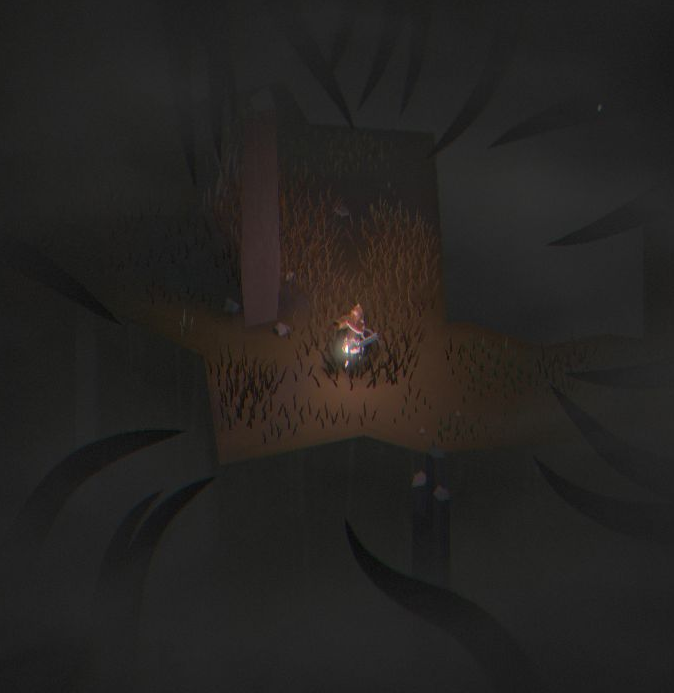


A Dark Mind

The AI of “The Dark” in BELOW



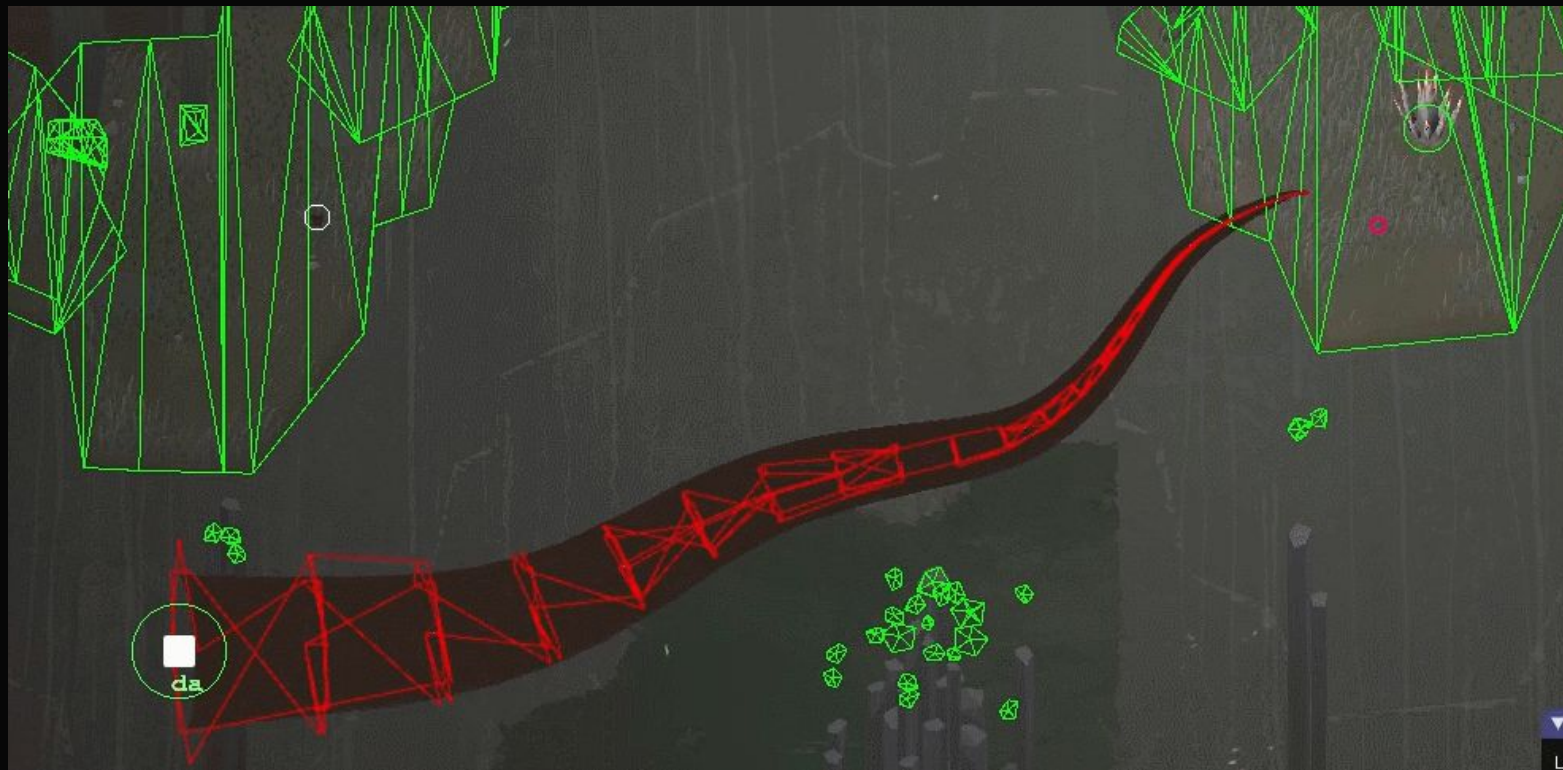


What is The Dark?

- Tentacle monster
- Omnipotent ancient evil, sealed away
- Sadistic, natural beast
- Cohesive intelligence, yet animalistic and raw

Background

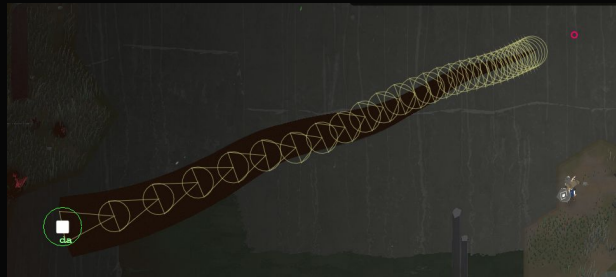
Mesh and Rig



Kinematics



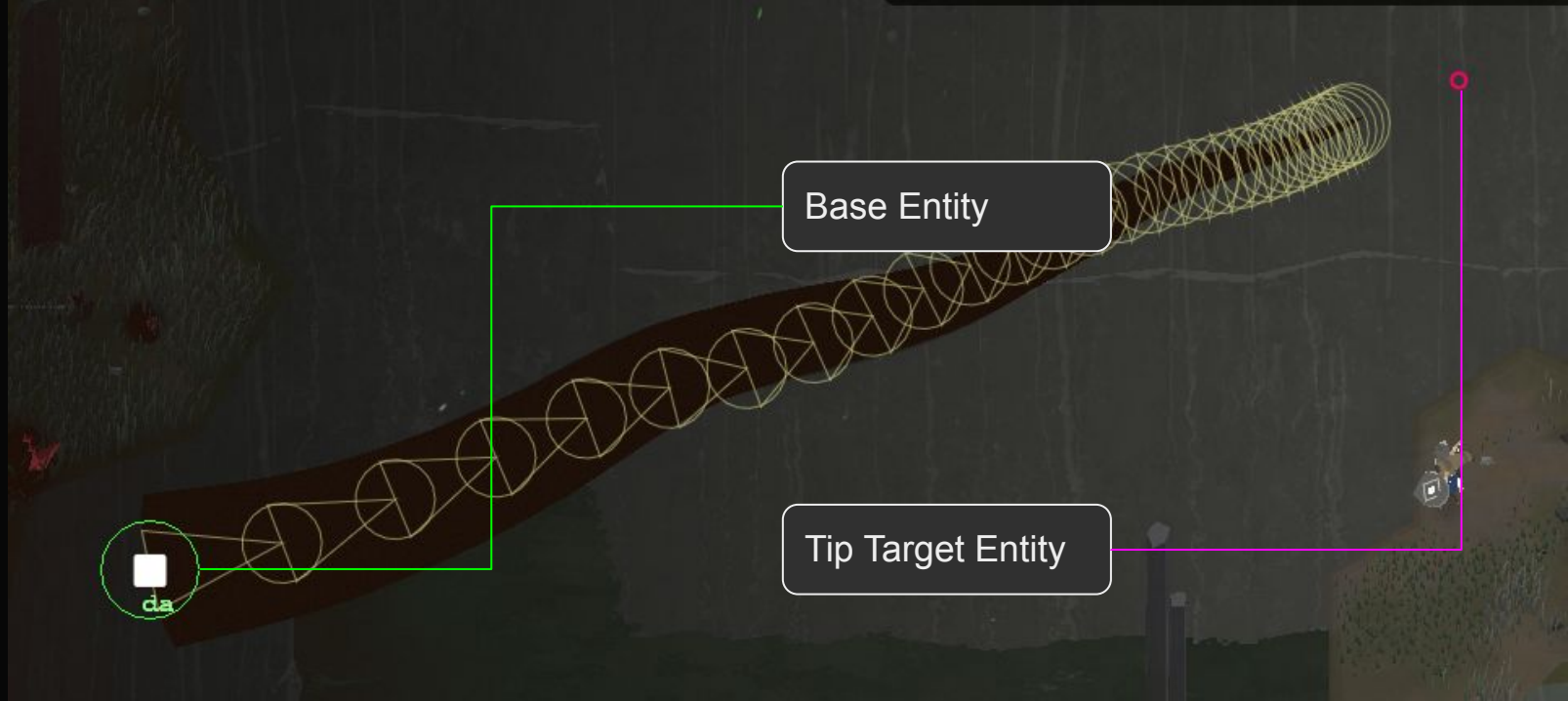
Animation Blend Tree



+

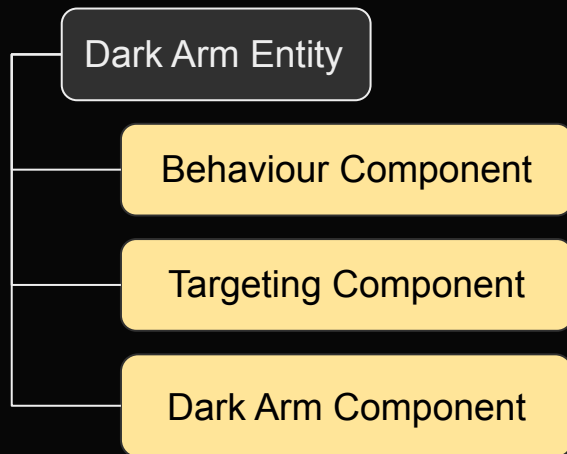


Basic Code Structure

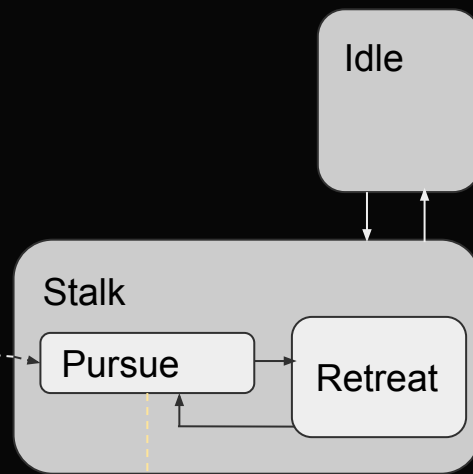


Basic Code Structure

Entity and Components



Lua HFSM



`moveBase(x,y)`

Where do we start?

- So, we have:
 - Rig and Animations
 - Kinematic Chain
- Prototype some simple combat

Basic Movement and Attacks

Goal: Basic Attack

1. Move to player
2. Play attack animation

Goal: Basic Attack

1. **Move to player**
2. Play attack animation

Movement

- “Arm Position” has 2 points
 - Base
 - Tip Target



Movement

Current Position

+ Target



```
find_goal_pos()
```



Movement

Current Position

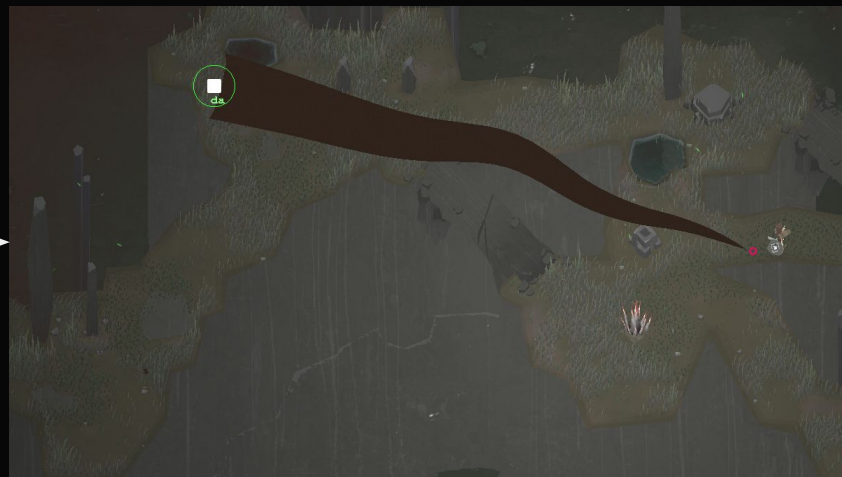
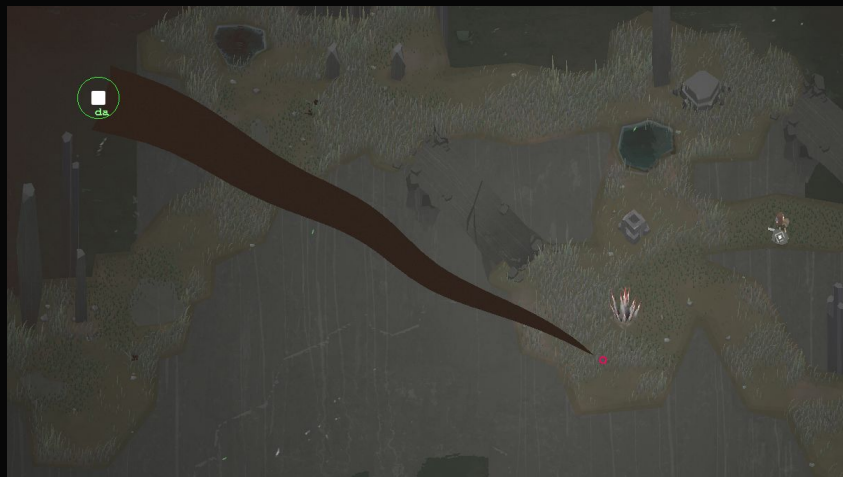
+ Target



`find_goal_pos()`

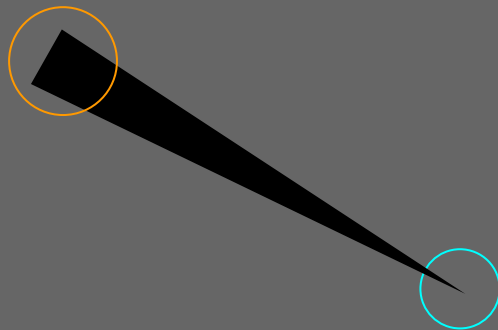


Goal Position



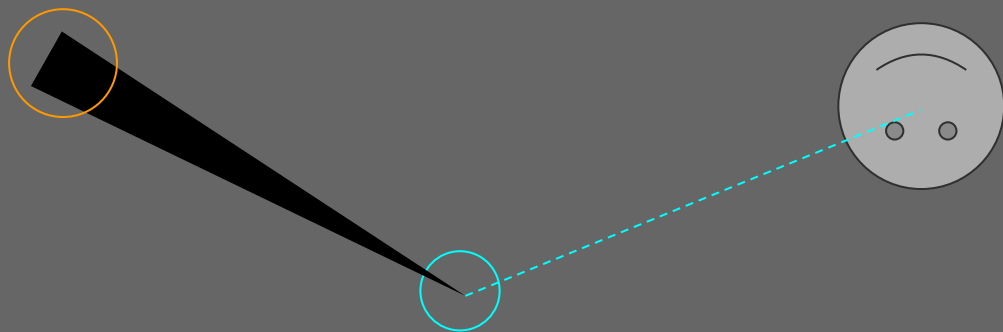
Pursue

- Move tip target to player
- Pull base



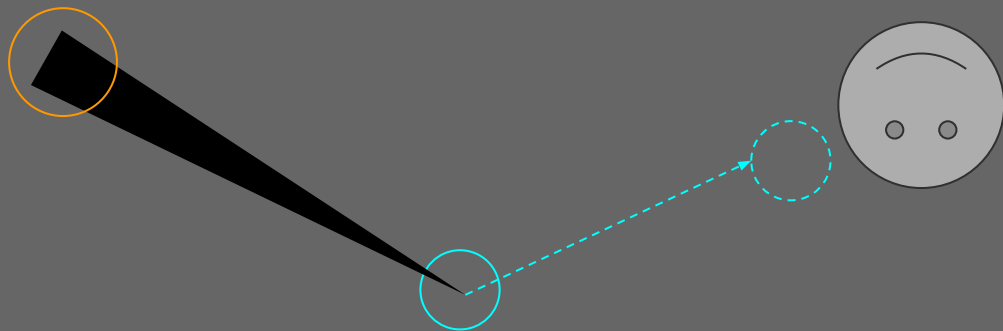
Pursue

- Line to target



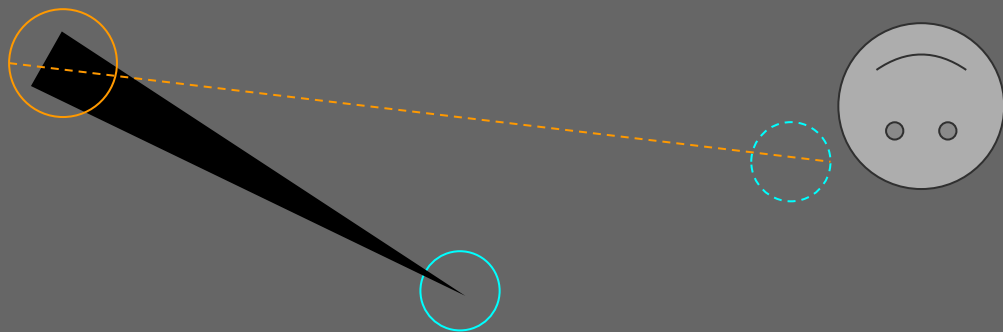
Pursue

- New tip target pos



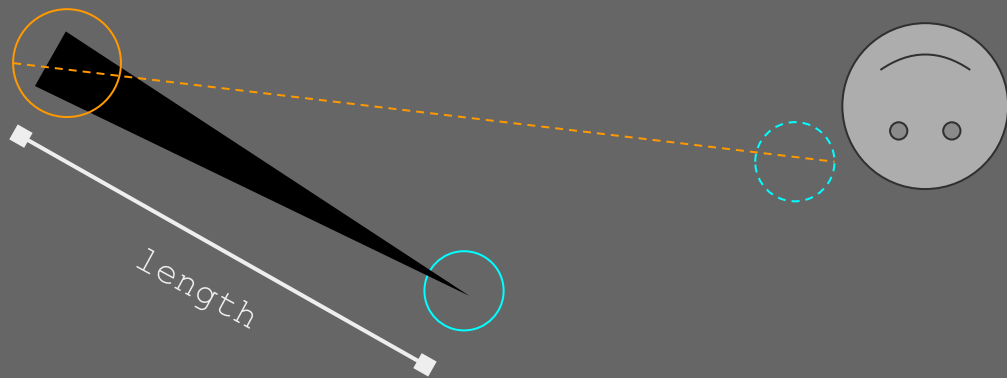
Pursue

- Base to tip target line



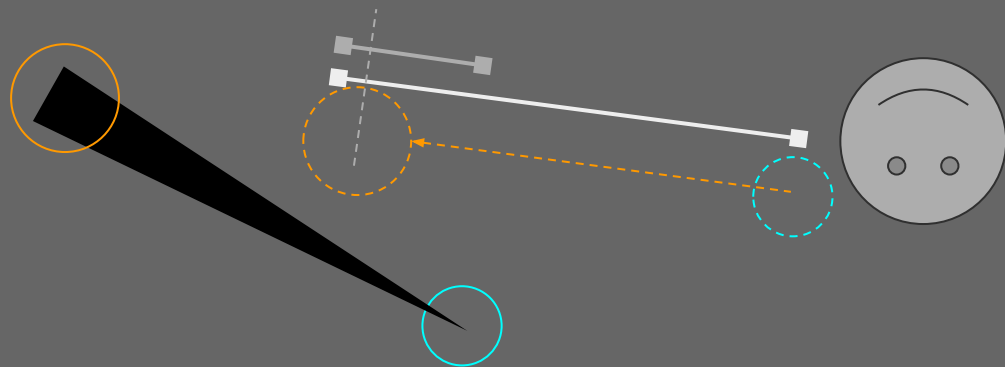
Pursue

- Get arm length



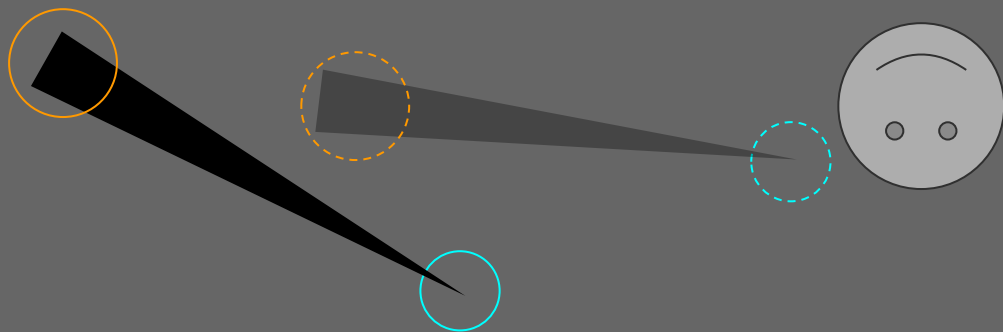
Pursue

- Move from tip target by length (+/- some range)



Pursue

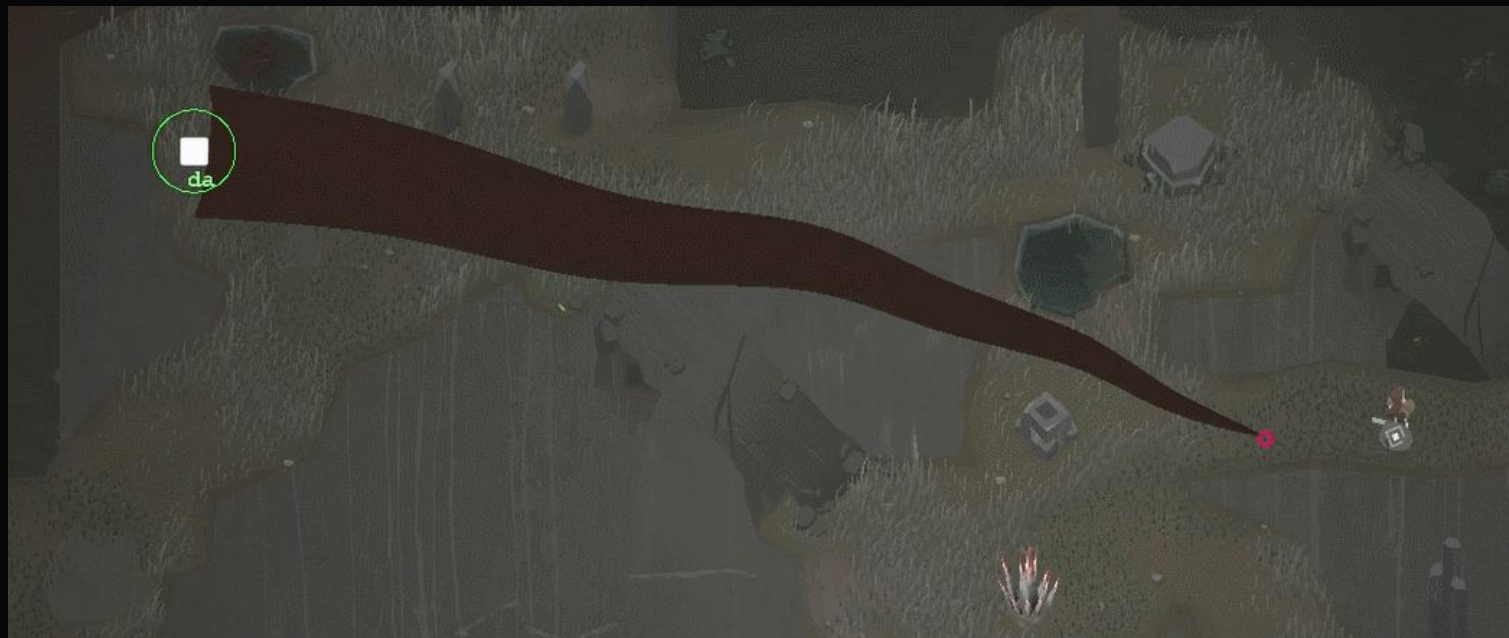
- Output goal position



Goal: Basic Attack

1. Move to player
2. **Play attack animation**

Attack



Basic Movement and Attacks

- **Pursue and Attack Behaviours:**

- ✓ Basic reactive movement
- ✓ Working attack

Attack Issues



Animation Blends

- Keep arm straight
- Absolute rotation constraints
- Lock kinematics

Basic Movement and Attacks

- Pursue and Attack Behaviours:

- ✓ Basic reactive movement

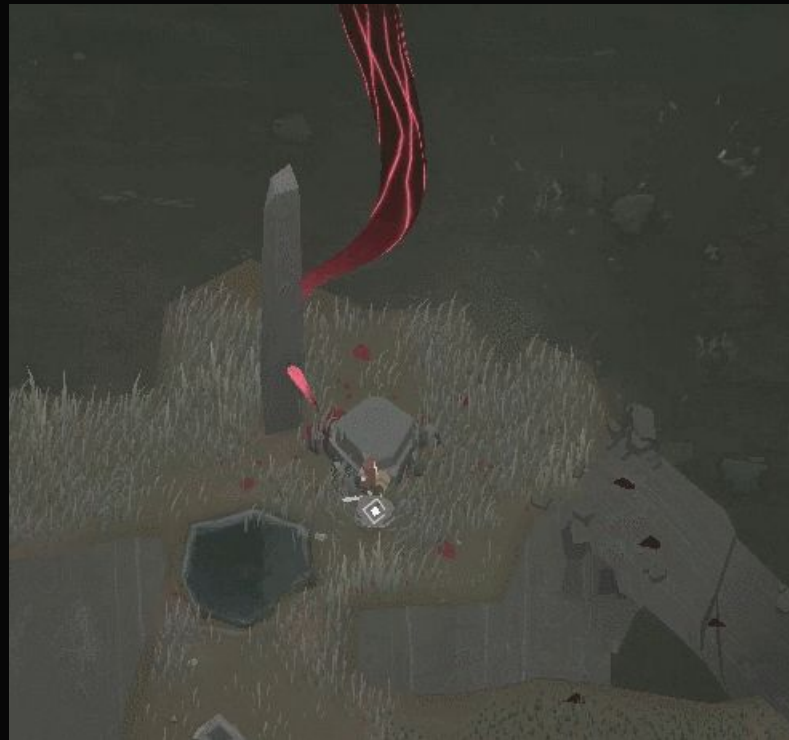
- ✓ Working attack

- **Kinematic Constraints:**

- ✓ **Prevent wonky animation blends**

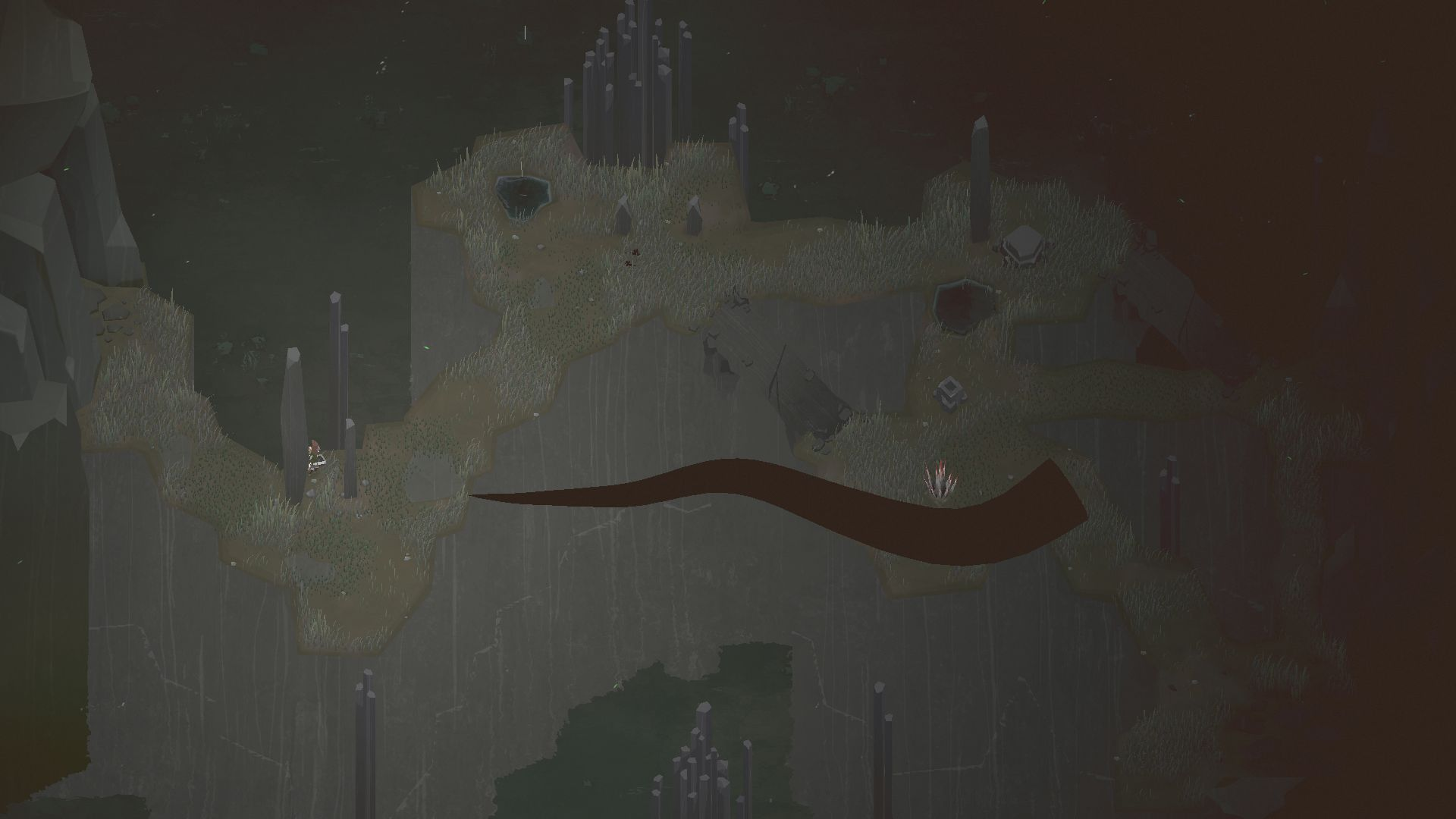
Attack Issues

- Unintentional animation blends
- **Unfair Clipping**

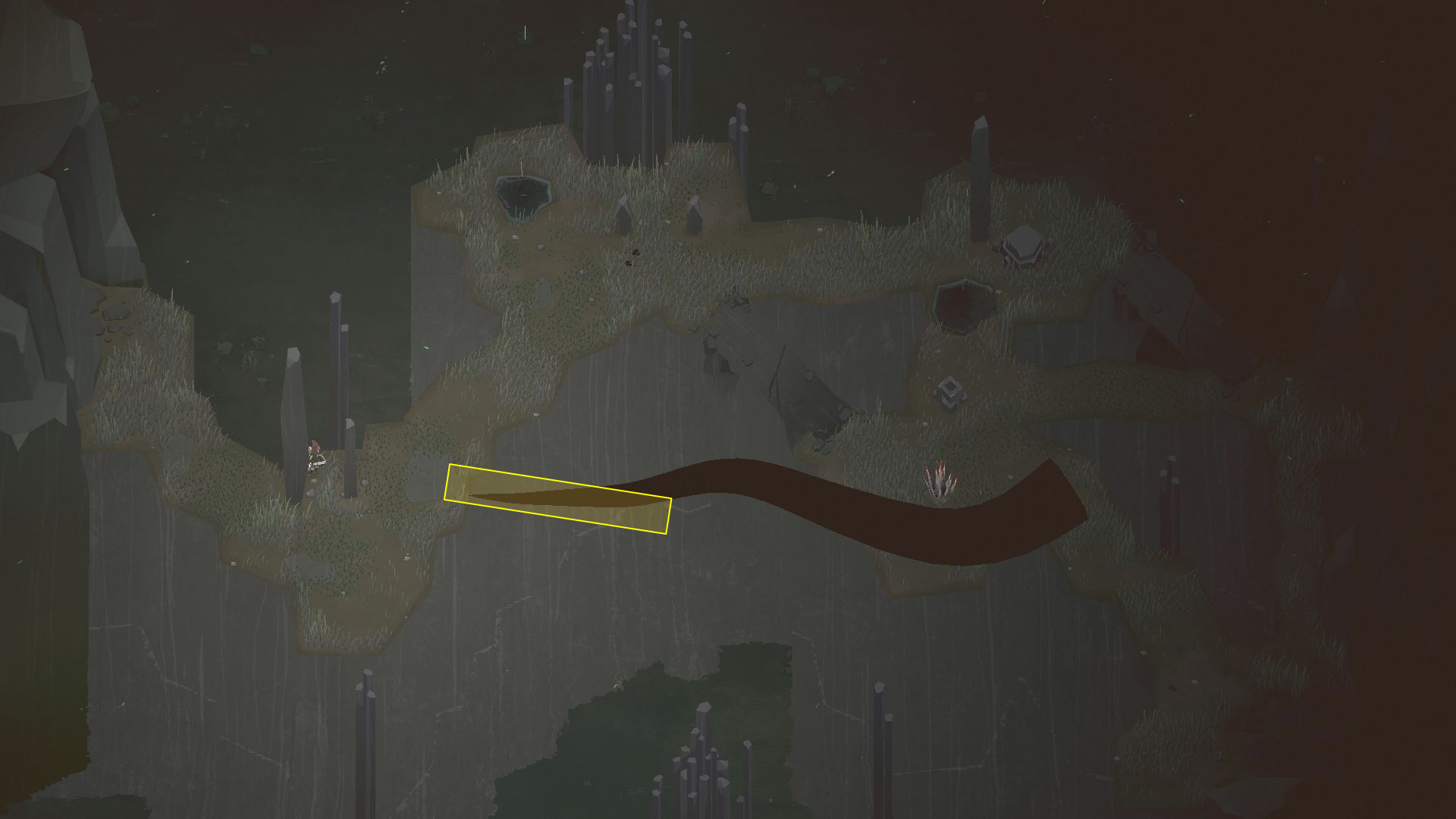


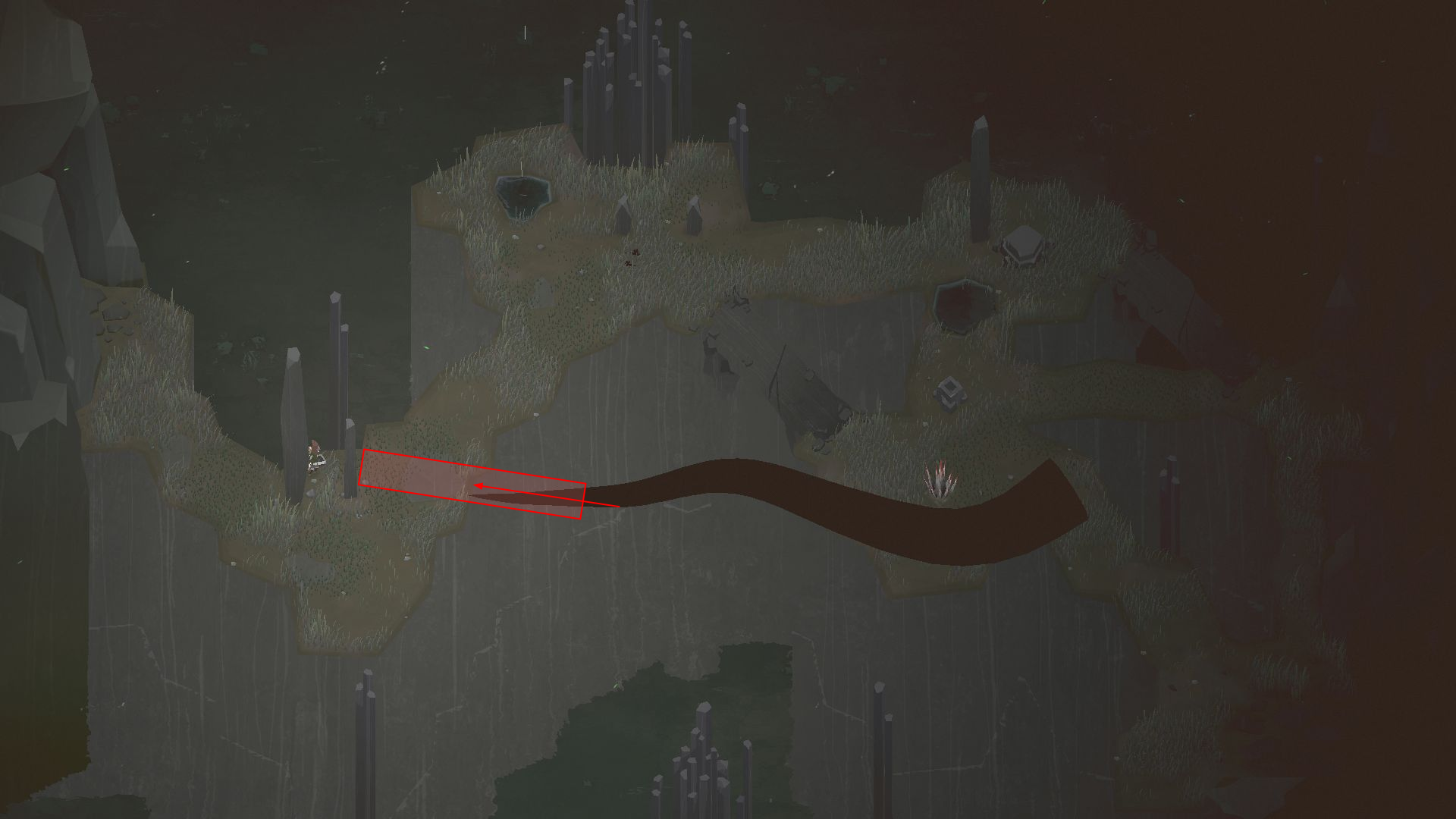
Radial Shapecasts

- Shapecast around target in circle
- Find final, unobstructed position

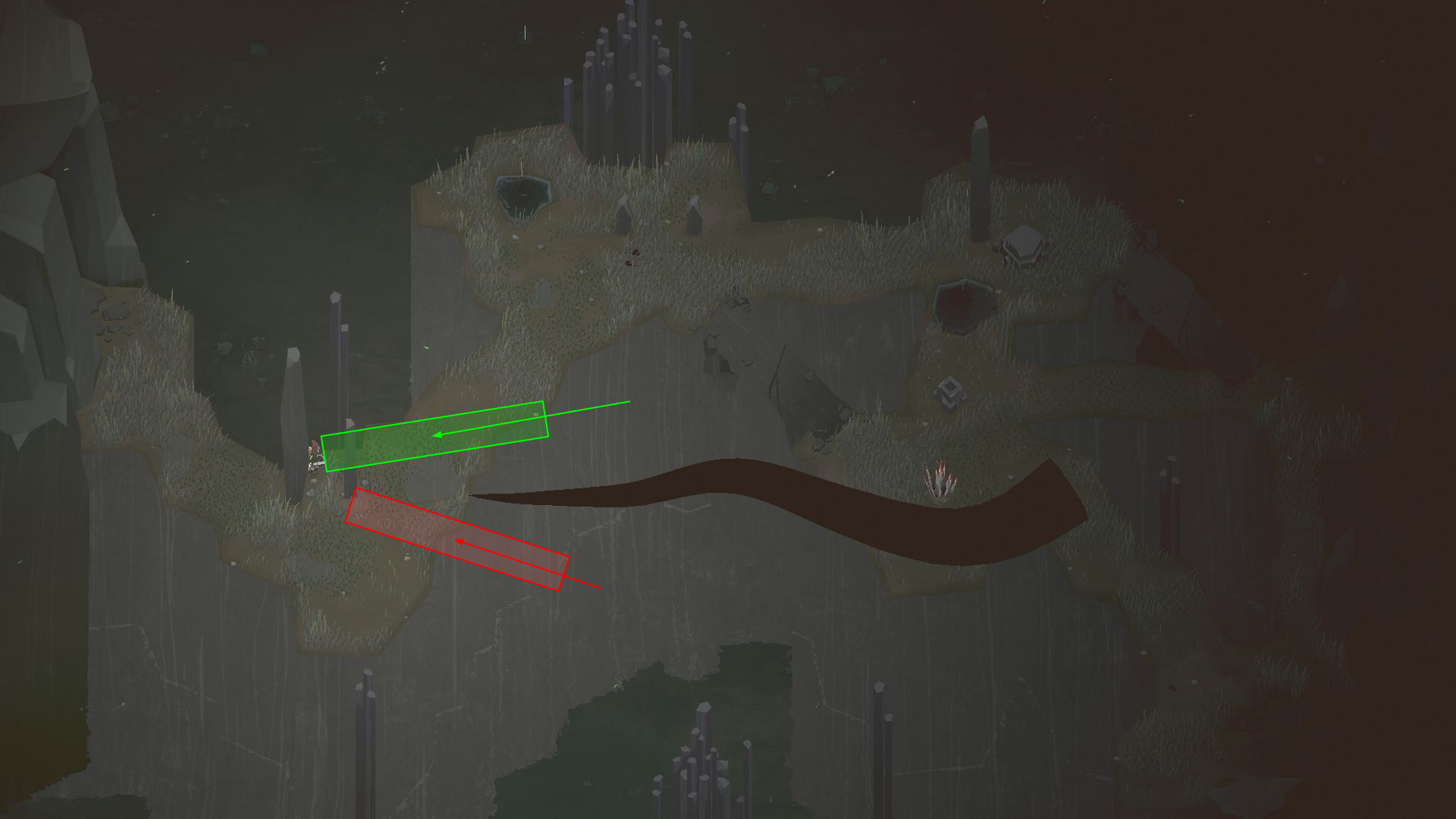
















Basic Movement and Attacks

- Pursue and Attack Behaviours:

- ✓ Basic reactive movement

- ✓ Working attack

- Kinematic Constraints:

- ✓ Prevent wonky animation blends

- **Radial Shapecasts:**

- ✓ **Prevent unfair clipping**

What's next?

- Functional, but not interesting
- Dark difficulty should ramp up
 1. Foreshadow
 2. Interact with world
 3. Fight player

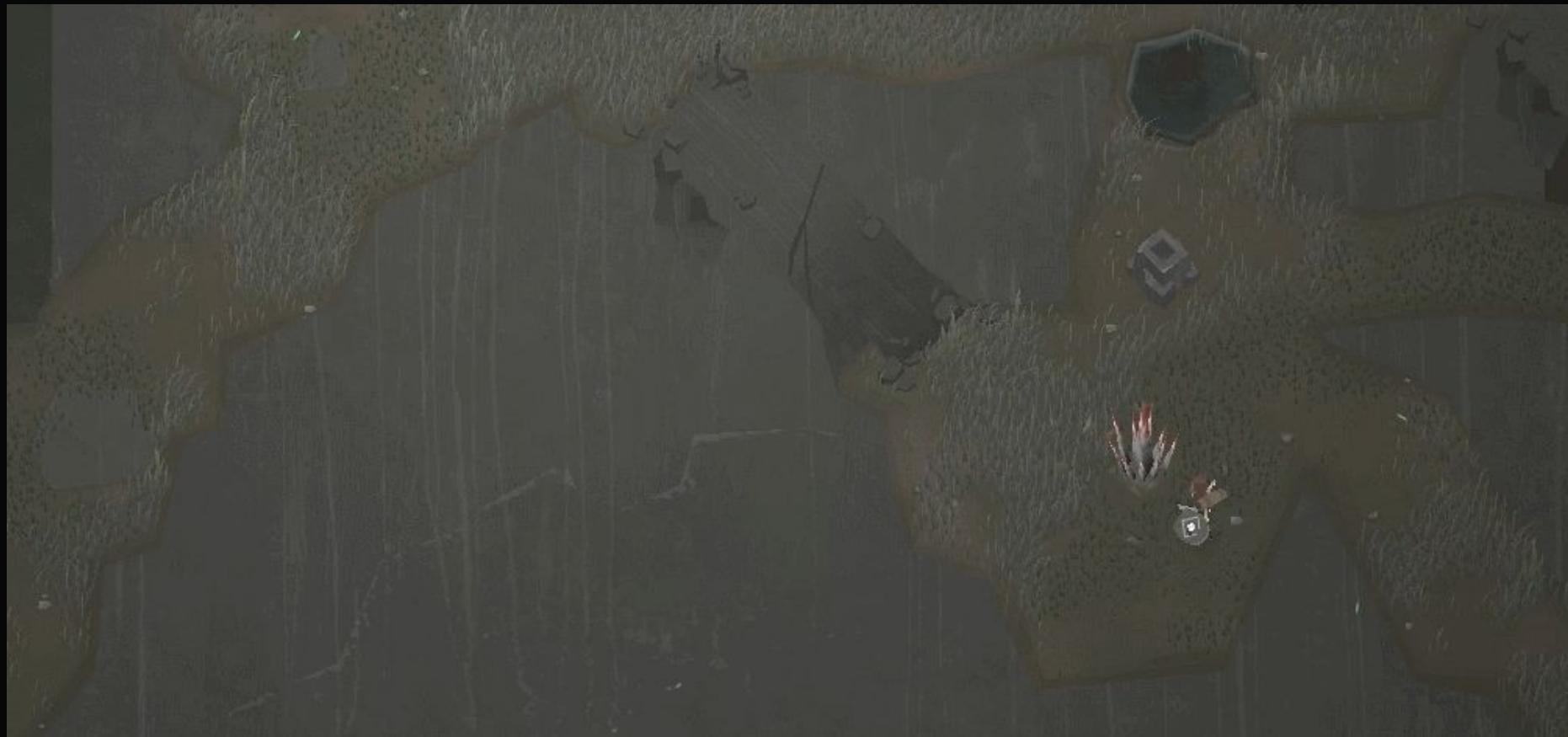
World Interactions

World Interactions

- Goal: Add some flavour and more gameplay impact
- Non-player targets
 - Eat Rats
 - Steal Gems
 - Kill Cultists

World Interactions

- Goal: Add some flavour and more gameplay impact
- Non-player targets
- Eat Rats
- **Steal Gems**
- Kill Cultists



New Problems

- Base is visible
- Arms bump player



New Movement Rules

- Current rules:
 - Push/Pull
 - Shapecasts
- Base is visible
+ Keep base off-level
- Arms bump player
+ “Opposite side” of target



World Interactions

- **New movement rules:**

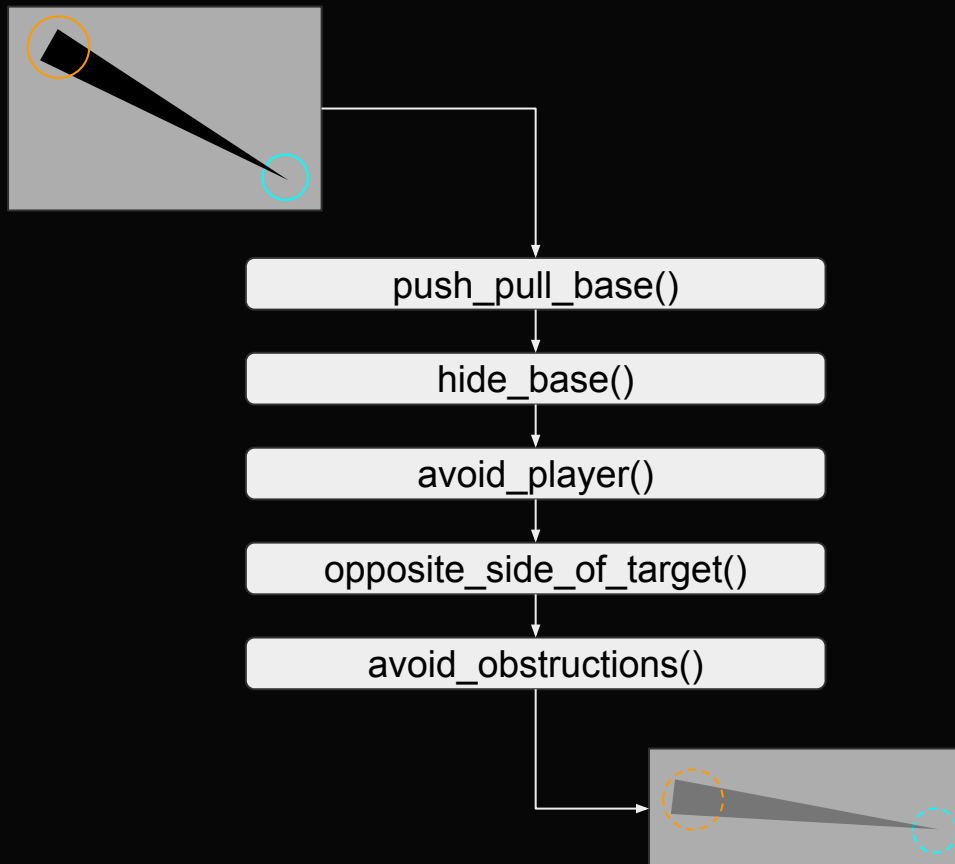
- ✓ **Reactive to player**
- ✓ **Non-player targets**

Positioning Issues

- Timing inconsistency
- Rule Conflicts

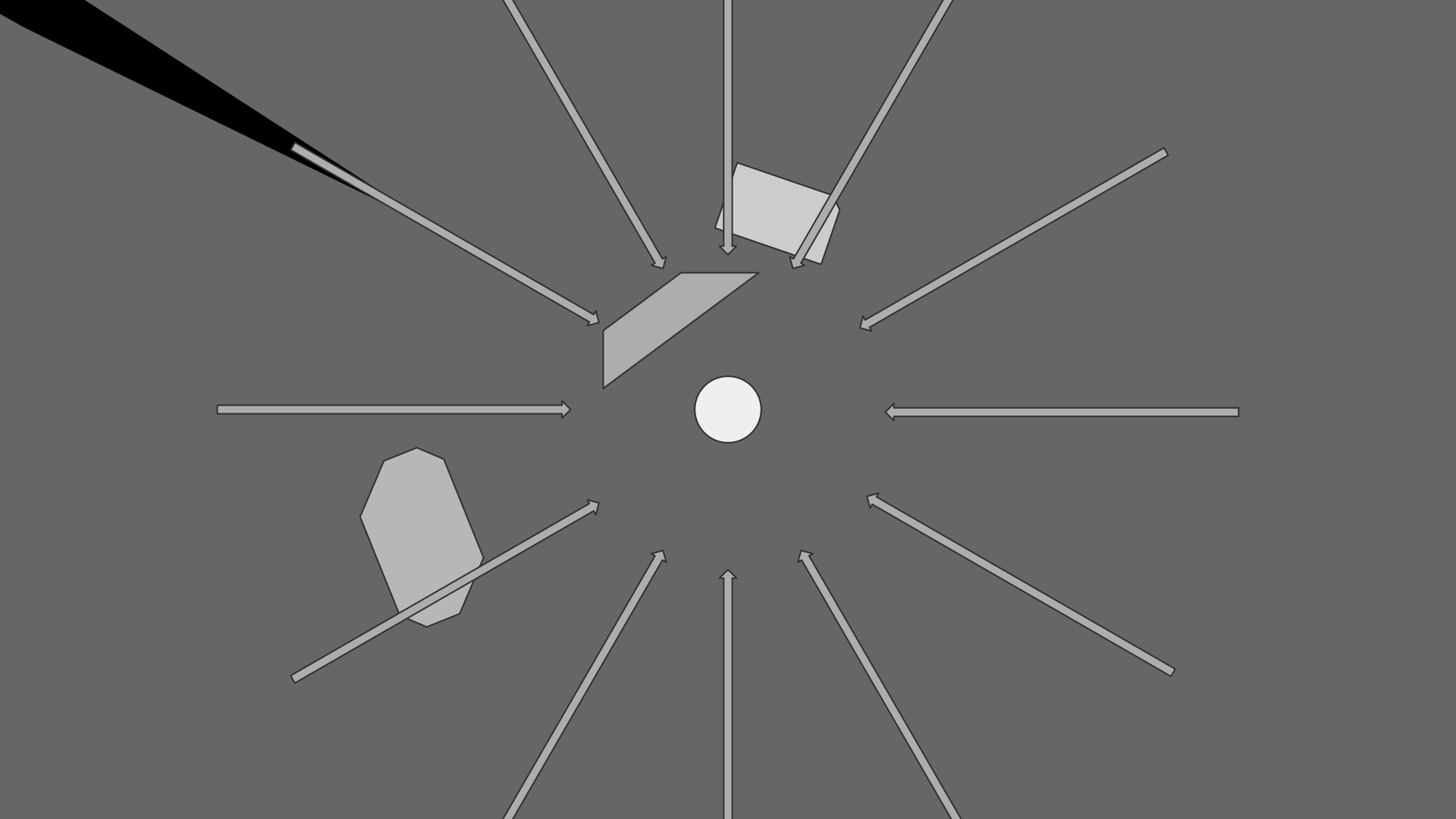
→ Hard to tune

→ Hard to meet design goals

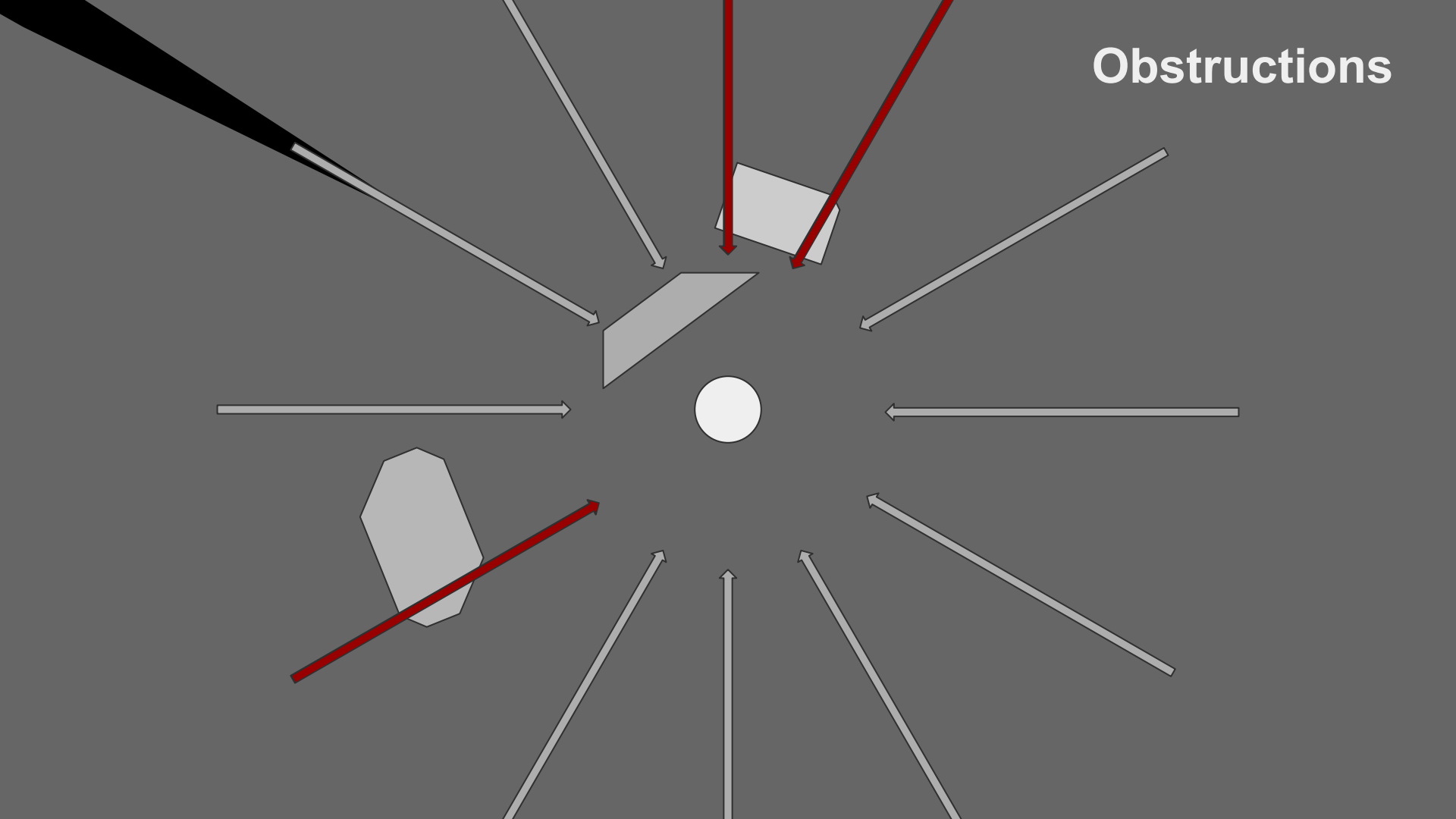


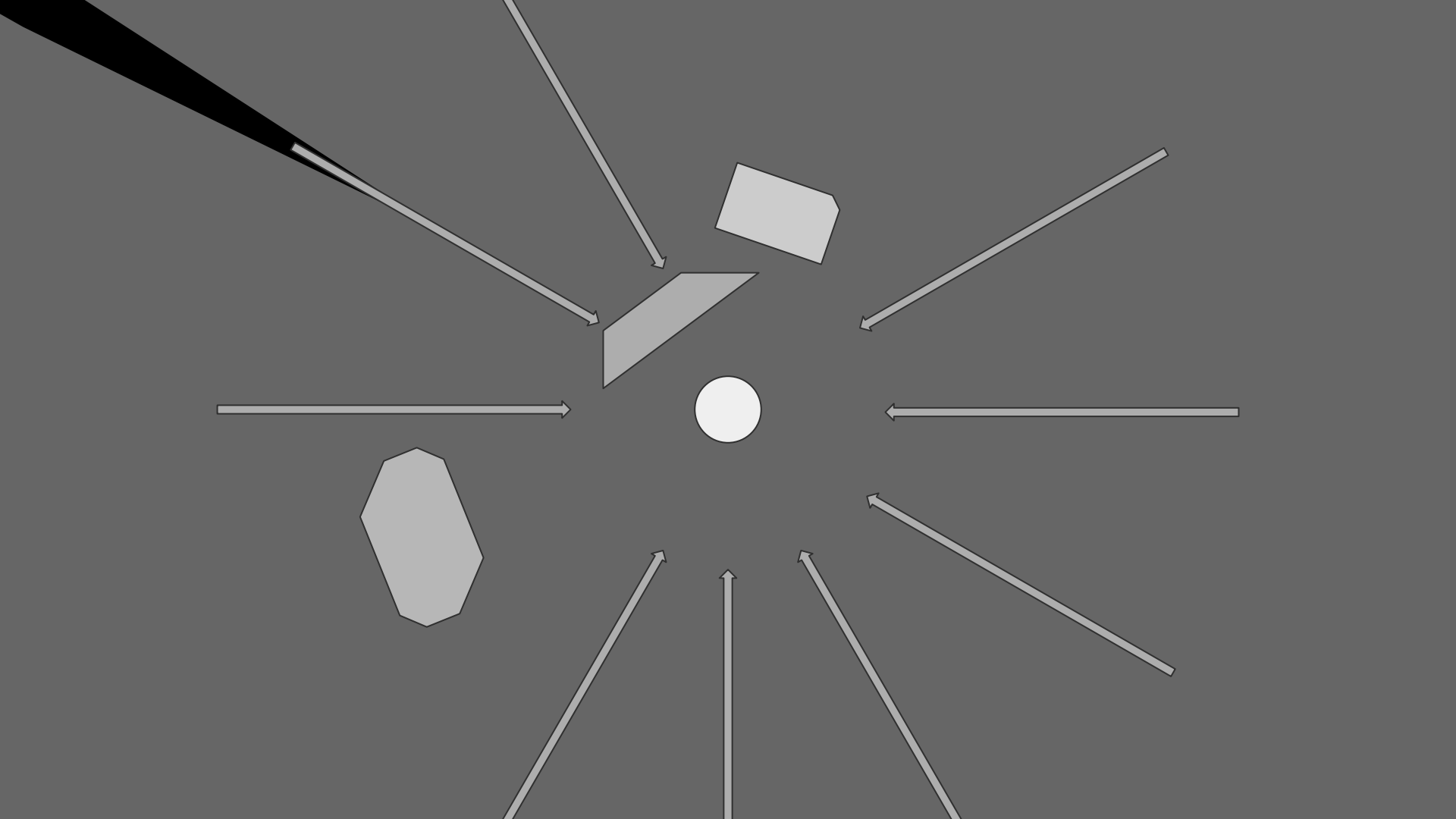
Utility System for Positioning



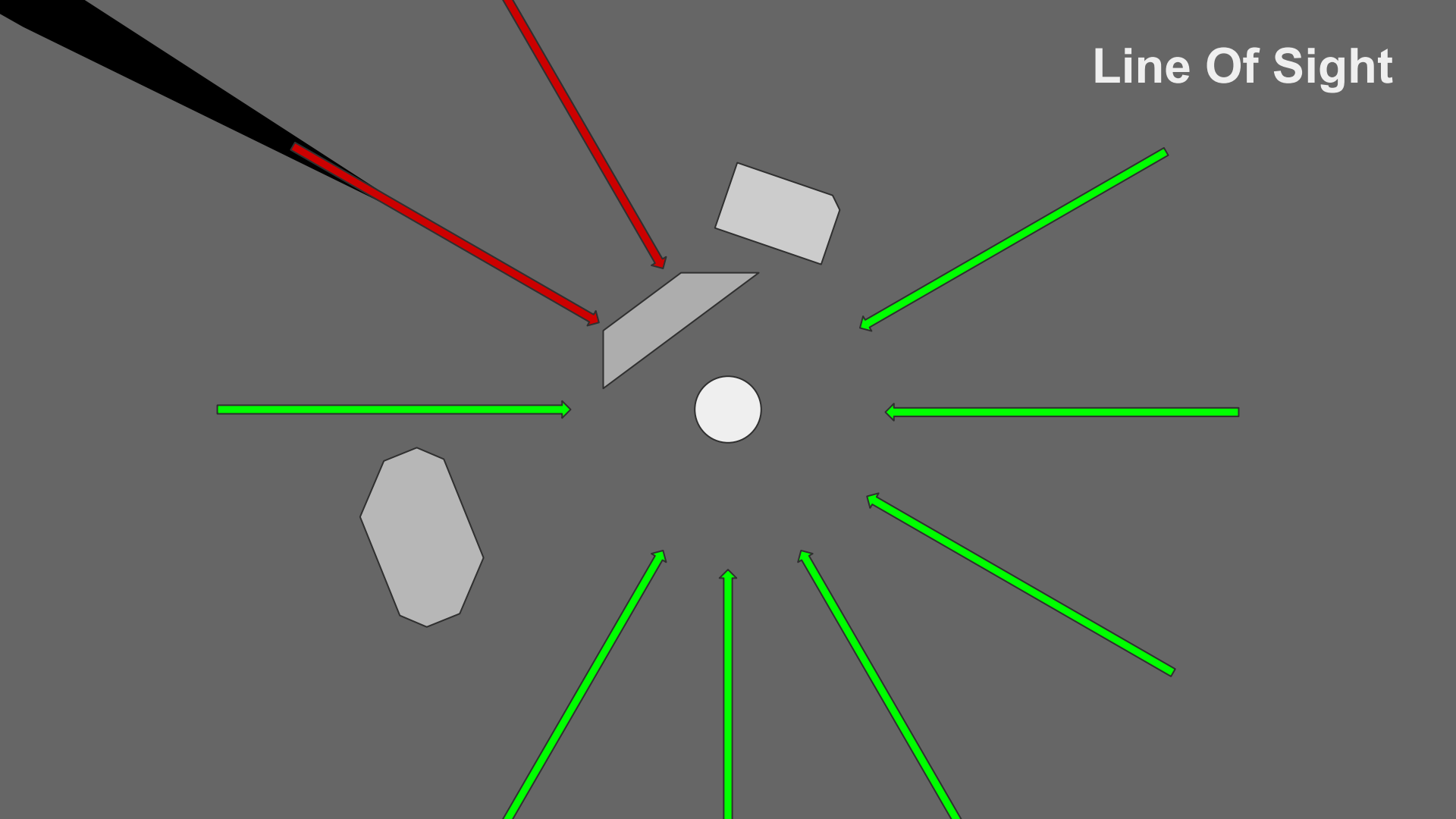


Obstructions

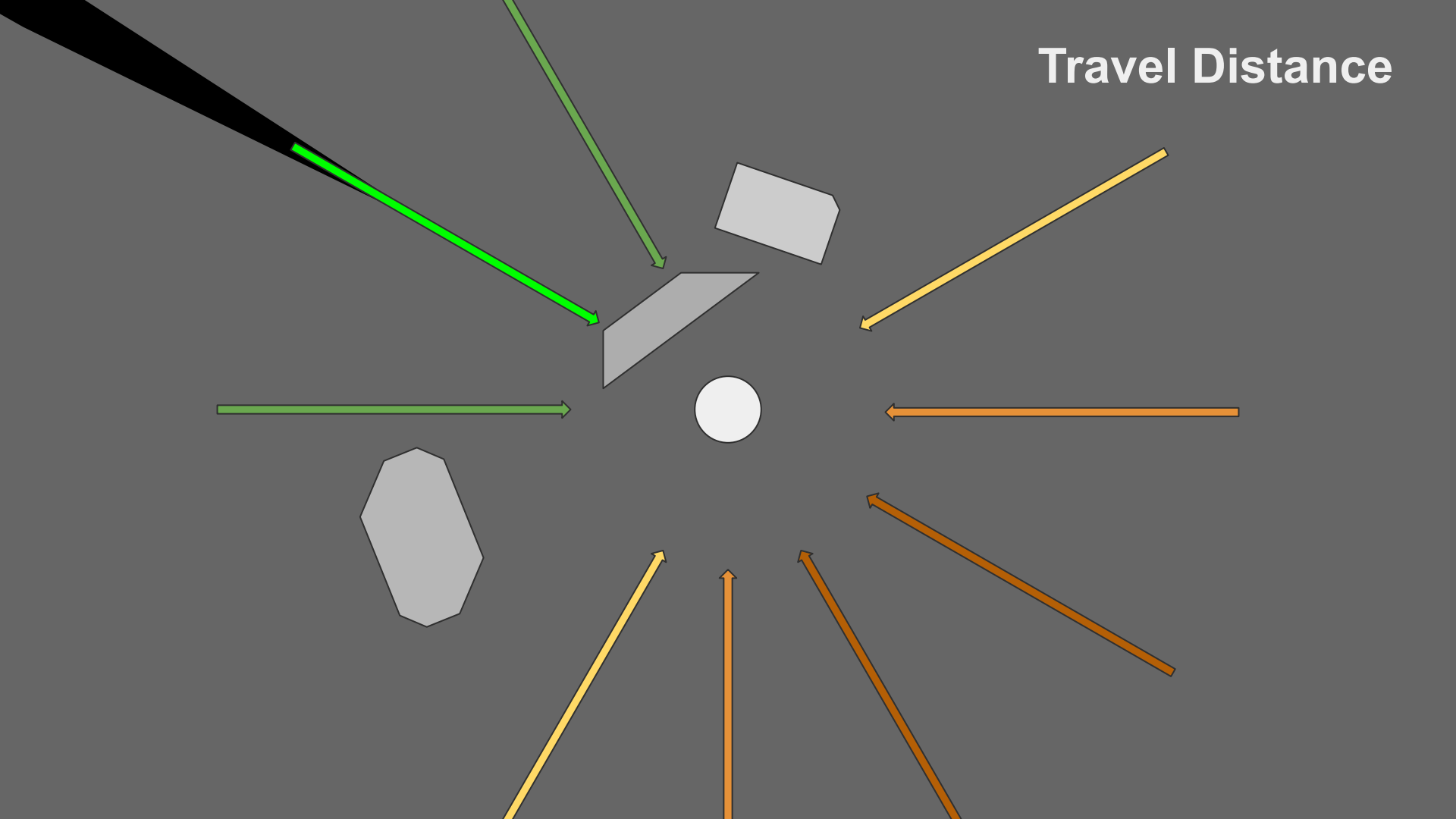




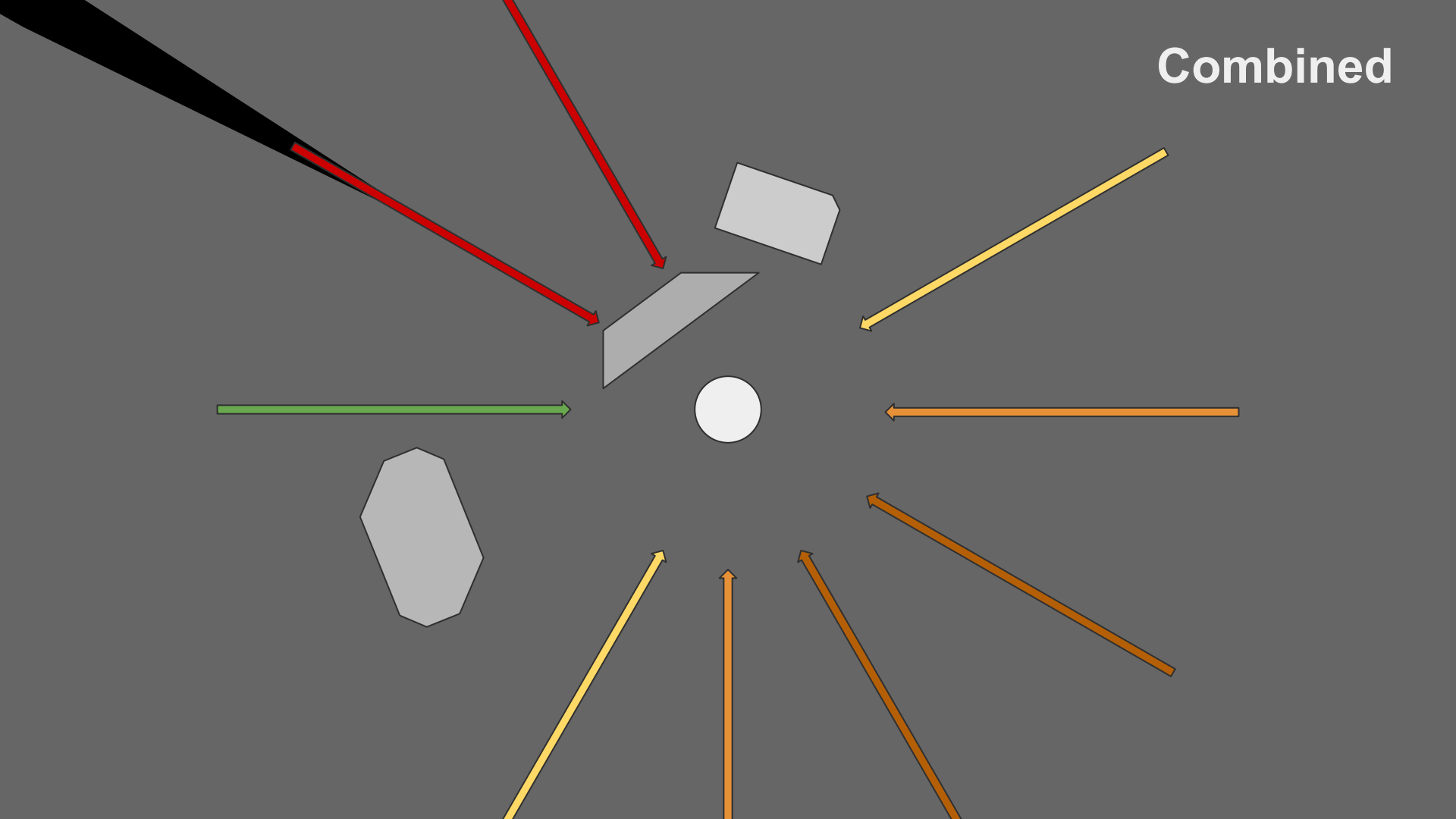
Line Of Sight



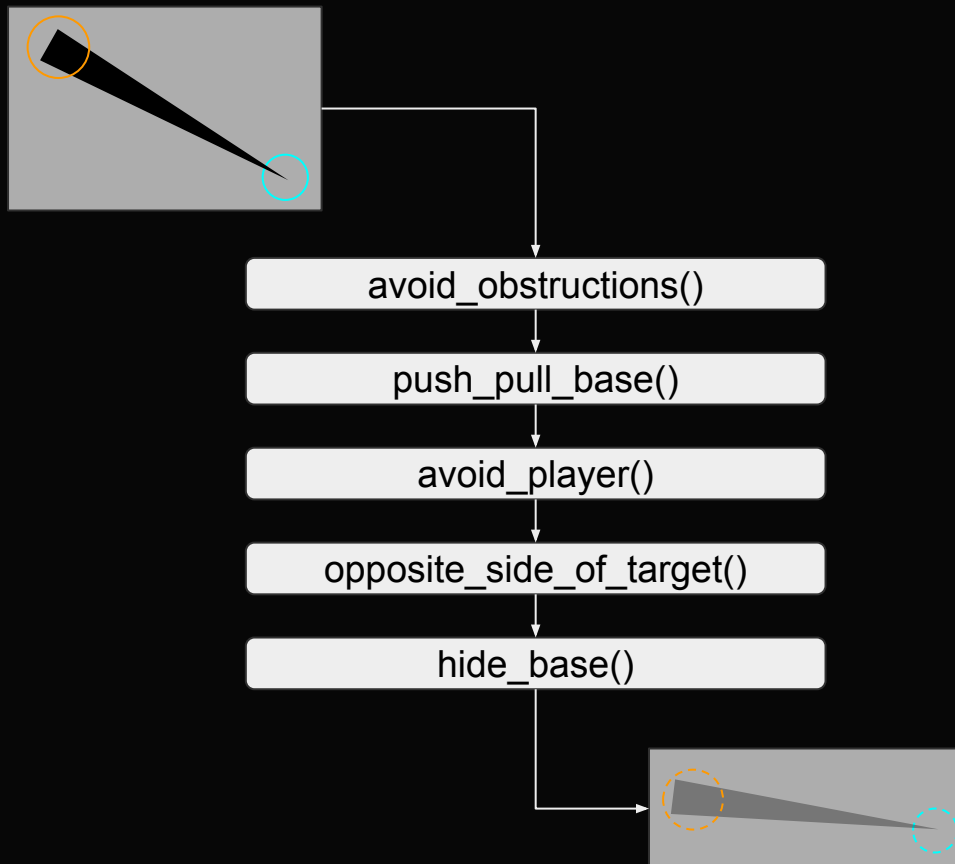
Travel Distance



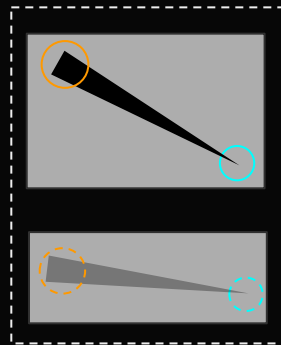
Combined



Before



Utility Positioning



avoid_obstructions()

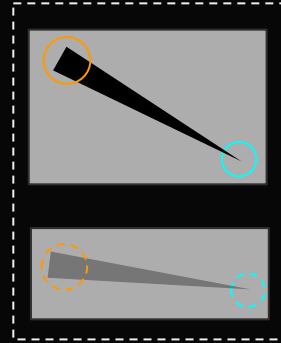
avoid_player()

opposite_side_of_target()

hide_base()

keep_straight()

Utility Positioning



avoid_obstructions()

10

avoid_player()

8

opposite_side_of_target()

5

hide_base()

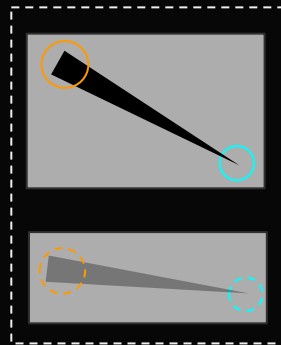
10

keep_straight()

5

Utility Positioning

- Predictable
- Independent
- Easy to extend



World Interactions

- New movement rules:

- ✓ Reactive to player
- ✓ Non-player targets

- **Utility positioning:**

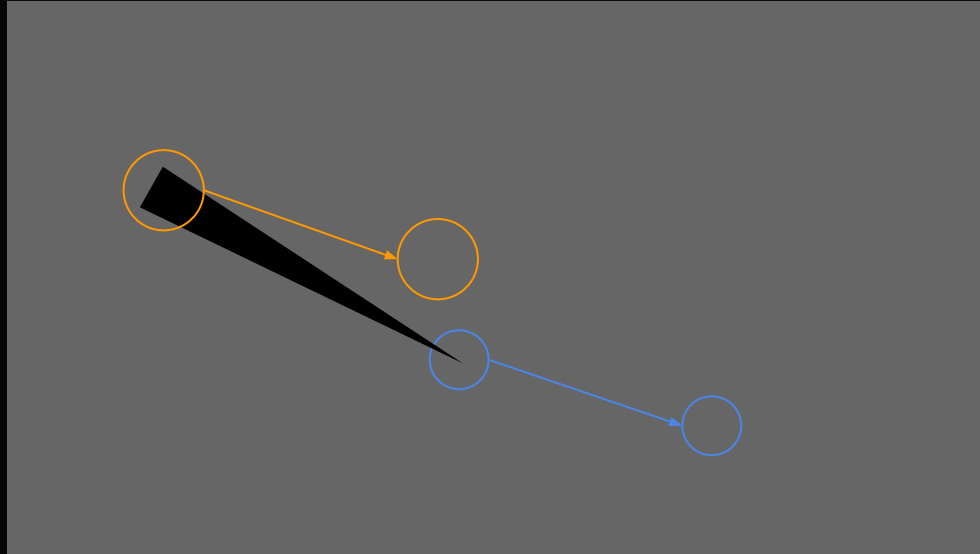
- ✓ **Consistent behaviour**
- ✓ **Extendable**

Pathing

- Just “circular” at this point
- Large movements still take too long
- Tentacle movement can look odd

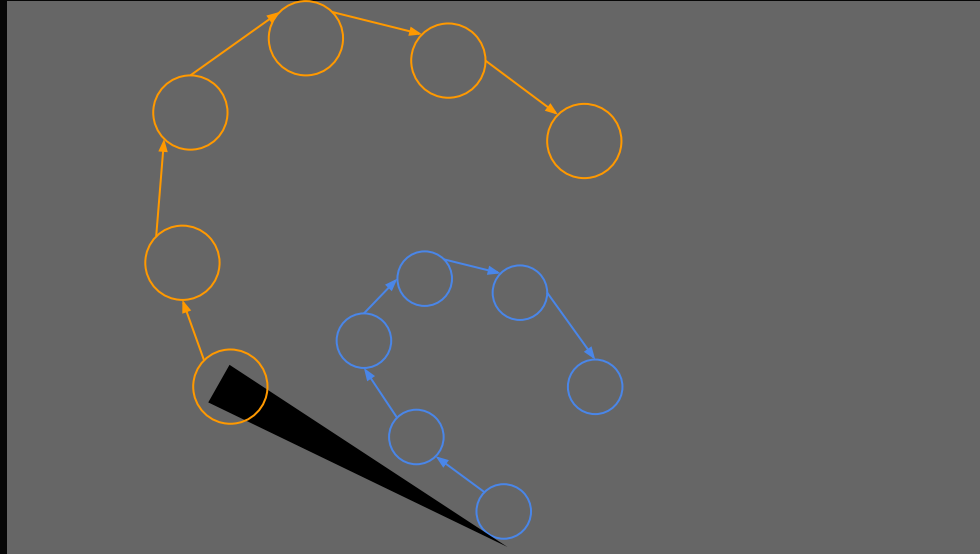
Direct Paths

- Quick, short movements



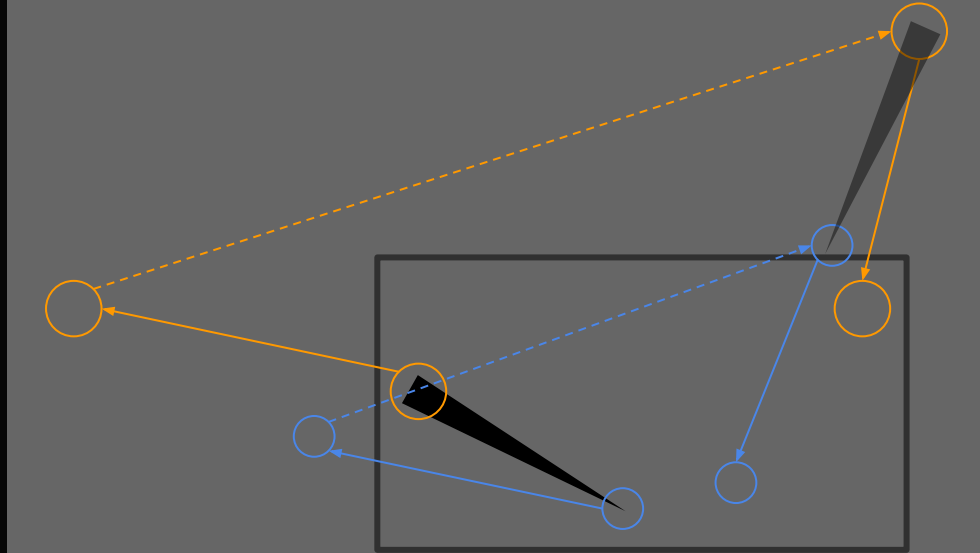
Oval Paths

- Medium \rightarrow Large movements
- Lateral movement looks weird



Teleport Paths

- Large, whole-level movements



World Interactions

- With new movement rules:

- ✓ Reactive to player
- ✓ Non-player targets

- **With pathing rules:**

- ✓ **Faster movement**
- ✓ **More natural**

- With utility positioning:

- ✓ Consistent behaviour
- ✓ Extendable

What's next?

- We have more behaviours, still feels empty
- Only using one or two tentacles..

MORE TENTACLES

More Tentacles

- Crank up tentacle count → random chaos
- Independent behaviours, no communication
- Create a **cohesive entity**

More Tentacles

- How do we control groups of tentacles cohesively?
- How do we choose what to do?
- How does this scale?

More Tentacles

- **How do we control groups of tentacles cohesively?**
- How do we choose what to do?
- How does this scale?

Dark Brain

- Makes high-level decisions
- Manages tentacle behaviours

Groups vs. Individuals

- Control groups of tentacles
- But, tentacles are also individual actors

Tasks

Eat Enemy

Steal Item

Attack Enemy

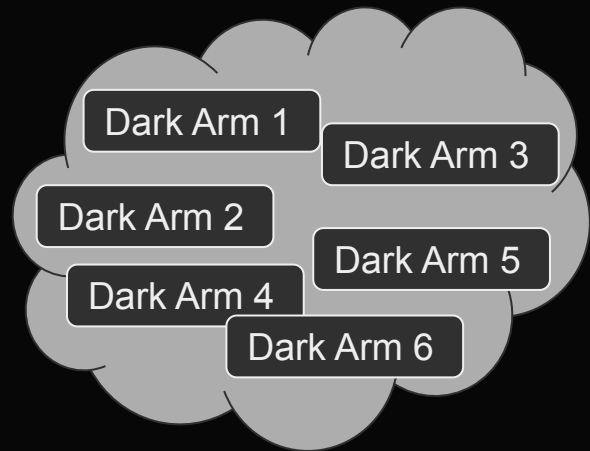
Inspect Area

Retreat

Supported Targets



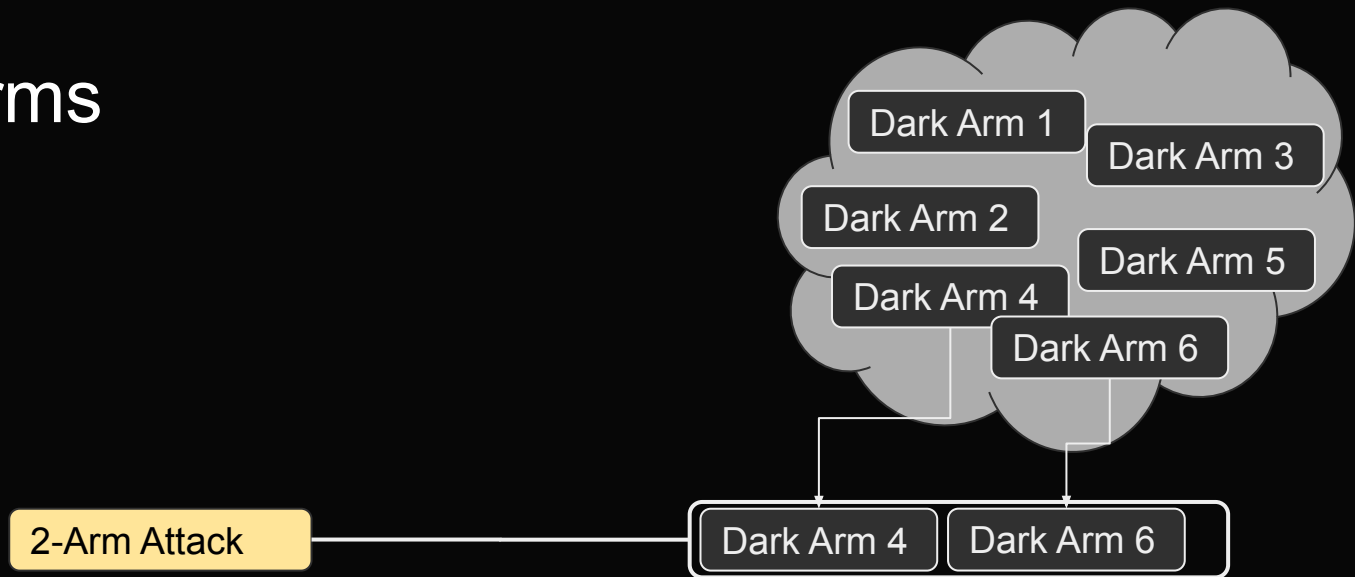
Task Arms

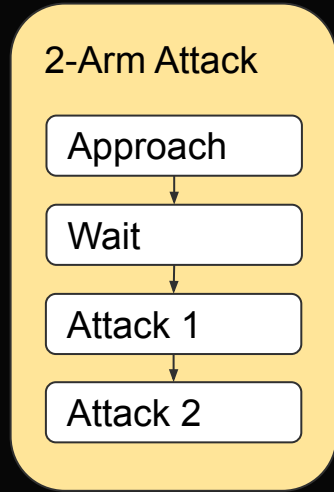


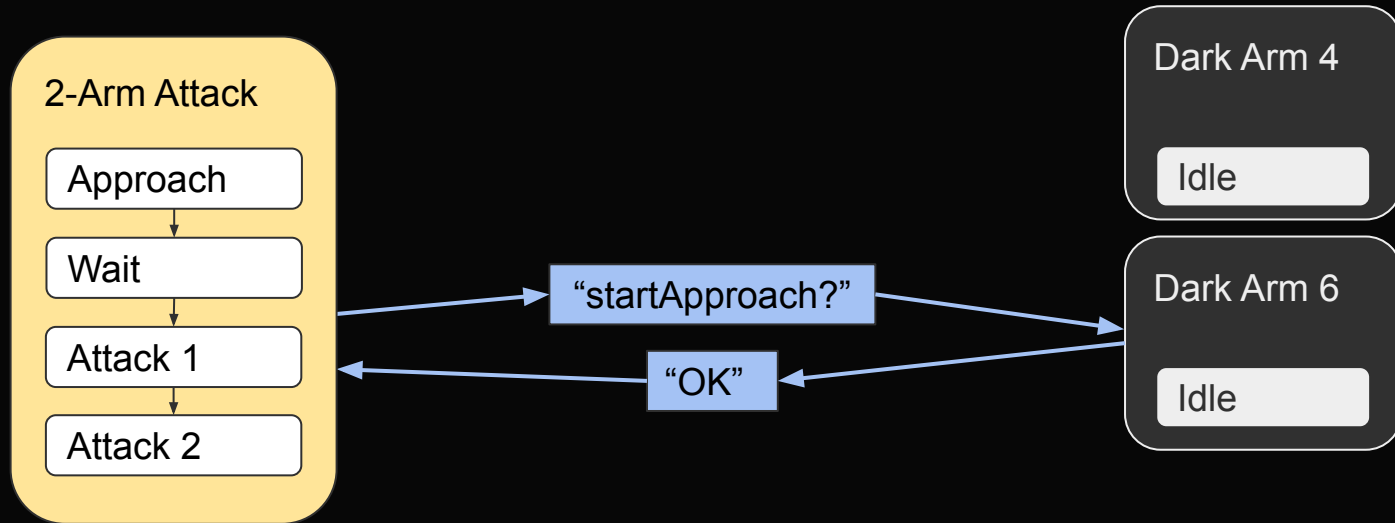
2-Arm Attack

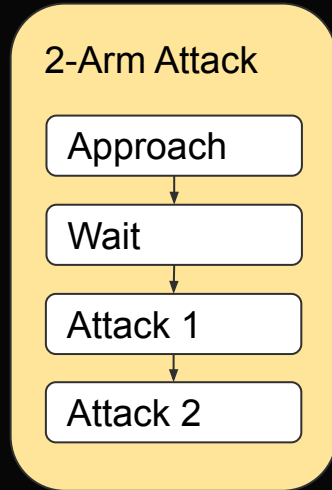


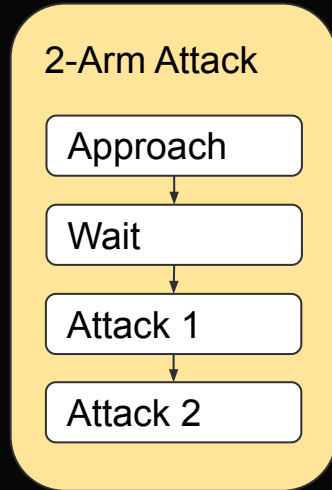
Task Arms

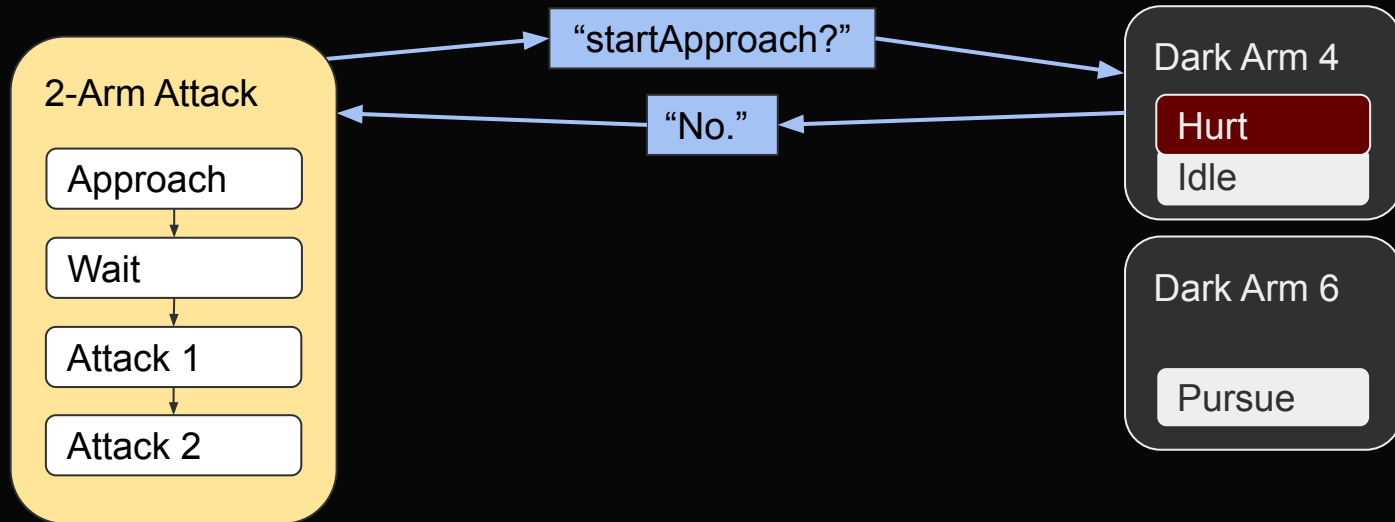












What if an arm says no?

- Cancel the task
- Trade arms
 - Faster behaviours
 - More cohesion

More Tentacles

- Dark Brain and Tasks

- ✓ Multi-arm coordination

- Arm Trading

- ✓ Consistent timing

- ✓ Feels natural

More Tentacles

- Where is the line between tentacles and brain?
- **How do we choose what to do?**
- How does this scale?

Task-Target Pairs

Task-Target Pair		
Weight	Task	Target
10	Eat	Rats
8	Attack	Cultists
5	Attack	Rats

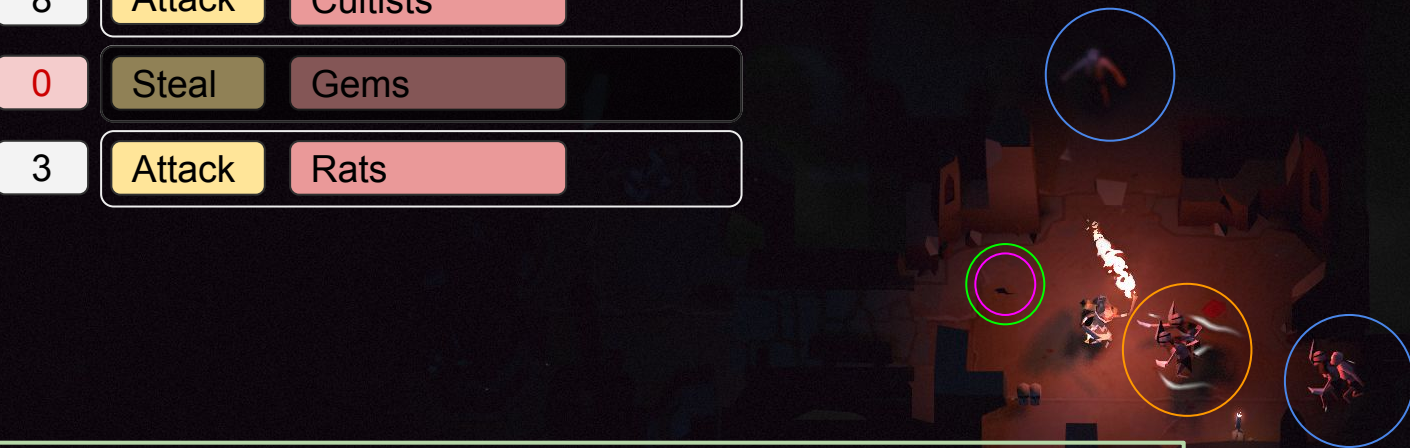
10	Eat	Rats
8	Attack	Cultists
5	Steal	Gems
3	Attack	Rats



10	Eat	Rats
8	Attack	Cultists
0	Steal	Gems
3	Attack	Rats



10	Eat	Rats
8	Attack	Cultists
0	Steal	Gems
3	Attack	Rats



More Tentacles

- Dark Brain and Tasks

- ✓ Multi-arm coordination

- Arm Trading

- ✓ Consistent timing

- ✓ Feels natural

- **Task-Target Pairs**

- ✓ **Configurable decisions**

More Tentacles

- Where is the line between tentacles and brain?
- How do we choose behaviours?
- **How does this scale?**

Scaling Up

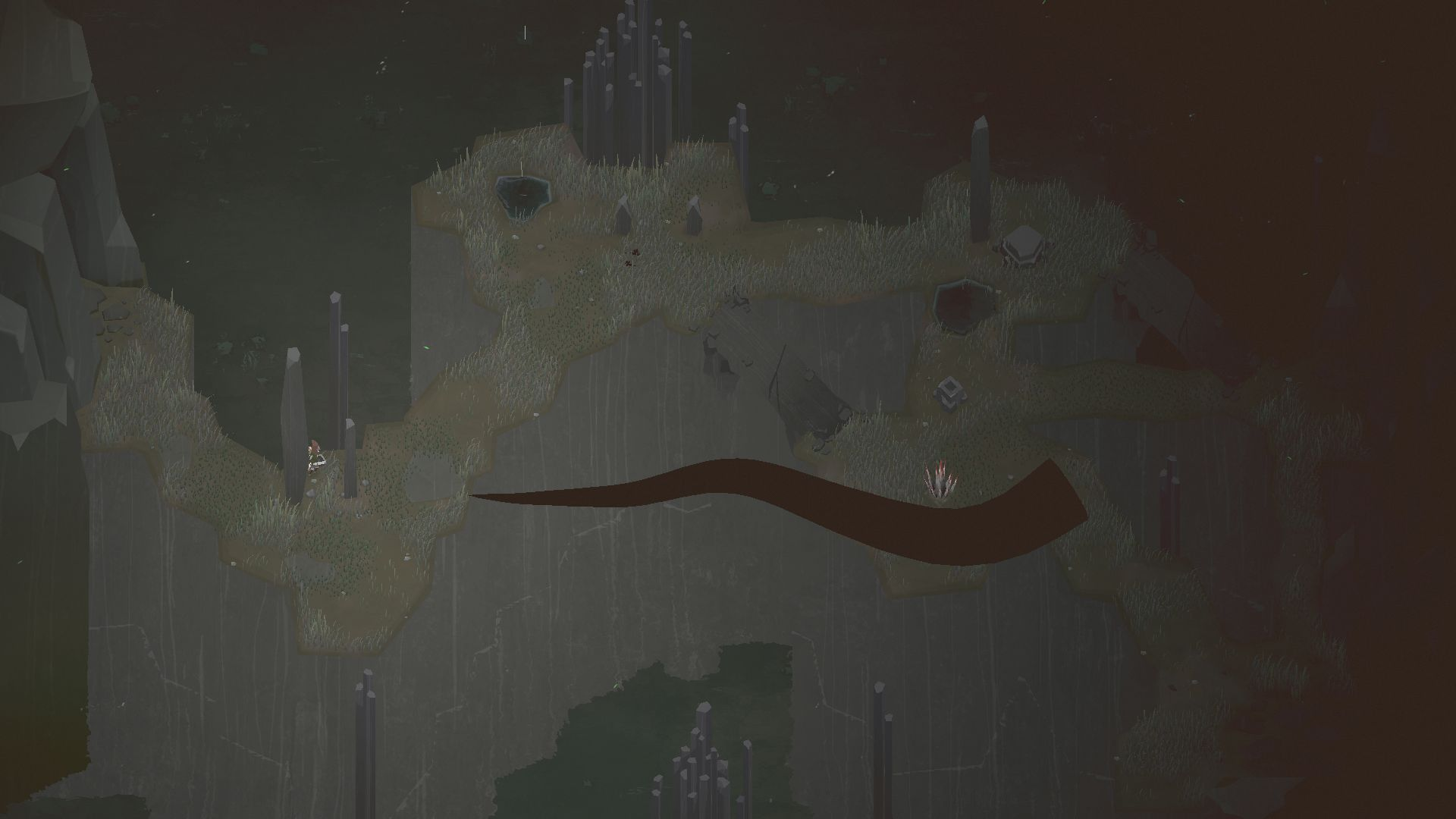
- Performance
- Audio

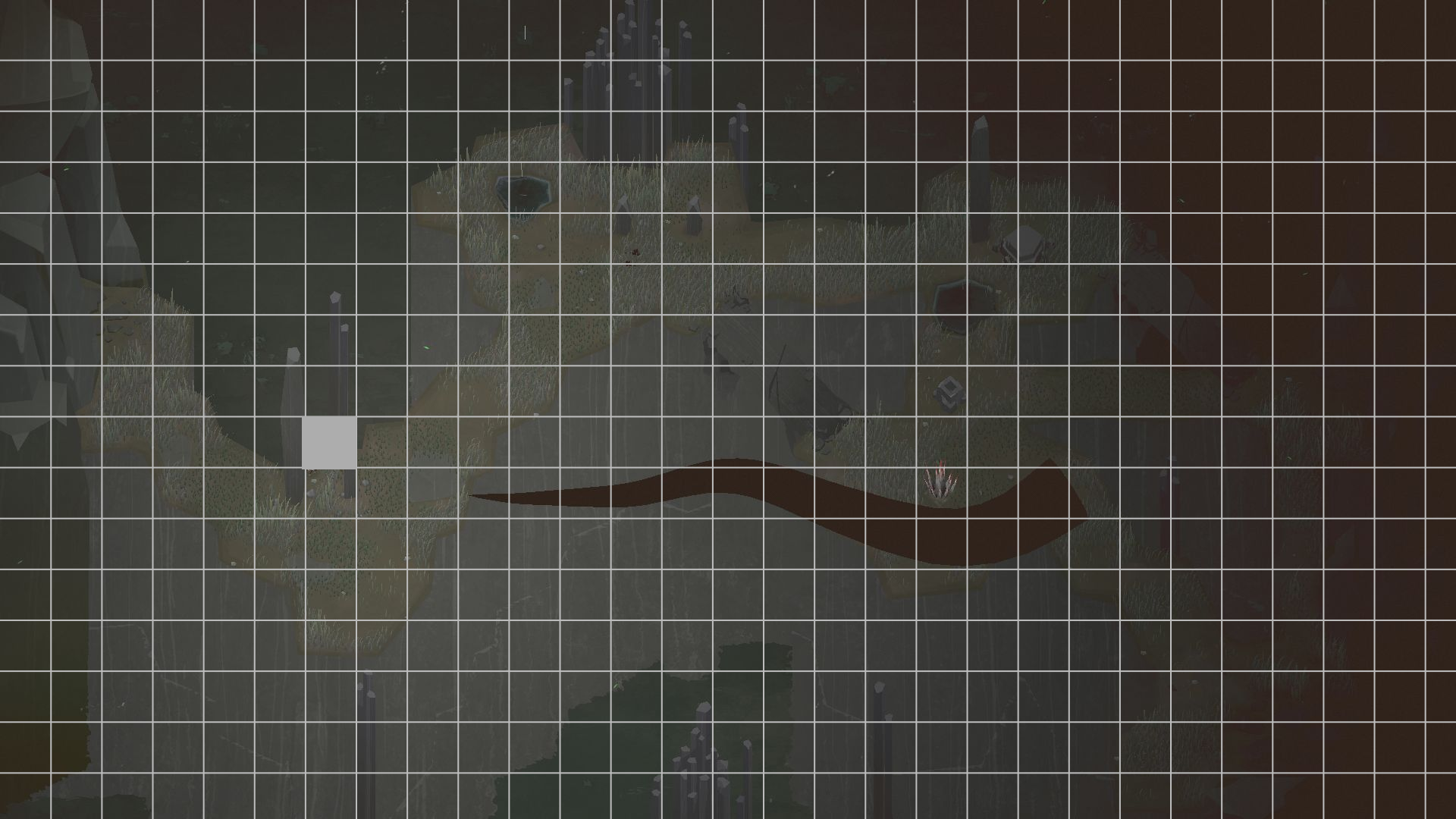
Performance Issues

- High overall CPU load → Move to C++
- Physics thread maxed-out → ?

Obstruction Checks

- 72 shapecasts per-arm
- Multiple targets
- Preprocess?



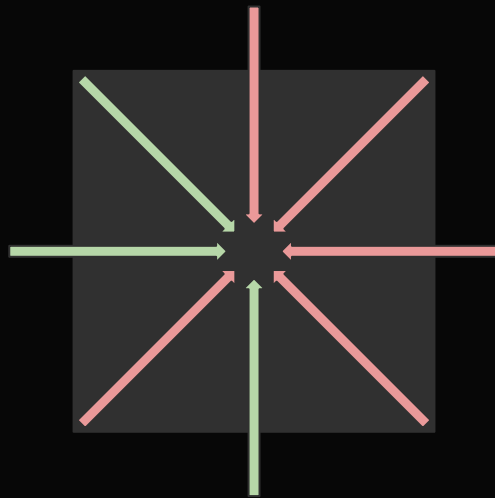




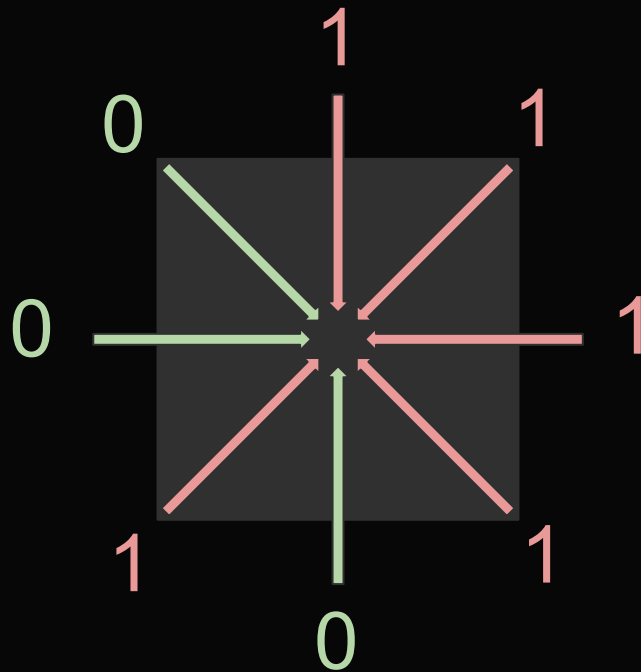




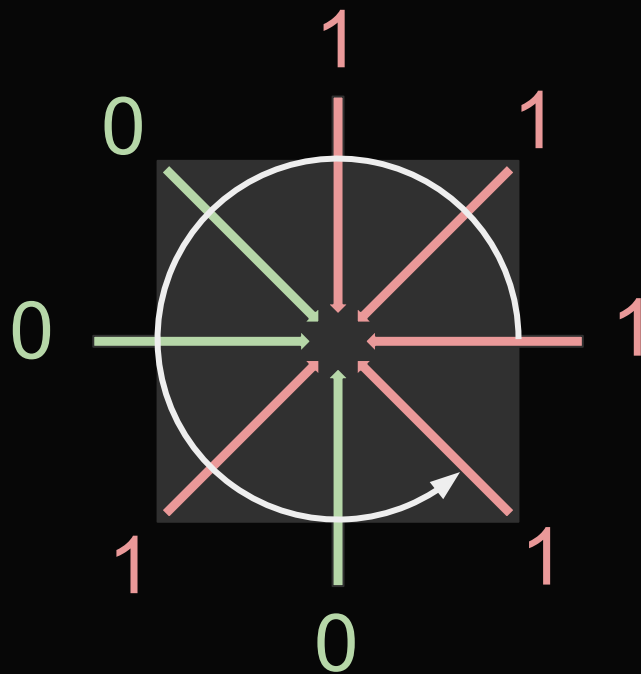
Cache Tile



Cache Tile



Cache Tile



1010 0111

←

▶ Select Dark Arm

RESUME GAME
OPTIONS
EXIT TO MAIN MENU

▼ Obstruction Cache Draws

- ☒ NORMAL_DISTANCE
☐ POUNCE_DISTANCE
☐ Enable single direction draws
 single direction
Closest bit: 4
Closest angle: 24.000000
Hovered Tile Pos: 745.000000, 765.000000

▼ Dark Arm Debug Draw Settings

- ☒ Enable draws
☐ Enable draws for unselected arms

Debug Draw Types

- ☐ Influence Map
☒ Obstruction Cache
☐ Show Labels
☐ Position Heuristics
☐ Steering
☐ Pathing Obstruction Check
☐ Floating Audio
☐ Fronts
☒ Pathing

More Tentacles

- Dark Brain and Tasks:

- ✓ Multi-arm coordination

- Arm Trading:

- ✓ Consistent timing

- ✓ Feels natural

- Task-Target Pairs:

- ✓ Configurable decisions

- **Obstruction Cache:**

- ✓ **Fast obstruction lookups**

Audio

- 1 emitter per arm
- Far too noisy
- Hard to control

▼ Select Influence Map Settings

- ☒ Arm Influence
- ☐ Kinematic Tip Influence (red arms)

Debug Draw Types

- ☒ Influence Map
- ☐ Obstruction Cache
- ☐ Show Labels
- ☐ Position Heuristics
- ☐ Steering
- ☐ Pathing Obstruction Check
- ☐ Floating Audio
- ☐ Fronts
- ☐ Pathing
- ☐ Target Prediction

▶ Select Dark Arm



▼ Select Influence Map Settings

- ☐ Arm Influence
- ☒ Kinematic Tip/Influenced arms

Debug Draw Types

- ☒ Influence Map
- ☐ Obstruction Cache
- ☐ Show Labels
- ☐ Position Heuristics
- ☐ Steering
- ☐ Pathing Obstruction Check
- ☒ Floating Audio
- ☐ Fronts
- ☒ Pathing
- ☒ Target Prediction

▶ Select Dark Arm

More Tentacles

- Dark Brain and Tasks:

- ✓ Multi-arm coordination

- Arm Trading:

- ✓ Consistent timing

- ✓ Feels natural

- Task-Target Pairs:

- ✓ Configurable decisions

- Obstruction Cache:

- ✓ Fast obstruction lookups

- **Influence Map:**

- ✓ **Good audio coverage**

Now what?

- Arms working together
- Tunable “full dark” behaviour
- Decent performance

Combat

Combat

- “Whole Dark” experience
- Focus everything on player
- Interesting and readable attack patterns

Combat

- How do we use the full space and *all* arms?
- How do we create interesting, readable attacks?
- How do we pace out the fight?

Combat

- **How do we use the full space and *all* arms?**
- How do we create interesting, readable attacks?
- How do we pace out the fight?

▶ Select Dark Arm

RESUME GAME
OPTIONS
EXIT TO MAIN MENU

▼ Obstruction Cache Draws

- ☒ NORMAL_DISTANCE
☐ POUNCE_DISTANCE
☐ Enable single direction draws
 single direction
Closest bit: 4
Closest angle: 24.000000
Hovered Tile Pos: 745.000000, 765.000000

▼ Dark Arm Debug Draw Settings

- ☒ Enable draws
☐ Enable draws for unselected arms

Debug Draw Types

- ☐ Influence Map
☒ Obstruction Cache
☐ Show Labels
☐ Position Heuristics
☐ Steering
☐ Pathing Obstruction Check
☐ Floating Audio
☐ Fronts
☒ Pathing

Fronts

- Contiguous sections of space
- Calculated using obstruction cache





Settings

- Game Type
- Gameplay
- Audio
- Visuals
- Controls
- Network
- Advanced
- Debug
- Target
- Performance

Formations

- Configurations of fronts
- Recognizable patterns of arms

▶ Dark Arm (default) ID:1556 (604.888000, 0.010000, 1541.986694)

▶ Dark Brain Debug

▼ Dark Arm Debug Draw Settings

Enable draws for unselected arms

Debug Draw Types

- ☐ Influence Map
- ☐ Obstruction Cache
- ☐ Show Labels
- ☐ Position Heuristics
- ☐ Steering
- ☐ Pathing Obstruction Check
- ☐ Floating Audio
- ☒ Fronts
- ☐ Pathing
- ☐ Target Prediction

RESUME GAME
OPTIONS
EXIT TO MAIN MENU

▶ Select Dark Arm

▶ Dark Arm (default) ID:1556 (128.075256, 0.000000, 793.090332)

▶ Dark Brain Debug

▼ Dark Arm Debug Draw Settings

Enable draws for unselected arms

Debug Draw Types

- ☐ Influence Map
- ☐ Obstruction Cache
- ☐ Show Labels
- ☐ Position Heuristics
- ☐ Steering
- ☐ Pathing Obstruction Check
- ☐ Floating Audio
- ☒ Fronts
- ☐ Pathing
- ☐ Target Prediction

da

▶ Select Dark Arm

RESUME GAME

OPTIONS

EXIT TO MAIN MENU

▶ Dark Arm (default) ID:1556 (561.671265, 0.000000, 268.689392)

▶ Dark Brain Debug

▼ Dark Arm Debug Draw Settings

Enable draws for unselected arms

Debug Draw Types

- ☐ Influence Map
- ☐ Obstruction Cache
- ☐ Show Labels
- ☐ Position Heuristics
- ☐ Steering
- ☐ Pathing Obstruction Check
- ☐ Floating Audio
- ☒ Fronts
- ☒ Pathing
- ☒ Target Prediction

▶ Select Dark Arm

RESUME GAME
OPTIONS
EXIT TO MAIN MENU

▶ Dark Arm (default) ID:1556 (298.379822, 0.010000, 1270.586914)

▶ Dark Brain Debug

▼ Dark Arm Debug Draw Settings

Enable draws for unselected arms

Debug Draw Types

- ☐ Influence Map
- ☐ Obstruction Cache
- ☐ Show Labels
- ☐ Position Heuristics
- ☐ Steering
- ☐ Pathing Obstruction Check
- ☐ Floating Audio
- ☒ Fronts
- ☐ Pathing
- ☐ Target Prediction

RESUME GAME
OPTIONS
EXIT TO MAIN MENU

▶ Select Dark Arm

Combat

- Fronts:

- ✓ Find available space
- ✓ Distribute arms

- Formations:

- ✓ Readable patterns
- ✓ Interesting use of space

Combat

- How do we use the full space and *all* arms?
- **How do we create interesting, readable attacks?**
- How do we pace out the fight?

Attack Tasks

- Consistent attacks using formations

Ex:

- One-Two attack
- One-Two-Three attack
- “Flurry” attack

Combat

- Fronts:

- ✓ Find available space
- ✓ Distribute arms

- Formations:

- ✓ Readable patterns
- ✓ Interesting use of space

- **Attack Tasks:**

- ✓ **Consistent timing**
- ✓ **Spacial readability**

Combat

- How do we use the full space and *all* arms?
- How do we create interesting, readable attacks?
- **How do we pace out the fight?**

Stances

- Communicate stages of fight
- Ideas from boxing, fencing
- Good feedback source for player
 - Attack -> Exit Pounce reaction implies “that hurt”

“Relax”

Stalking in background



“Setup”

Preparing to attack



“Pounce”

Active combat



Combat

- Fronts:

- ✓ Find available space
- ✓ Distribute arms

- Formations:

- ✓ Readable patterns
- ✓ Interesting use of space

- Attack Tasks:

- ✓ Consistent timing

- **Stances:**

- ✓ **Fight pacing**

Summary

- Basic Movement
 - Pursue and Attack Behaviours
 - Kinematic Constraints
 - Radial Shapecasts
- World Interactions
 - New movement rules
 - Utility positioning
 - Pathing
- More Tentacles
 - Dark Brain and Tasks
 - Arm Trading
 - Task-Target Pairs
 - Obstruction Cache
 - Influence Map
- Combat
 - Fronts
 - Formations
 - Attack Tasks
 - Stances

Thank You!

Robin Vierich

@robinvierich

robinvierich@gmail.com