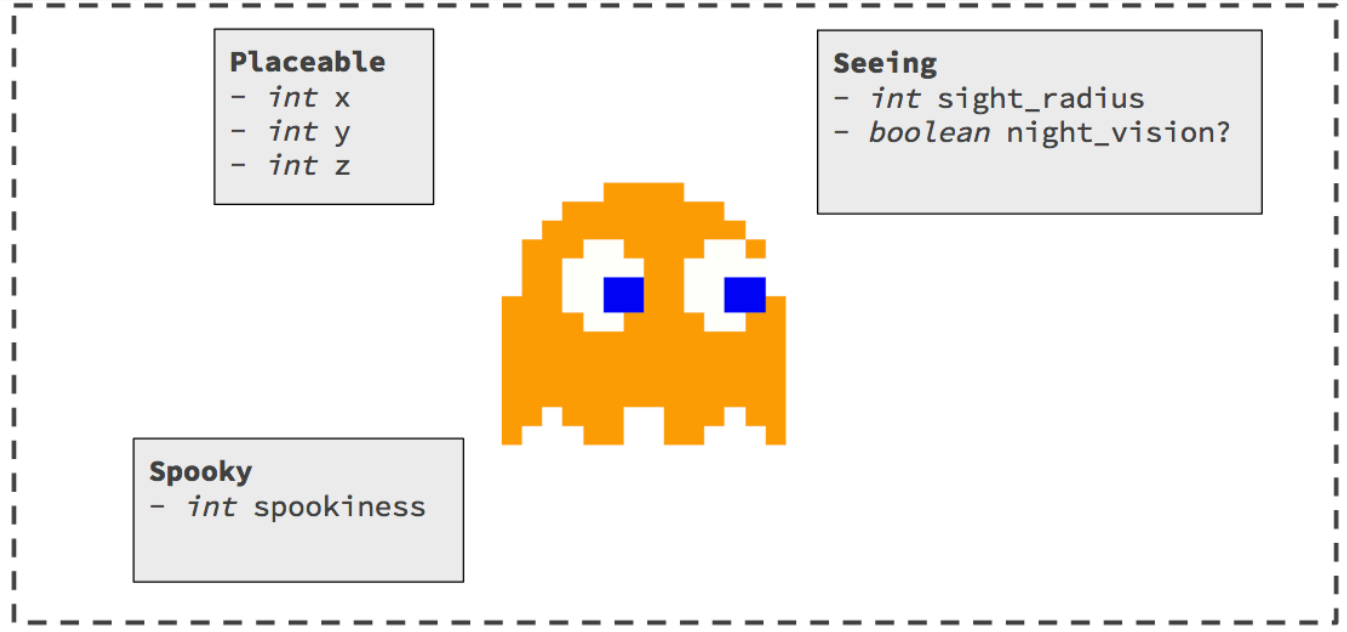


OOP allows for Polymorphism, Encapsulation and Abstraction. Large projects can be created in a sane, organised fashion.

Entity Component System

ECS follows composition over inheritance.
Every entity consists of components which add or define additional behaviour. ECS is better for very large projects because of it's inherent modularity.

A Pacman ghost has some of the following behaviours,



ECS or OOP?

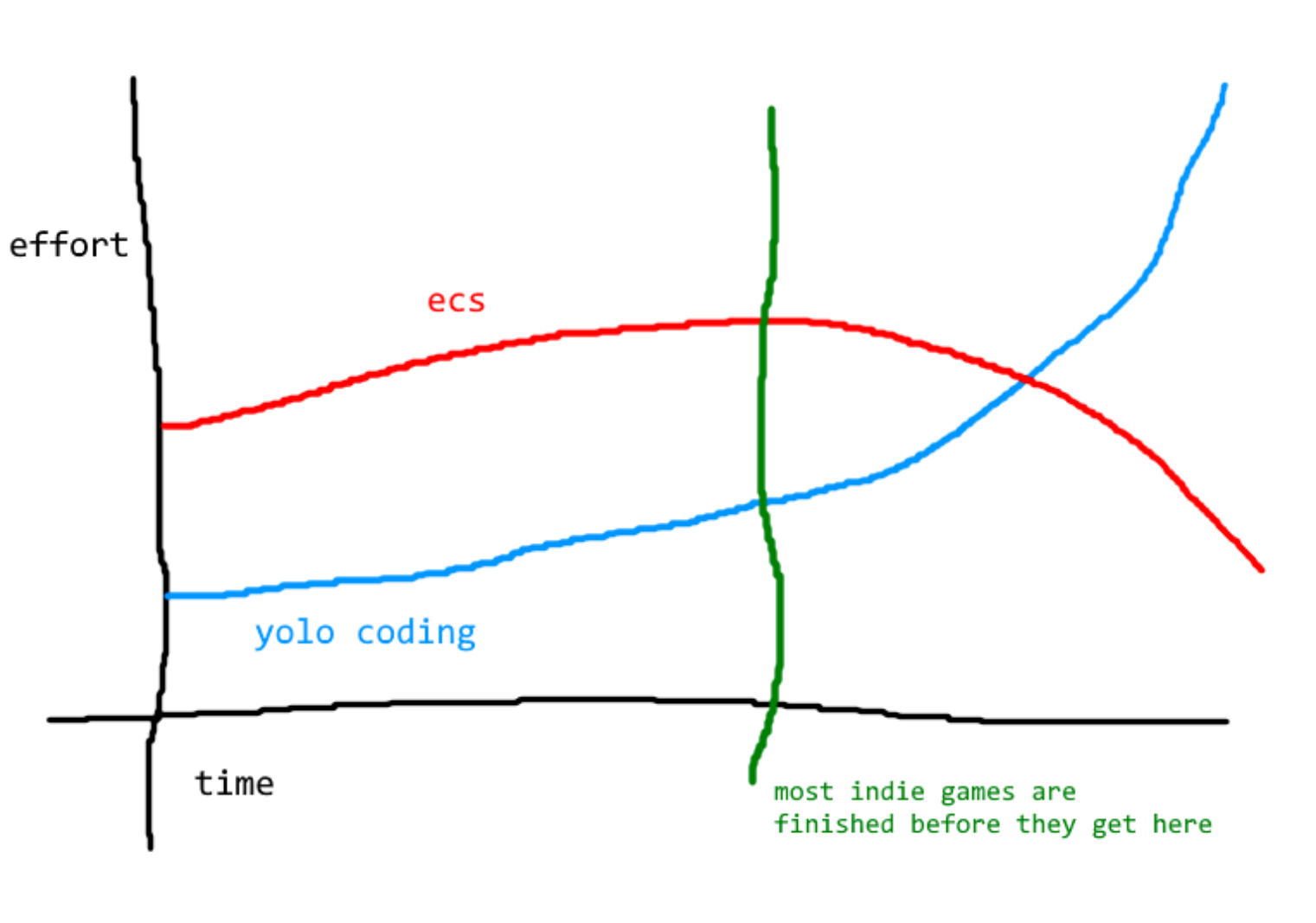


Figure 5: https://github.com/SSYGEN/blog/issues/24

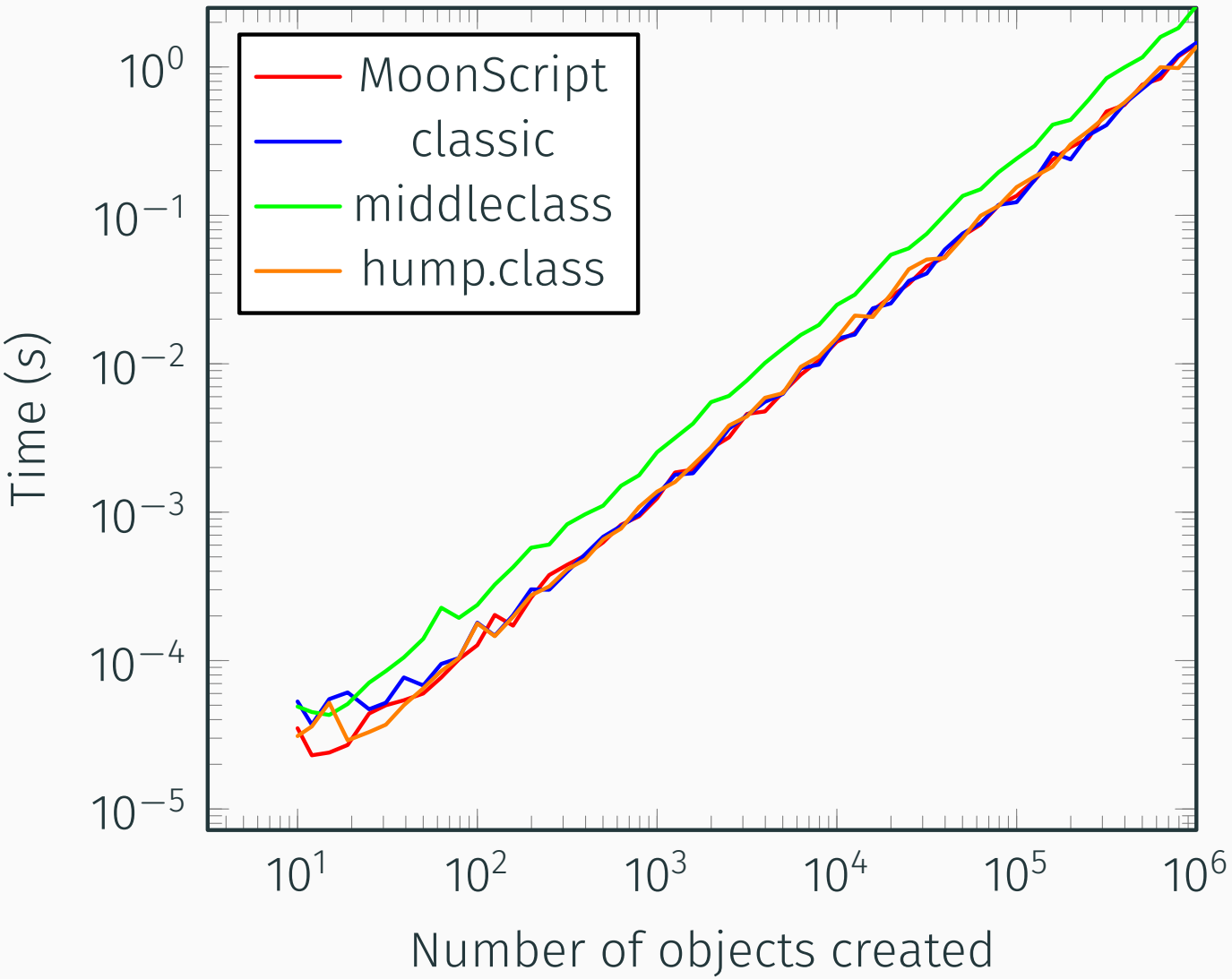
Choosing an OO library

A **library** is a set of reusable functions that perform a set of usually complex tasks that would take a long time to develop yourself.
Lua doesn't natively support *OO*, however the Lua community have created a number of libraries, that allow you to do OOP with Lua.
Tests were performed on popular OO libraries to see which was the fastest/memory efficient.

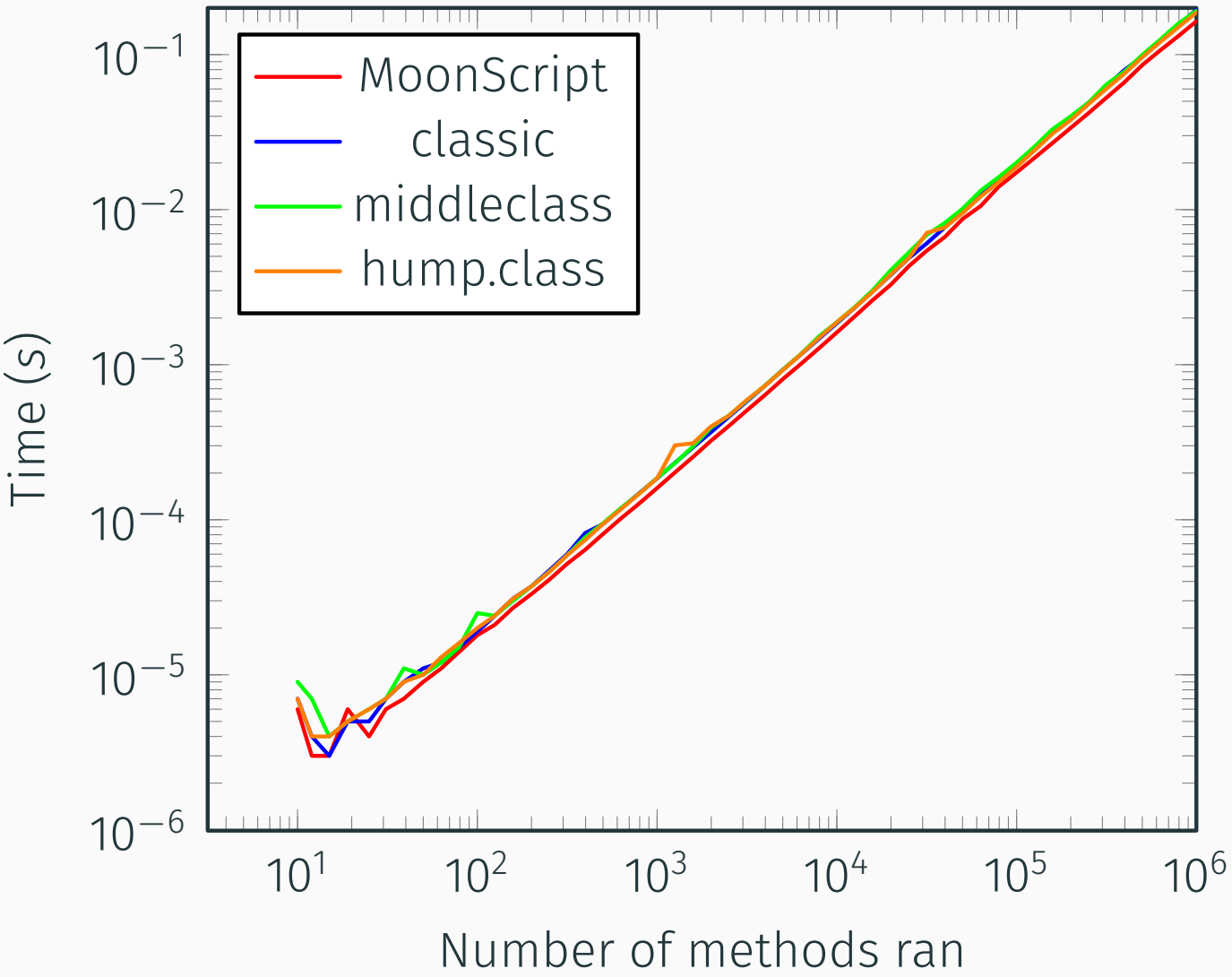
- Creating instances of objects
- Performing methods
- Testing inheritance

From 10 to 1 million objects.

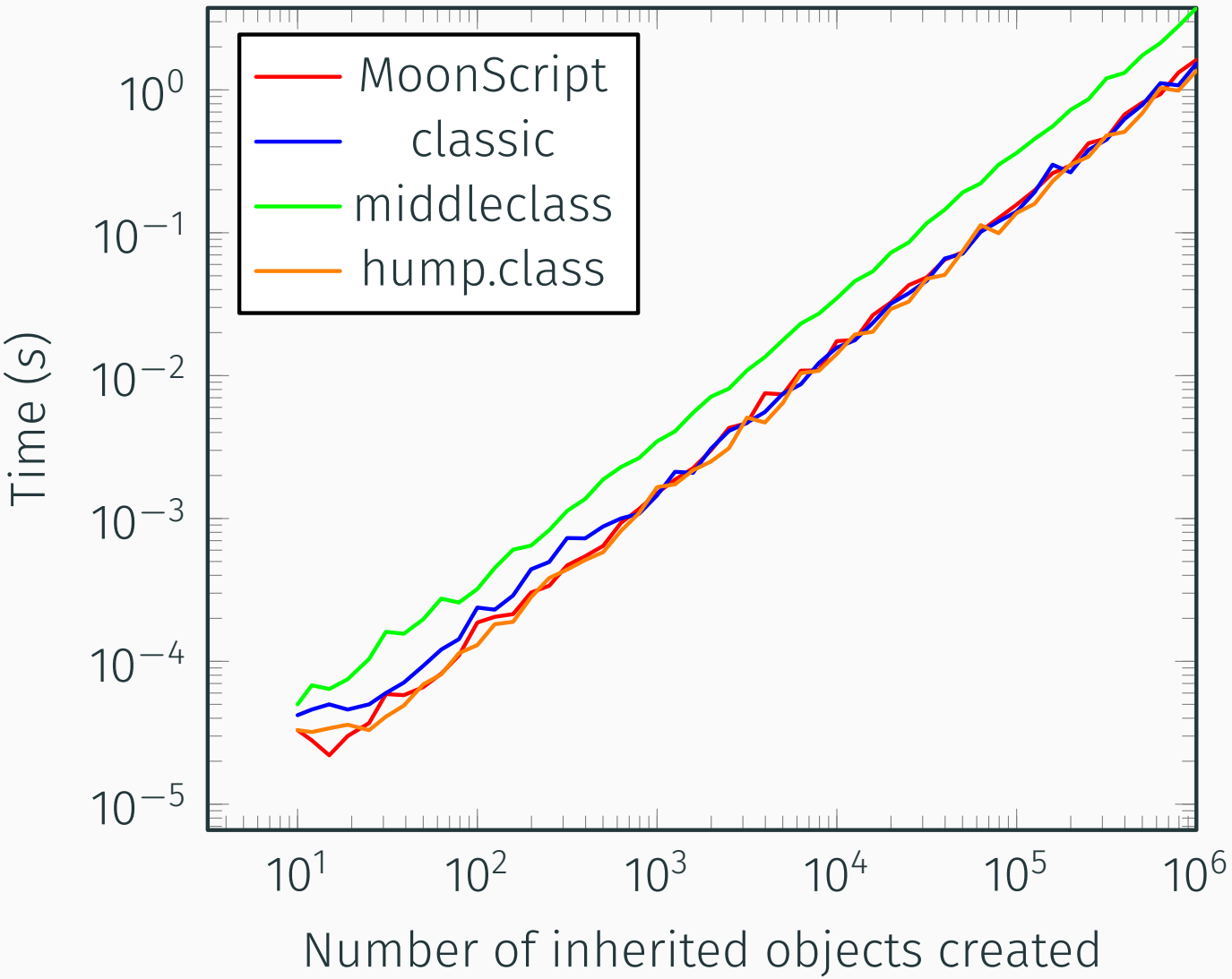
Creating objects



Performing methods



Testing inheritance



Results and conclusion

MoonScript is the leader when dealing with a smaller amount of objects (< 100).

MoonScript is not a library, but is a dynamic scripting language that compiles into Lua, so it can be used with LÖVE.

MoonScript chosen as it has the fastest OO, has greater readability because of the reduced syntactic sugar and therefore errors less likely to be made.

$$\text{MoonScript} \rightarrow \text{Lua} \Rightarrow \text{LOVE + Box2D}$$

MoonScript compiled into Lua

The following MoonScript code:

```
Director.gameStart = () ->
  Timer.every 2, ->
    Pickup(math.random(2000), math.random(2000))
    Asteroid(100+math.random(1800),
      ↪  100+math.random(1800))
```

Is compiled into the following Lua code:

```
Director.gameStart = function()
  return Timer.every(2, function()
    Pickup(math.random(2000), math.random(2000))
    return Asteroid(100 + math.random(1800), 100 +
      ↪  math.random(1800))
  end)
end
```

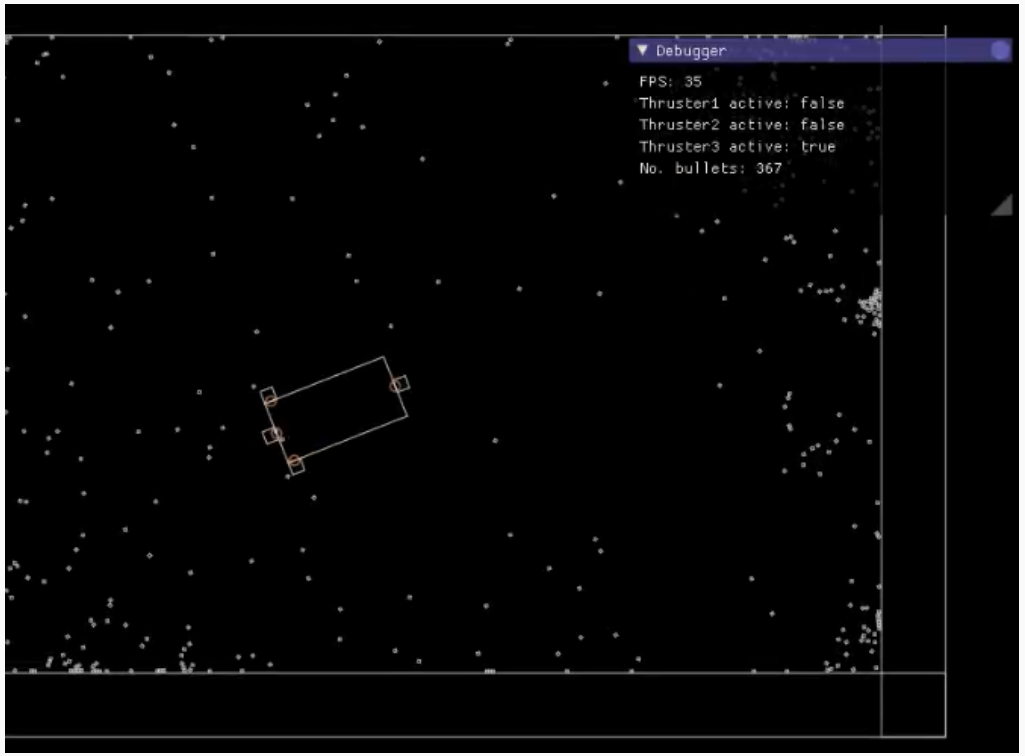
Visually fewer lines of code.

Programming Philosophies

- **Ease-of-use**, complexity should be avoided, even at the cost of speed
- **Modularity**, the engine should be easily extendable through modular programming
- **Readability**, the code should be easy to read, with most contents' operation being understandable at first-viewing

Rapid prototyping

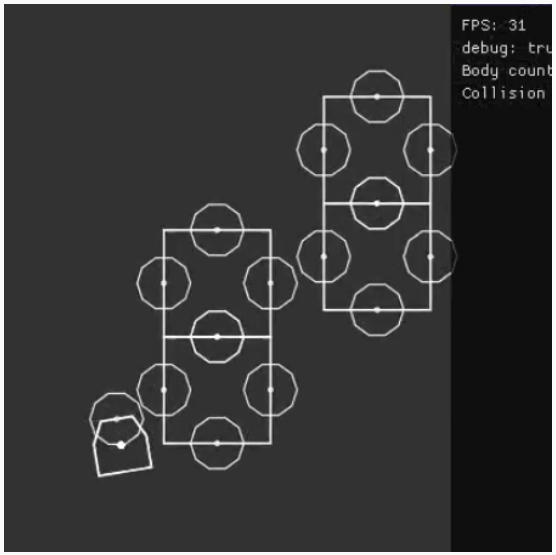
A small prototype was created in under a week to test if the project was feasible.

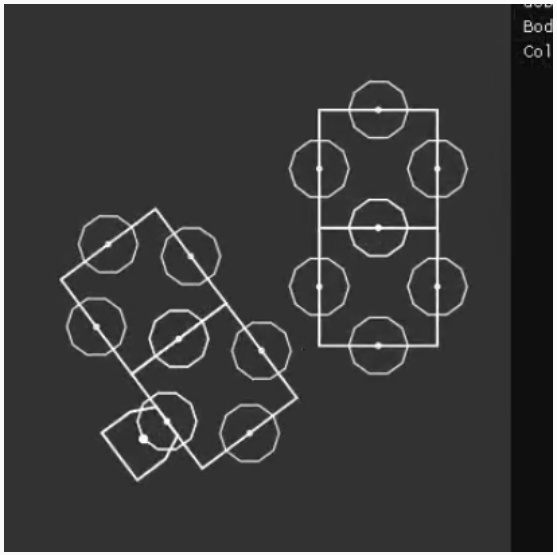


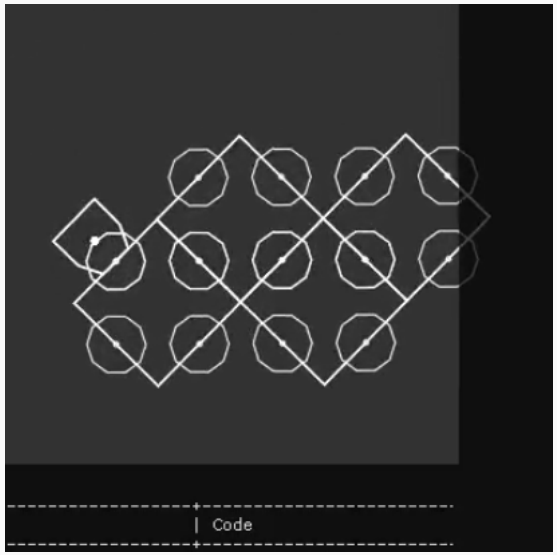
Being a prototype, all the code used had to be re-written to make sure the engine was scalable to the project demands

Deciding on a game loop

Initially toyed around with the idea of destructible ships, thrusters, weapons etc. could be shot off, impairing your ship's abilities - a la **Reassembly**.







After two days of experimenting with the attachment code using a flood fill algorithm I decided this direction would be too complicated.

Alpha preview

A few weeks into development,
`https://youtu.be/RZMrNIuRyXk`

zephyr

Mid-way through the project I realised the current method of handling collisions was un-scalable and had to be re-worked.

I created **zephyr**, a Box2D wrapper designed to simplify physics management by streamlining collision detection and resolution between Box2D objects.

Approx 1500 lines of code.

```
Physics.beginContact = (a, b, coll) ->
  -- pass a->b and b->a
  lssx.objects[a\getUserData().hash]\beginContact(b)
  lssx.objects[b\getUserData().hash]\beginContact(a)
```

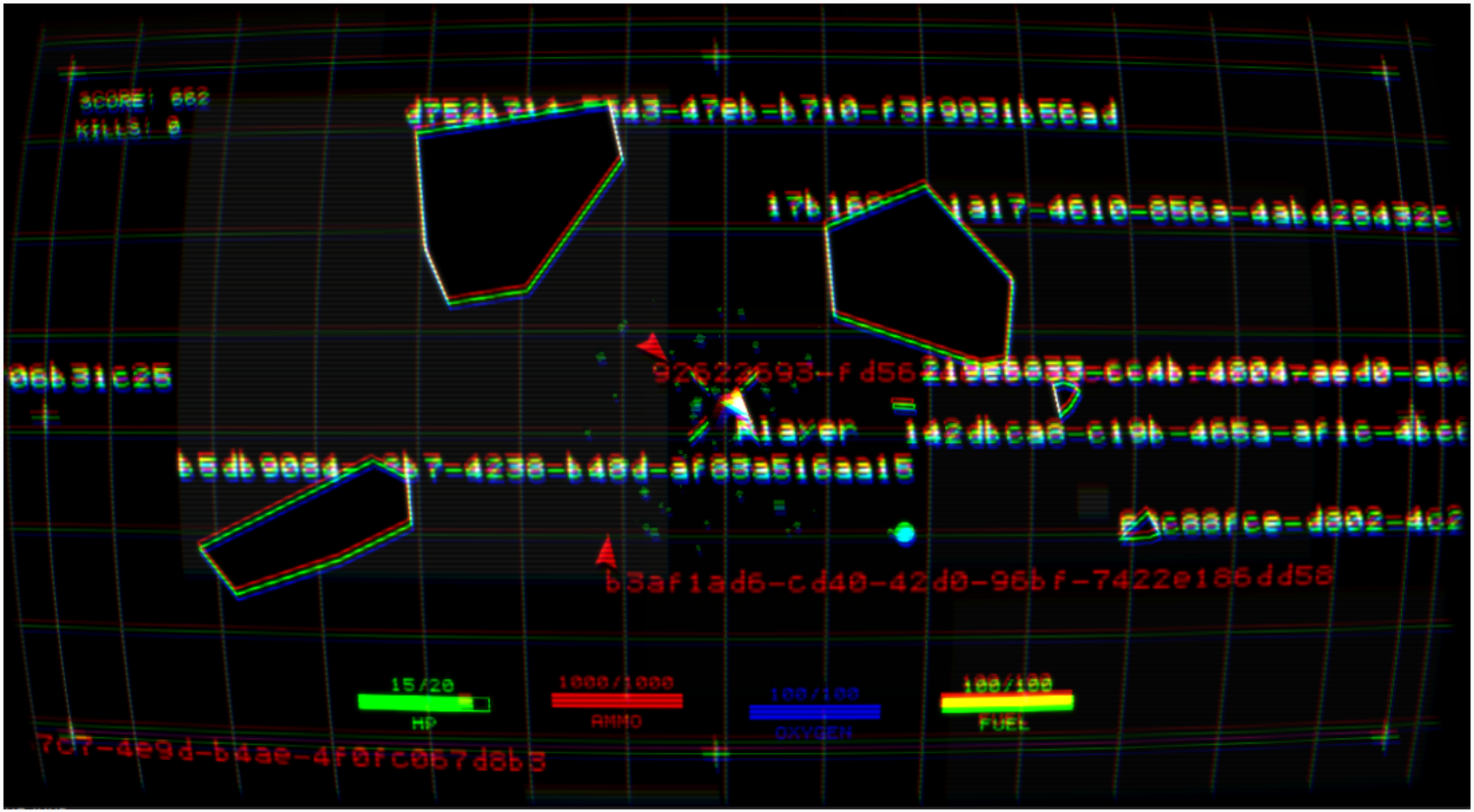
zephyr and Entity Management

The main feature of *zephyr* is it's fast object identification with the use of **Universally Unique IDentifier**'s organised in a hash-table.

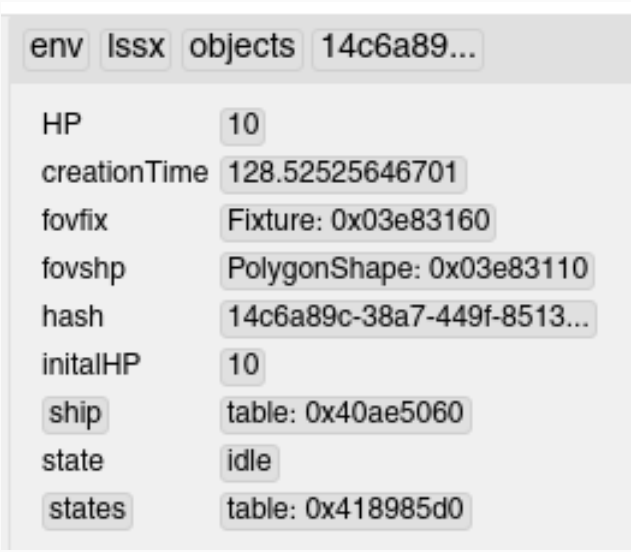
A typical **UUID** looks like:
`0264d794-e06a-4a8c-b018-d61aee5aa2b3`

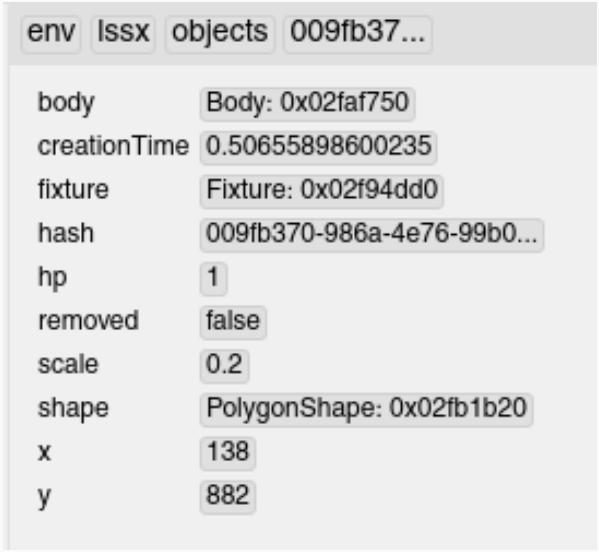
UUID’s visualized

Drawing all objects’ UUIDs:



All objects are placed inside a single table which is iterated through running each objects' draw/update functions.

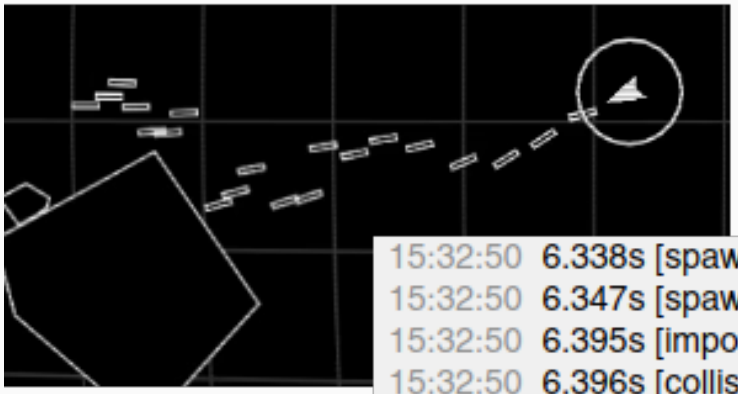




zephyr also allows colliding fixtures to communicate with each other and change each others values by the use of a buffer.

zephyr and Entity Management cont.

A typical interaction between two objects prints the following to the debug log.



```
15:32:50  6.338s [spawn ] Spawned Bullet
15:32:50  6.347s [spawn ] Spawned Bullet
15:32:50  6.395s [important ] beginContact() triggered
15:32:50  6.396s [collision ] -> Bullet, k: 39b9afaf-d39f-4e5f-a46f-31408079c768
15:32:50  6.398s [collision ] -> Asteroid, k: 07db2a45-a8f0-4d93-abe7-411ef3b0a90f
```

This shows a collision between an *Asteroid* and *Bullet*, with their **UUID**'s defined as **k**, each object was found within 2 milliseconds.

Procedural Generation

Procedural Generation is a method of computationally generating content. `https://youtu.be/O9KZFE1G6b0`

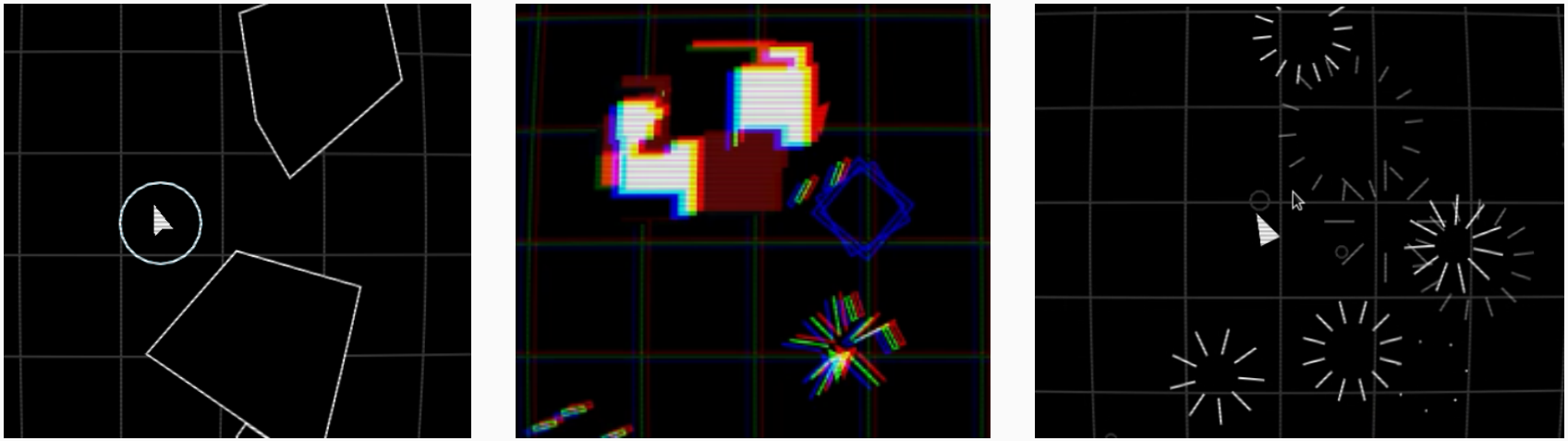
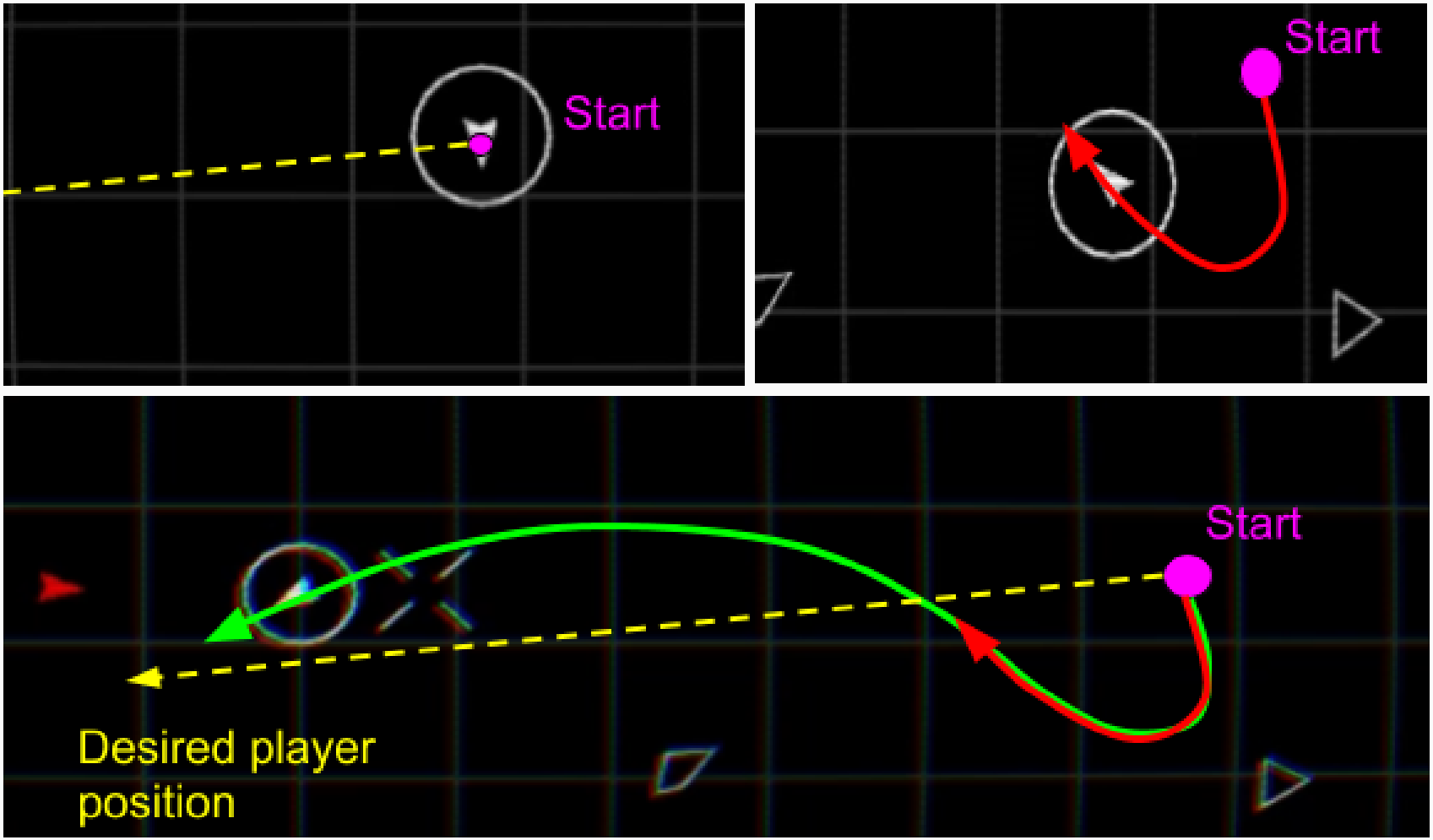


Figure 6: Procedurally generated content

All explosions, asteroids, particle effects and HP/ammo/fuel/oxygen pickups are procedurally generated and placed throughout the world.

Artificial Intelligence

Player ship AI uses an algorithm to follow the players cursor by applying forces to the ship. - Natural movement



AI cont.

Enemy AI works in a similar fashion to the Player's, except it follows the players position.

Enemy AI also uses a **Finite State Machine** to decide on what action it should take from: **Idle**, **Chasing**, **Firing** and **Retreat**.

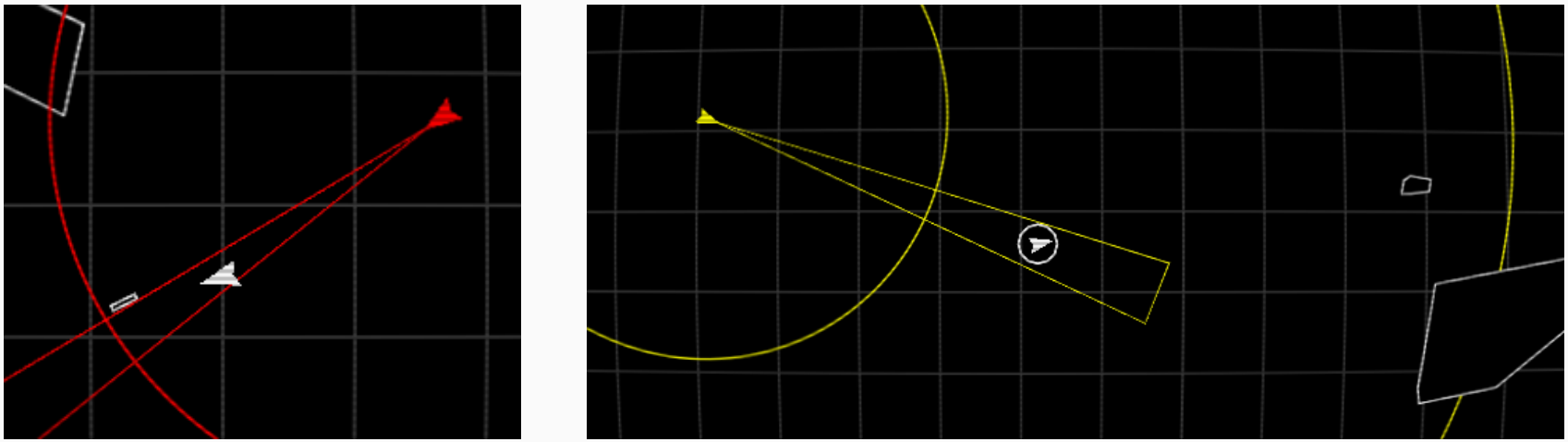


Figure 7: Red: Fire, **Yellow**: Chase

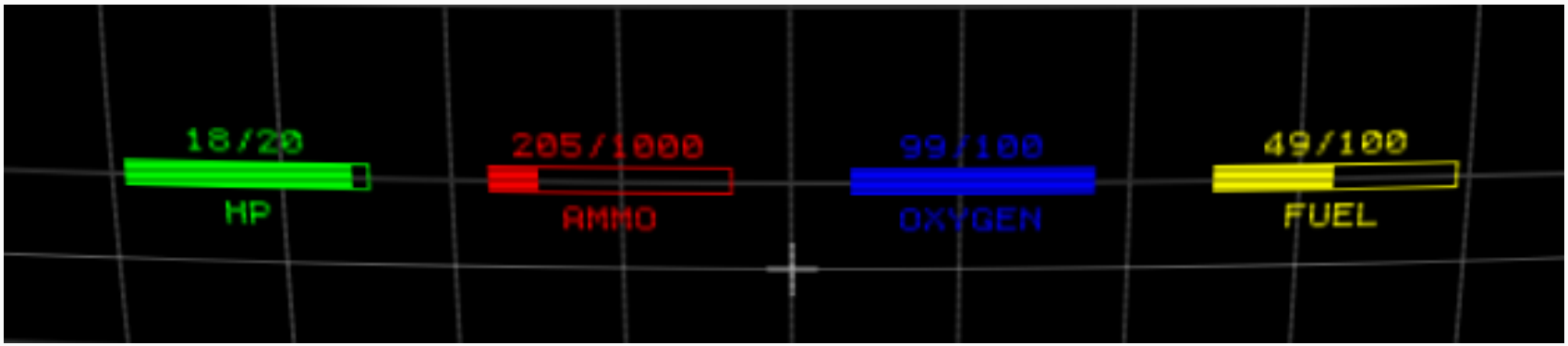
States are decided based on HP, player distance and object count in the world.

Resources, HUD (Heads-Up-Display)

Displays player's Ship details, introduces a layer of difficulty for player to manage.

- **Ammo**, no longer able to shoot
- **Fuel**, speed significantly reduced
- **Oxygen**, lose HP over time
- **HP** (Health Points), when = 0, game over

These can be restored by collecting pickups scattered throughout the world.



Timers and ”tweening”

- **Timers**, allows for events to be repeated / done at specific intervals
- **”Tweening”**, In-be*tweening*, modify a value over time with different easing functions

```
-- Toggle light on and off every second
Timer.every(1, -> lamp\toggleLight())

-- Moves "ball" object to the position 200, 300
 ↪  over 4 seconds
flux.to(ball, 4, { x: 200, y: 300 })
```

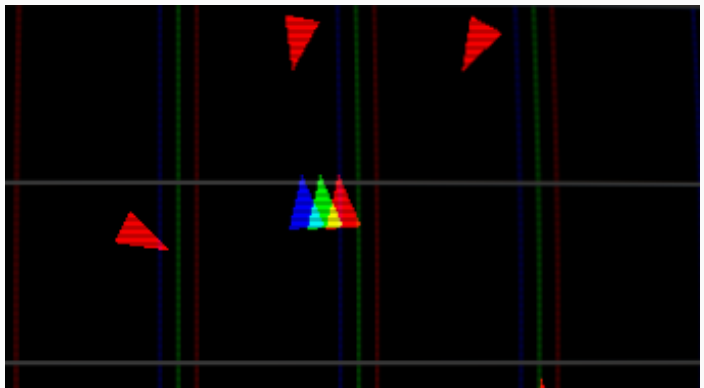
Timers used to spawn new enemies and pickups in the world. Tweening largely used in UI, e.g. particle effects, explosions etc.

Shaders and Cameras

- **Shaders**, post-processing effect that modifies the attributes of pixels, e.g. blurring, shadows and specular highlights.
- **Cameras**, allows for panning, zooming and scaling

e.g. When player hit by a bullet the following occurs,

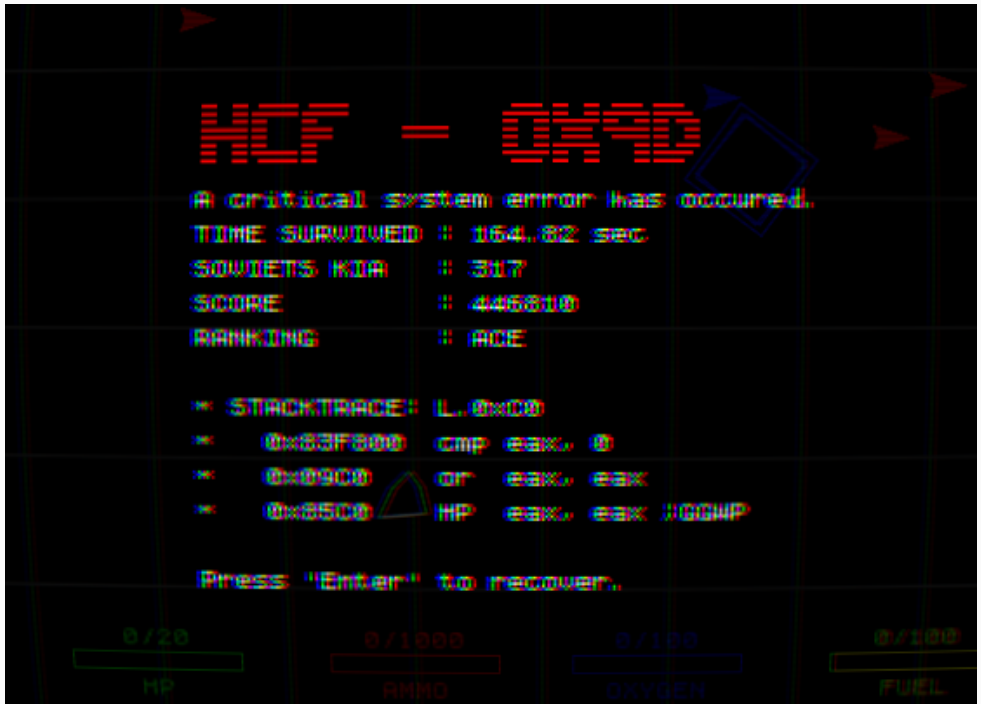
- Instance of class **LineExplosion** at player x/y created
- Tween chromatic aberration strength to random value
- Shake screen by *x* amount for *y* seconds
- Blink screen for $0.1 \pm x$ seconds



Scoring

Higher score is better.
Staying alive for longer grants higher score.
Destroying more enemies/asteroids and collecting pickups increases overall score.

A rank is calculated from overall score:
ACE, SS, S, A, B, C, D, E, F

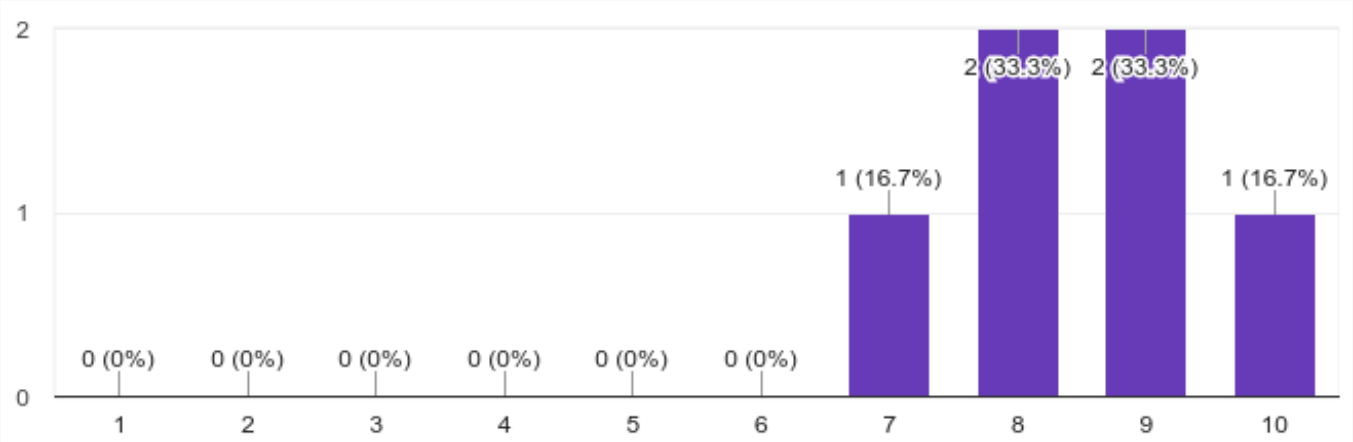


Playtesting and Feedback

Feedback gathered from 8 play-testers on what they liked/disliked and would like to see added/removed. Common positive/negative feedback included:

- ”well thought-out aesthetic”
- ”fast, enjoyable pace and high learning curve”
- ”annoying, jarring shooting noise”
- ”too much camera shake”

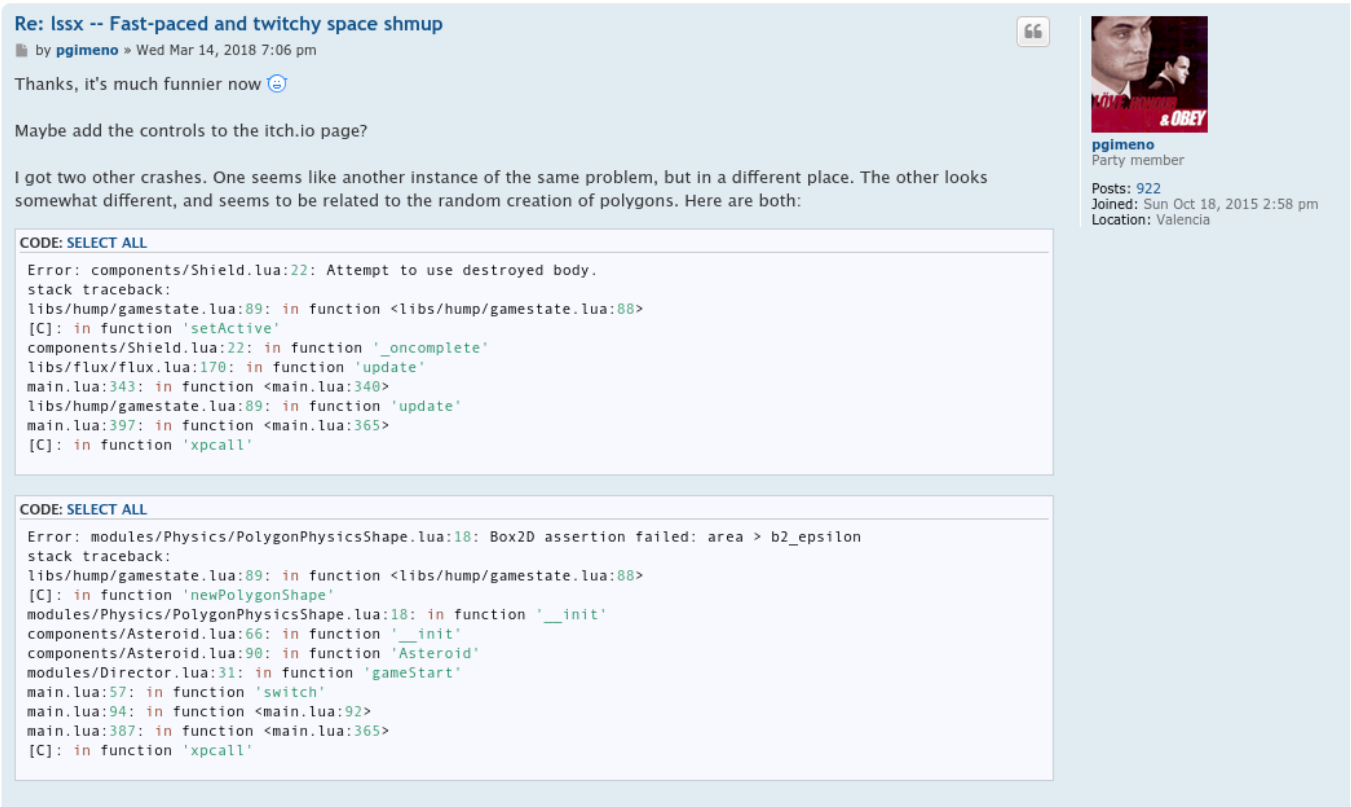
Players rated game in current state an average of *8.5/10*.



Bugs

During play-testing several bugs were discovered that needed to be resolved,

- Errors related to accessing nil objects
- Memory leaks when restarting game



Re: lssx -- Fast-paced and twitchy space shmup

by **pgimeno** » Wed Mar 14, 2018 7:06 pm

Thanks, it's much funnier now

Maybe add the controls to the itch.io page?

I got two other crashes. One seems like another instance of the same problem, but in a different place. The other looks somewhat different, and seems to be related to the random creation of polygons. Here are both:

CODE: SELECT ALL

```
Error: components/Shield.lua:22: Attempt to use destroyed body.
stack traceback:
libs/hump/gamestate.lua:89: in function <libs/hump/gamestate.lua:88>
[C]: in function 'setActive'
components/Shield.lua:22: in function '_oncomplete'
libs/flux/flux.lua:170: in function 'update'
main.lua:343: in function <main.lua:340>
libs/hump/gamestate.lua:89: in function 'update'
main.lua:397: in function <main.lua:365>
[C]: in function 'xpcall'
```

CODE: SELECT ALL

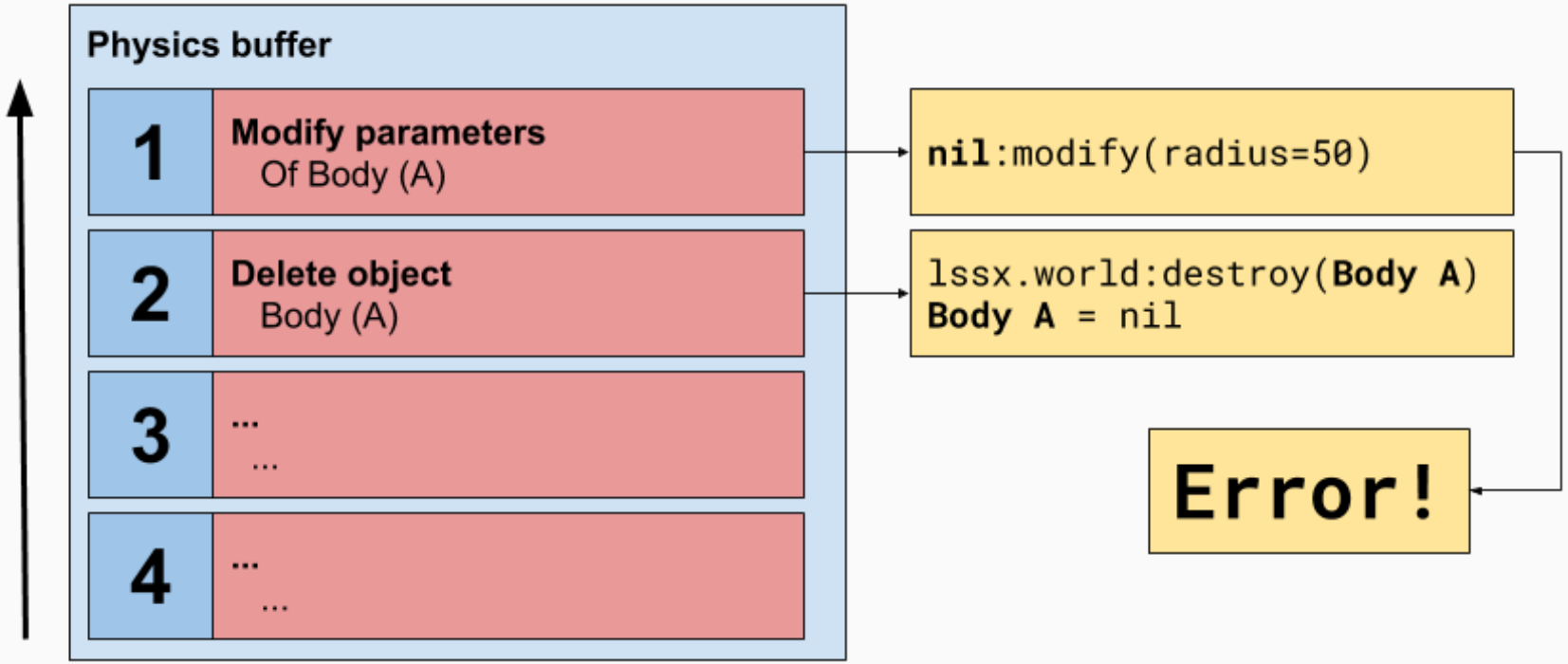
```
Error: modules/Physics/PolygonPhysicsShape.lua:18: Box2D assertion failed: area > b2_epsilon
stack traceback:
libs/hump/gamestate.lua:89: in function <libs/hump/gamestate.lua:88>
[C]: in function 'newPolygonShape'
modules/Physics/PolygonPhysicsShape.lua:18: in function '__init'
components/Asteroid.lua:66: in function '__init'
components/Asteroid.lua:90: in function 'Asteroid'
modules/Director.lua:31: in function 'gameStart'
main.lua:57: in function 'switch'
main.lua:94: in function <main.lua:92>
main.lua:387: in function <main.lua:365>
[C]: in function 'xpcall'
```


pgimeno
Party member

Posts: 922
Joined: Sun Oct 18, 2015 2:58 pm
Location: Valencia

Debugging and buffers/stacks

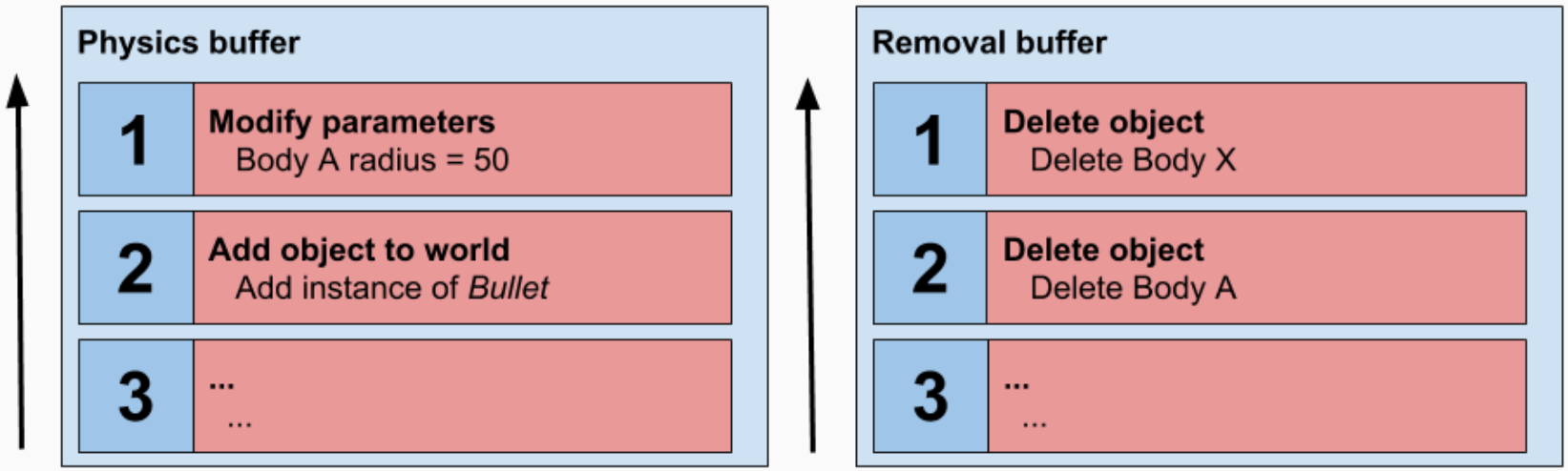
After researching the issue, it turned found out the following situation was the culprit of errors related to nil objects.



Memory leaks were resolved by running a garbage collector on occasion.

The solution...

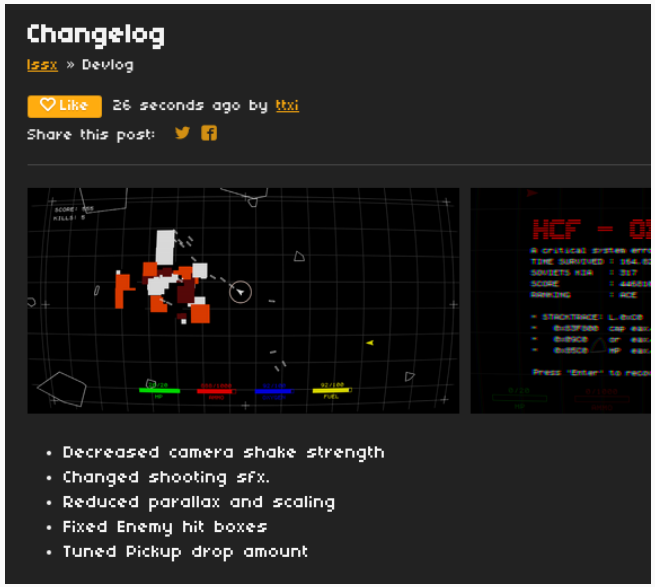
Two buffers.



- **Physics buffer**: General buffer that handles transformations and modifies parameters of objects
- **Removal buffer**: Buffer solely dedicated to the removal of objects, ran at the end of a frame - after everything else is finished.

Release

After resolving previous issues with the game, **lssx** was now ready for release.
Released for free with an optional donation feature on **itch.io**, a website for users to host, sell and download indie video games.



Live at : `https://ttxi.itch.io/lssx`

Final thoughts

Overall pleased with outcome, achieved my goal of making a short enjoyable game with a fair amount of re-playability. Gained a strong understanding of *Box2D* and appreciation for simple, elegant solutions to problems.

Things learned:

- Physics is hard
- Desire to work on a project / code quality drops off exponentially over time
- 90% effort required for the last 10% of work

After EPQ I'd like to further develop **zephyr** make it easier for people to develop their own games.

Special thanks & Questions.

- **SSYGEN**, STALKER-X camera library
- **rxi**, flux.lua tweening library, lovebird browser console
- **vrld**, HUMP utilities, moonshine post-processing library
- **videah**, splash-screen library
- **Taehl**, sound management library
- **bfxr**, used to generate game audio
- **slime et al.**, LÖVE framework
- **leafo**, MoonScript programming language
- **d.notive**, Background music

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