



Scroll Back

The Theory and Practice of Cameras in Side-Scrollers

Itay Keren

Untame

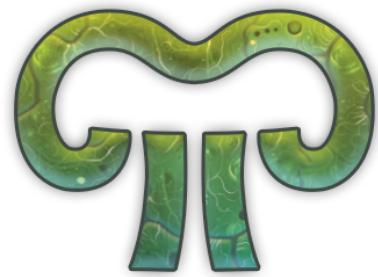


itay@untame.com

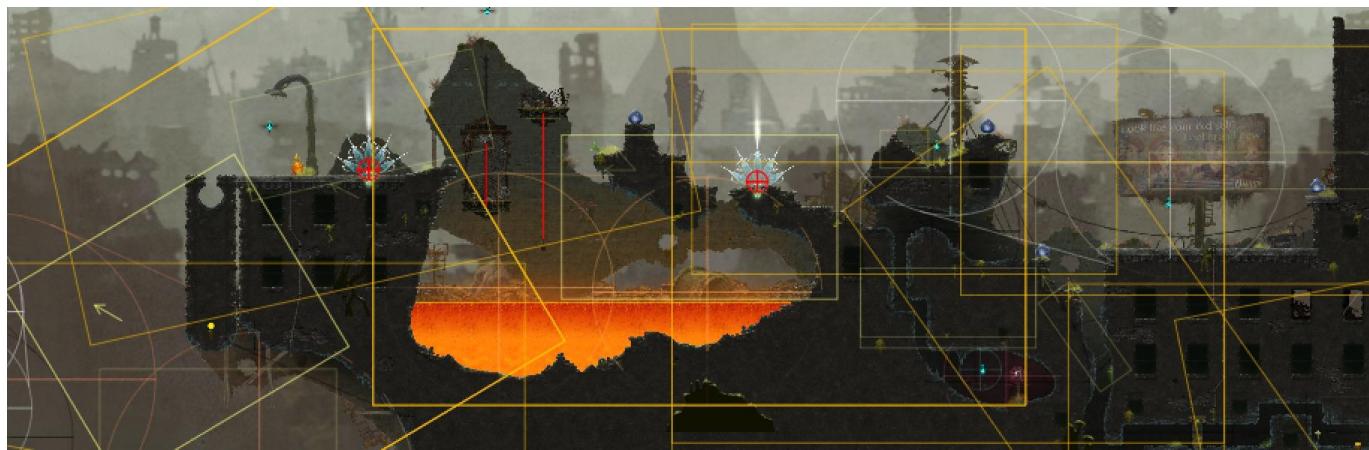


@itayke

GAME DEVELOPERS CONFERENCE®
MOSCONC CENTER · SAN FRANCISCO, CA
MARCH 2-6, 2015 · EXPO: MARCH 4-6, 2015



MUSHROOM 11





Scrolling

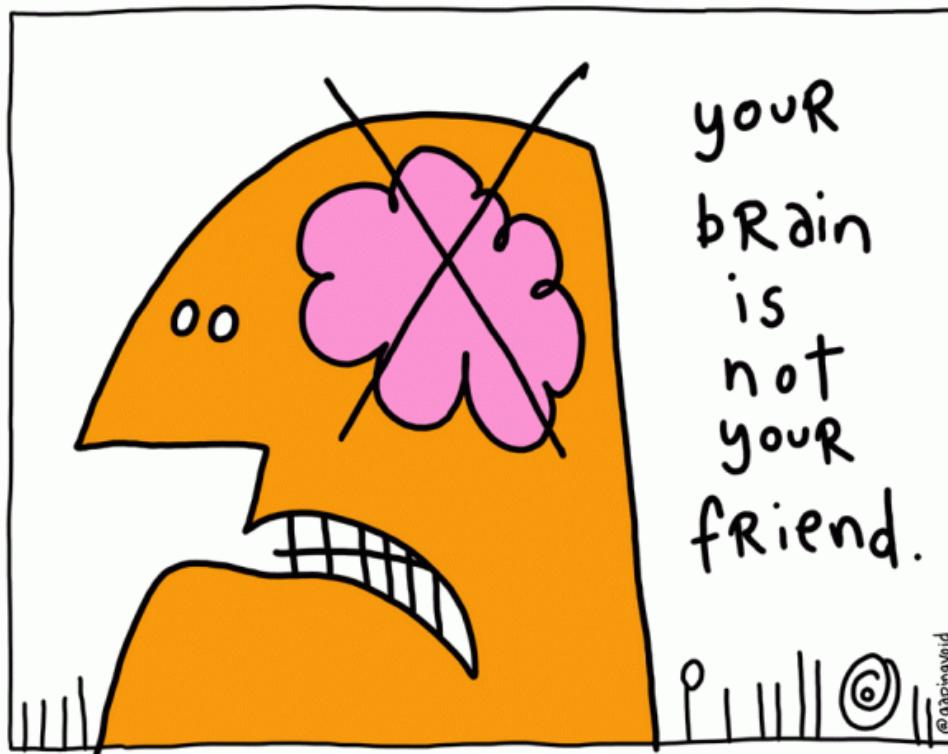
Big World, Small Screen

It is said that hope flies on death's wings,
Prepare then, for as the Elder Scrolls foretold,
it will be here that your adventure begins...





Scrolling: Neural Background





Fovea centralis

High cone density

Sharp, hi-res central vision

Parafovea

Lower cone density

Perifovea

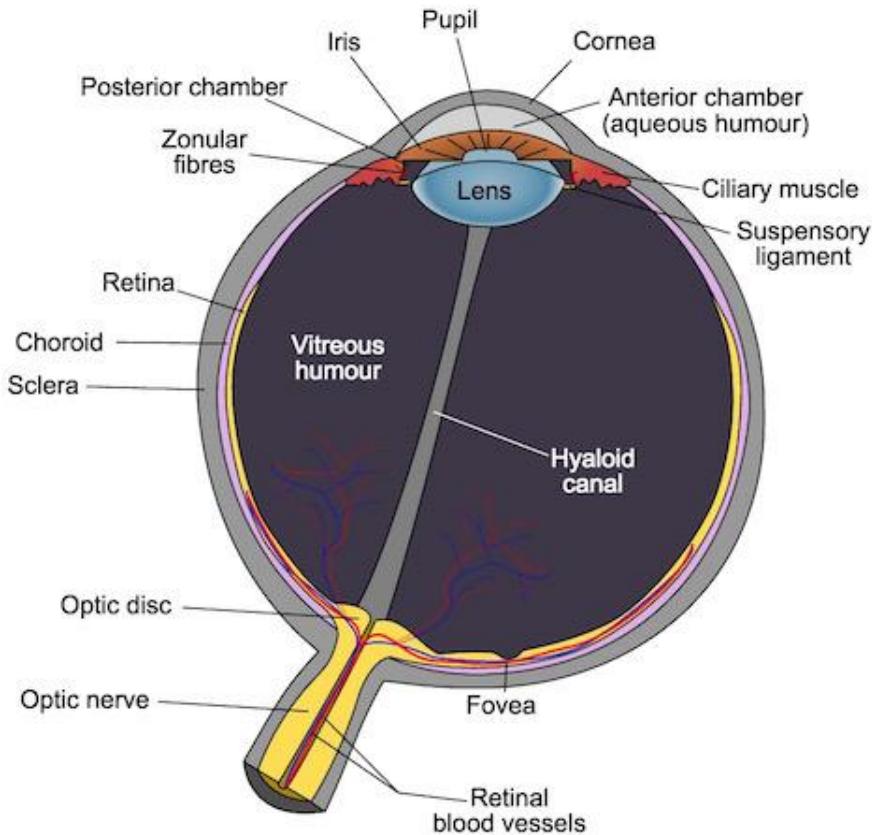
Lowest density,

Compressed patterns.

Optimized for quick

pattern changes:

shape, acceleration,
direction





Fovea centralis

High cone density

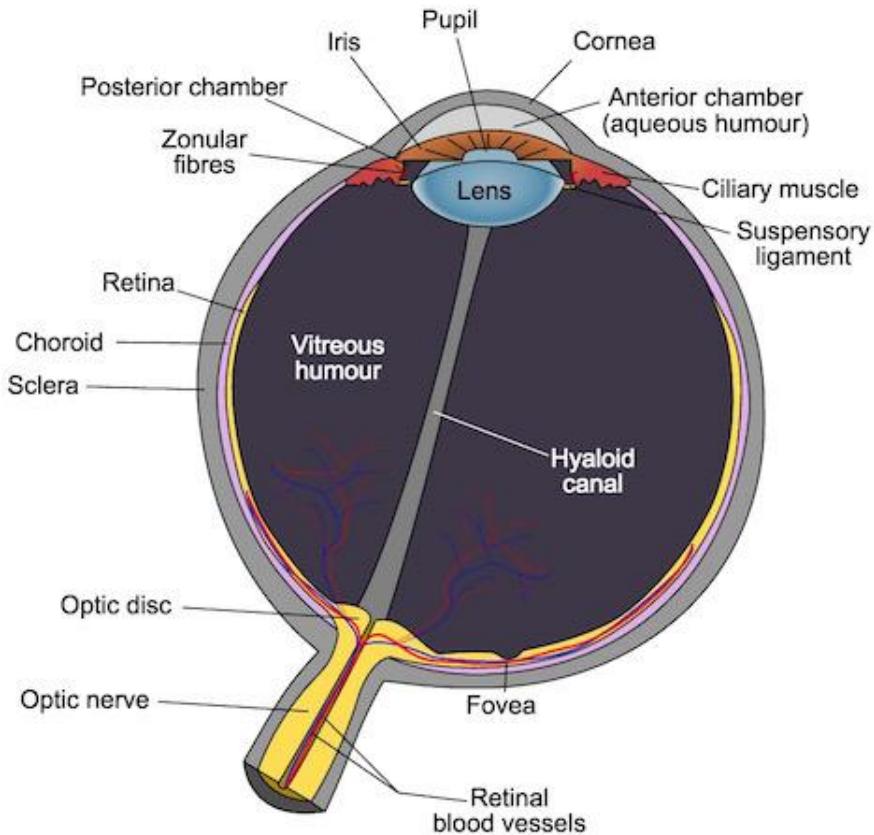
Sharp, hi-res central vision

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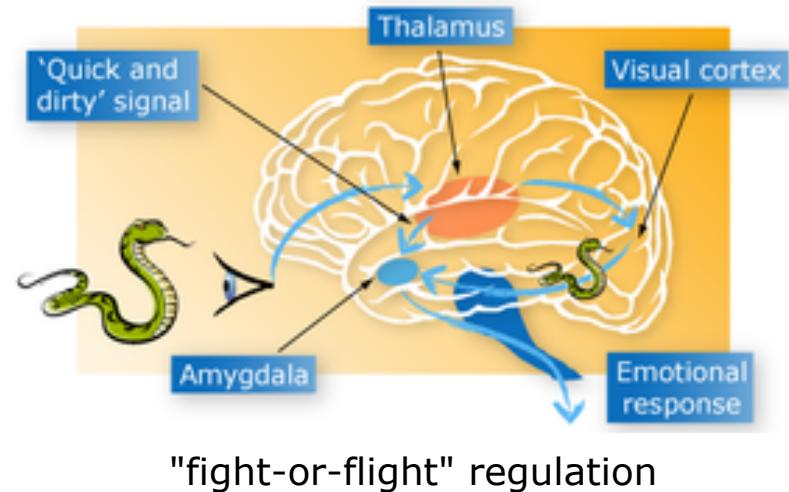


Thalamus

Relay sensory signals to the cerebral cortex (e.g. vision, motor)

Amygdala

Emotional reactions of fear and anxiety, memory regulation and conditioning





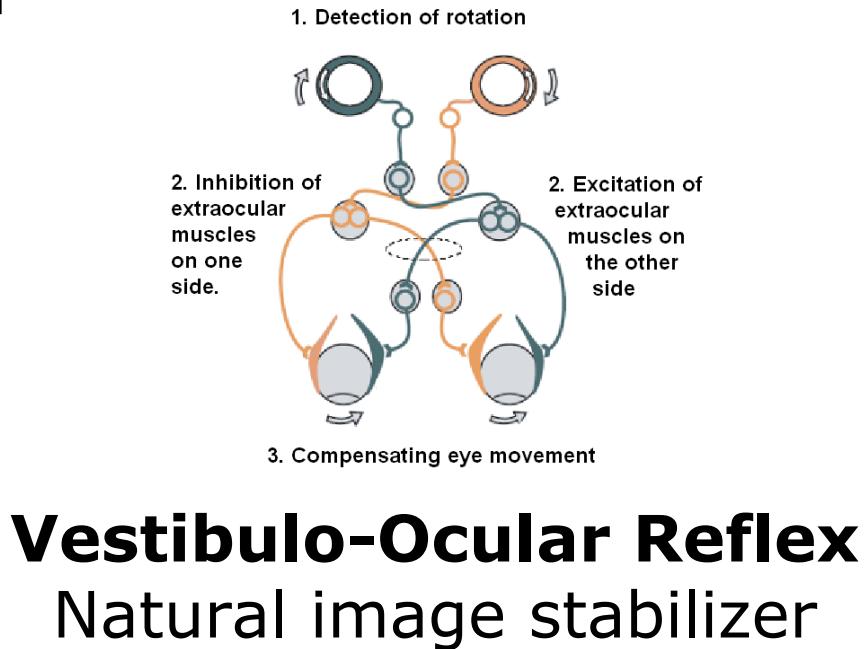
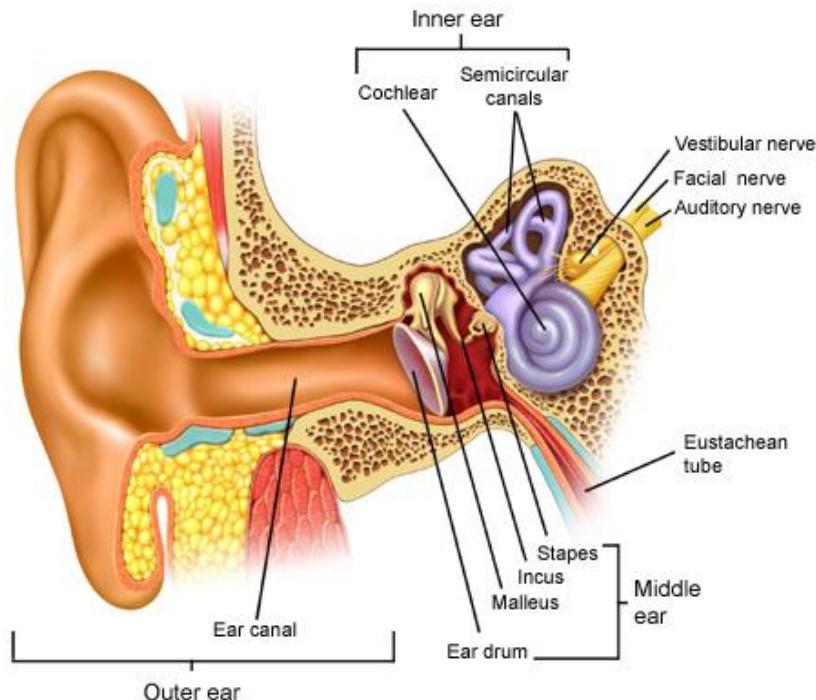
Familiar visual patterns as well as pattern changes may cause anxiety unless regulated





Vestibular System

Balance, Spatial Orientation



Vestibulo-Ocular Reflex

Natural image stabilizer



Conflicting sensory signals
(Visual vs. Vestibular) may
lead to discomfort and nausea*

* much worse in 3D (especially VR), but still
effective in 2D



Scrolling with Attention, Interaction and Comfort



Attention: Use the camera to provide sufficient game info and feedback



Interaction: Make background changes predictable, tightly bound to controls



Comfort: Ease and contextualize background changes

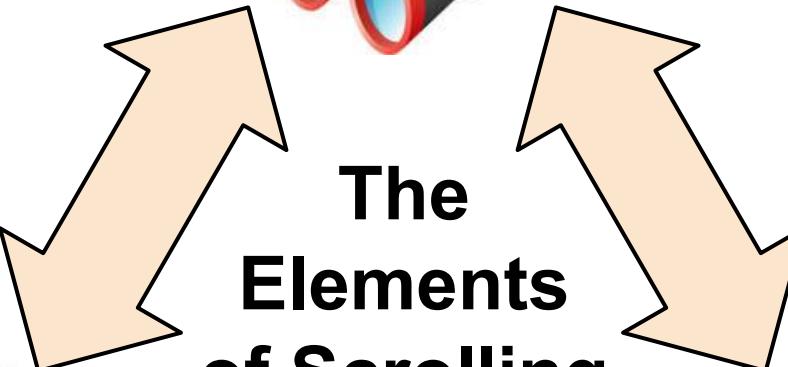




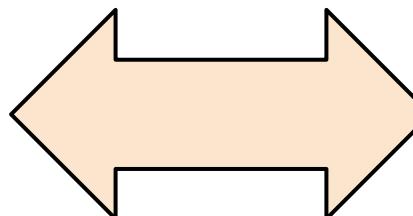
Attention



The
Elements
of Scrolling



Interaction



Comfort



Scrolling Nostalgia



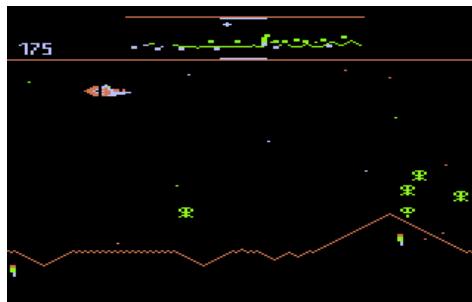
Rally-X © 1980 Namco



Scramble © 1981
Konami



Jump Bug © 1981
Hoei/Coreland (Alpha Denshi)



Defender © 1981
Williams Electronics



Vanguard © 1981
SNK (Tose)



Moon Patrol © 1982
Williams Electronics (Irem)



Jungle Hunt © 1982
Taito



Hover Attack © 1983
Compac



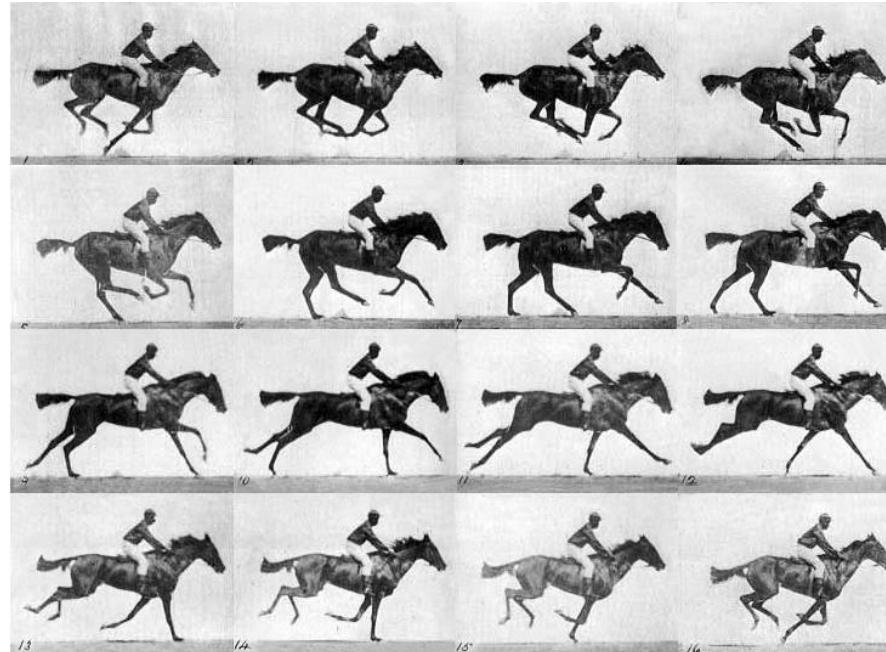
Indie





Follow the Action

Keep attention on your control subject





position-locking

Camera is locked to the player's position



Rally-X © 1980 Namco

position-locking



terminology



edge-snapping

Set a hard edge for camera positioning



Kung-Fu Master © 1984 Irem
(Takashi Nishiyama)

**[*edge-snapping*]
*position-locking***



position-locking

Terraria © 2011 Re-Logic



Curb Camera Motion

Avoid unnecessary or unpredictable bumps





camera-window

Character pushes the camera as it hits the window edge



camera-window

Jump Bug © 1981
Hoei/Coreland (Alpha Denshi)



camera-window

Standard jump-height tall window allows some jumps to keep camera steady



Rastan Saga © 1987 Taito

camera-window



Fez © 2012 Polytron Corporation

***camera-window** (horiz.)**

** Enforced even during dimension shifts*

***position-locking* (vert.)**

lerp-smoothing



Snapping

Fix camera drift within window





position-snapping

Constantly reduce window drift by (gently) focusing the camera back on the player



Shinobi © 1987 Sega

position-snapping (vert.)
camera-window (vert.)
position-locking (horiz.)
static-forward-focus



Super Mario World © 1990 Nintendo

***region-based-anchors
platform-snapping****

* Where applicable

***camera-window* (vert.)
dual-forward-focus****

* Threshold triggered

manual-control*

* Controller provides extra panning



Rayman © 1995 Ubisoft

platform-snapping*

* where applicable

camera-window* (vert.)

region-based-anchors

dual-forward-focus*

lerp-smoothing



camera-window (vert.)
platform-snapping*

* Jetpack character is always snapped
(=vert. position-locking)

position-locking (horiz.)

Awesomenauts © 2012 Ronimo Games



Smoothing

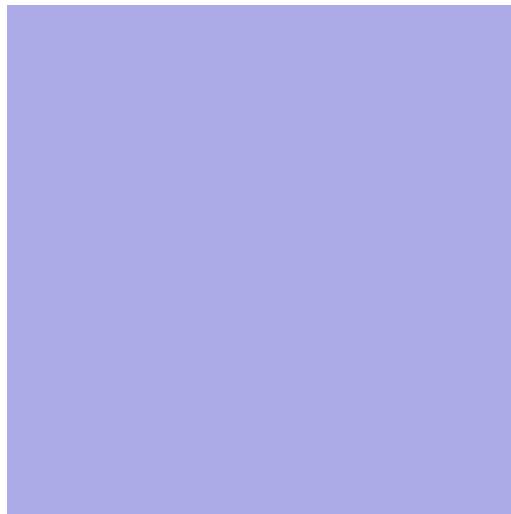
Avoid sudden camera speed and direction changes



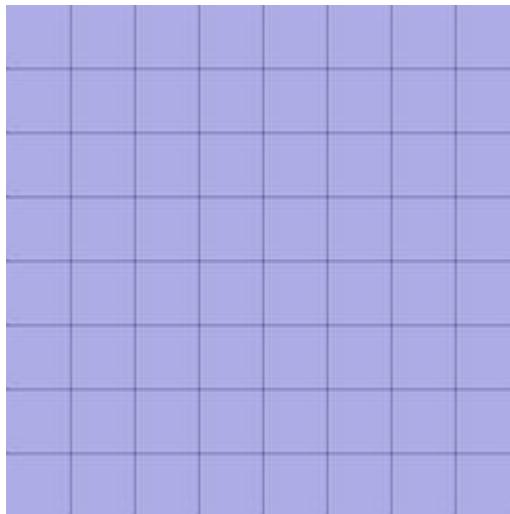


Pixel Boundary

Motion smoothing is a forgotten challenge (almost)



80s Pixel
(NES: 256x240 resolution)



Indie Pixel



Smoothing with (pseudo) physics

With a position-locked camera, physics based character can smooth camera motion



Pac-Land © 1984 Namco

***position-locking
static-forward-focus***



Shigeru Miyamoto

Early experiments in scrolling



Excitebike © 1984 Nintendo



Devil World © 1984 Nintendo
Denied release in North America





speedup-push-zone

Gradually push camera to catch up with character's speed and reduce jarring camera movements as character hits the line



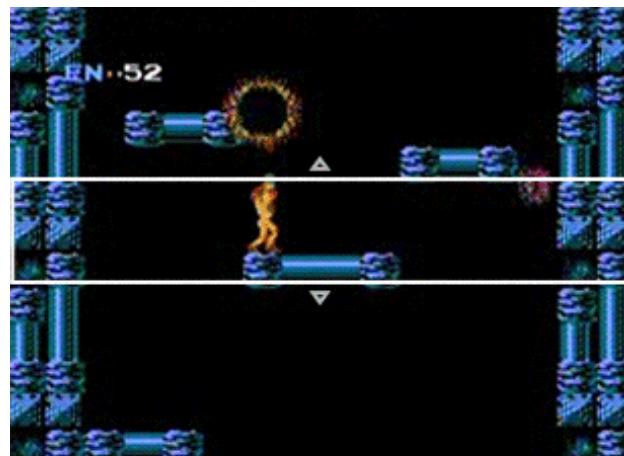
Super Mario Bros. © 1985 Nintendo

***speedup-push-zone
camera-window****
** One-sided
static-forward-focus*



speedup-pull-zone

Pull the camera to catch up with character's speed
after it hits the line



Metroid © 1986 Nintendo



camera-window (horiz./vert.)
speedup-pull-zone

lerp-smoothing

Continuously reduce distance between camera and character using Linear Interpolation



Donkey Kong Country © 1994
Nintendo (Rare Ltd)

lerp-smoothing
position-locking (vert.)
region-based-anchors
dual-forward-focus



lerp-smoothing

Continuously reduce distance between camera and character using Linear Interpolation (e.g. *multiply the distance by t=0.05*)



```
float lerp (float a, float b, float t) {  
    return a + t * (b - a);  
}
```

lerp-smoothing position-locking

Super Meat Boy © 2010 Team Meat



physics-smoothing

Camera is a physics enabled character, constantly closing on the character (or composite target position).



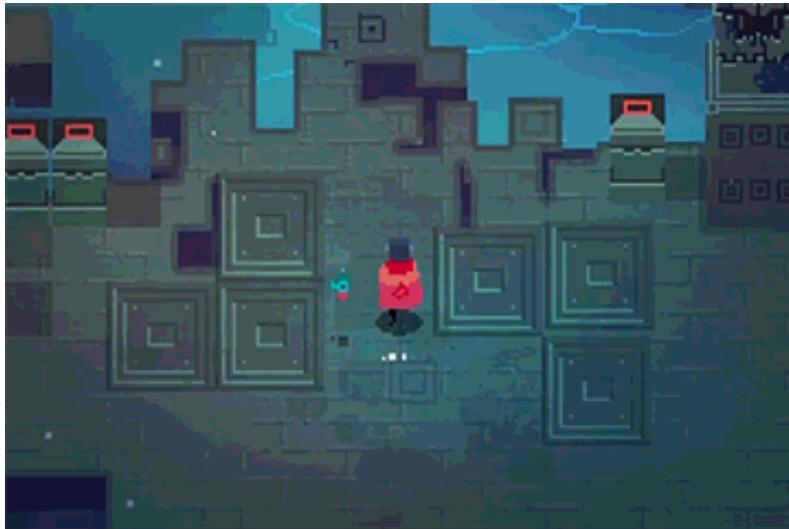
Never Alone © 2014
Upper One Games

physics-smoothing
position-averaging
cinematic-paths
region-based-anchors
cue-focus



Pixel Perfect Smoothing

Even when using pixel art, scrolling at full resolution can smooth an otherwise choppy scrolling effect



Hyper Light Drifter © [Release TBA] Heart Machine

physics-smoothing*

Game canvas resolution is 480x270.
Camera scrolling uses full resolution.

region-based-anchors
target-focus
cue-focus
gesture-cues



Framing

Keep the important details in the frame





auto-scrolling

Player only has authority over its placement in the frame, facing the threats coming ahead (and behind)



[*auto-scrolling*]

Scramble © 1981 Konami



static-forward-focus

Extra space in the principal progression direction. It also serves as a directional guide: *aim for the center*.



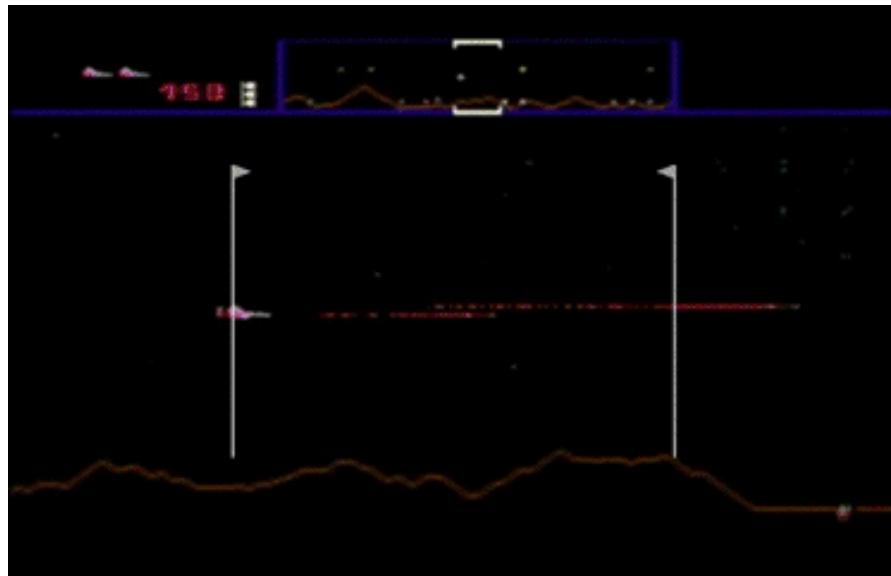
Pac-Land © 1984 Namco

***position-locking
static-forward-focus***



dual-forward-focus

Switch focus with each turn to enable wide forward view



dual-forward-focus

Defender © 1981
Williams Electronics



Bonanza Bros. © 1990 Sega

dual-forward-focus*

* Focus switch is based on walking speed

Threshold triggered dual-forward-focus

Camera focus is switched after backtracking a set distance



*camera-window** (vert.)
region-based-anchors
*platform-snapping**

* Where applicable

dual-forward-focus*

* Threshold triggered

manual-control*

* Controller provides extra panning



Cave Story © 2004 Studio Pixel

***position-locking (vert.)
dual-forward-focus
physics-smoothing
manual-control****

* Controller provides extra up/down panning



target-focus

Camera follows controller input to provide true visual forward focus



Jazz Jackrabbit 2 © 1998 Epic Games

lerp-smoothing (vert.)

target-focus*

* Stick/cursor-keys push the focus point in the desired direction

[manual-control*]

* Manual extended look = *target-focus*



target-focus

Camera follows pointer target to provide true visual forward focus

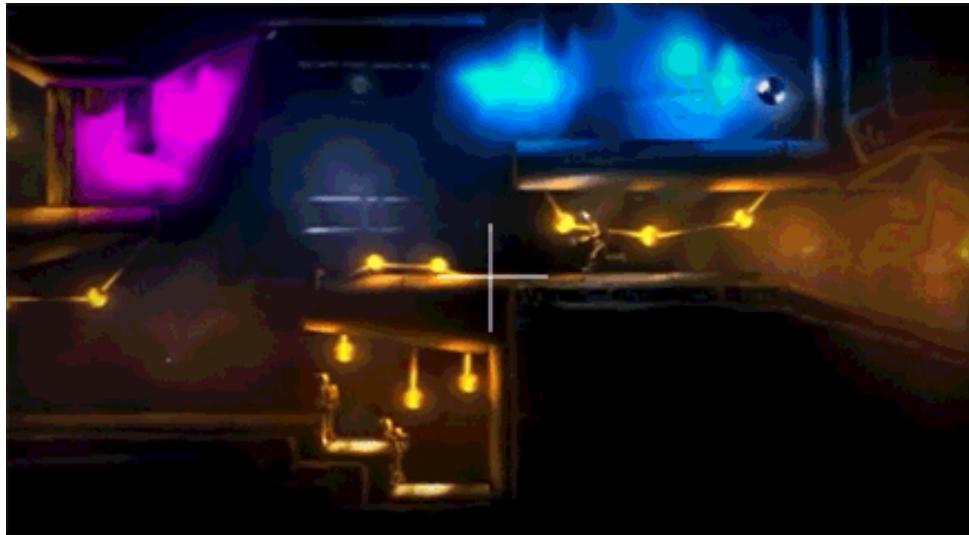


Snapshot © 2012 Retro Affect

target-focus*

* Average between player and pointer

lerp-smoothing



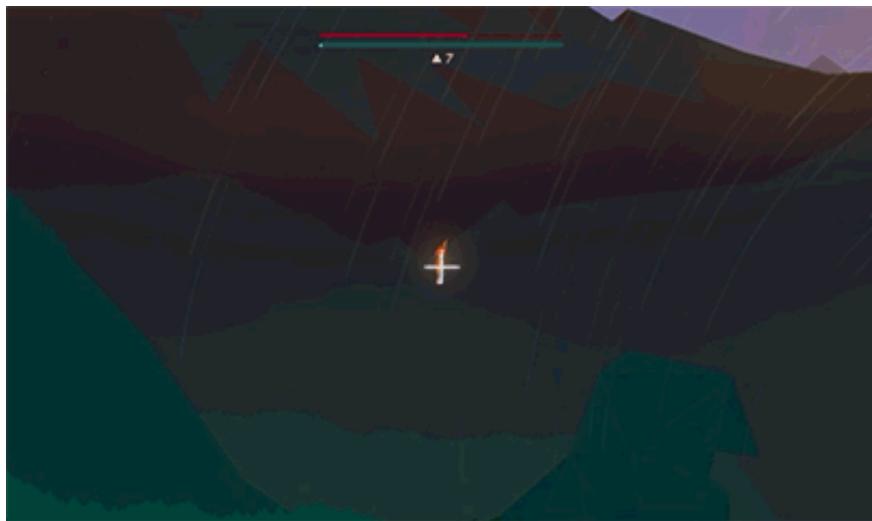
The Swapper © 2013 Facepalm Games

target-focus
physics-smoothing
region-based-anchors
cue-focus
cinematic-paths



projected-focus

Camera follows the projected position of the character



projected-focus
physics-smoothing
cue-focus*

* Position and zoom based on attractors

gesture-cues*

* Certain actions invoke preset camera behaviors, e.g. zoom-out when flying

cinematic-paths



Luftrausers © 2014 Vlambeer

***physics-smoothing
target-focus / projected-focus
cue-focus***



Direction

Set up scene cues, context and progression





camera-path

Predefined progression path throughout the level



Wonder Boy © 1986 Sega

camera-path

camera-window*

* One-sided

static-forward-focus



Klonoa: Door to Phantomile © 1997
Namco

camera-path*

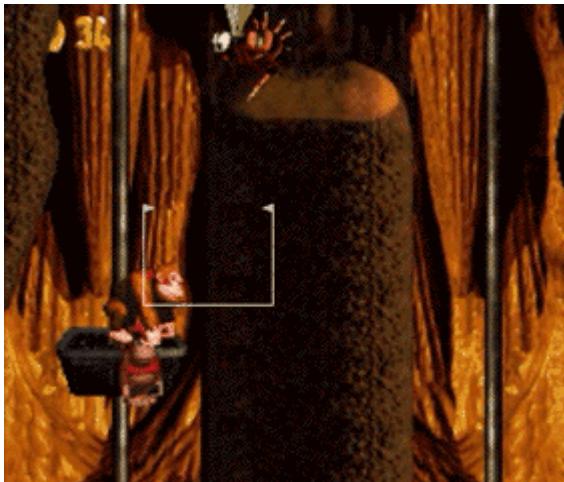
* Path hint, actually. Includes zooming and tilt.

camera-window (vert.)

lerp-smoothing
dual-forward-focus

region-based-anchors

Different levels (and regions within levels) set different anchors for position and focus



Donkey Kong Country © 1994
Nintendo (Rare Ltd)

region-based-anchors
position-locking (vert.)
lerp-smoothing
dual-forward-focus

zoom-to-fit

Change zoom (between min-max values) to provide a close-up view of relevant elements



Yoshi's Story © 1997 Nintendo (N64)

zoom-to-fit

dual-forward-focus

camera-window (vert.)

platform-snapping

manual-control



cue-focus

Focus is influenced by world cues. E.g. Attractors which pull the camera towards gameplay elements when in range.



Insanely Twisted Shadow Planet © 2011 Shadow Planet Productions
Footage from “Shadow Planet Productions Blog: ITSP Camera Explained”

cue-focus*

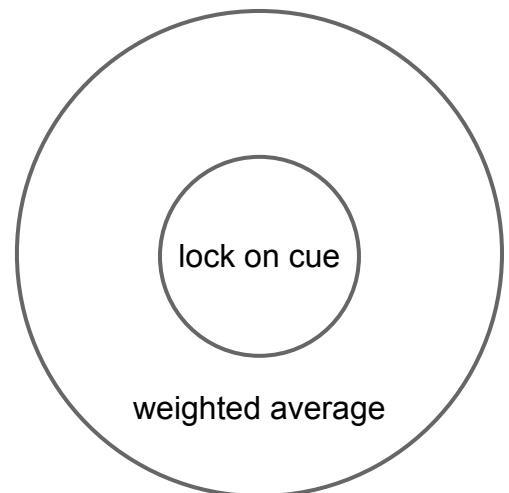
* Position and Zoom based on Double-Ring Attractors for various cues such as enemies and checkpoints

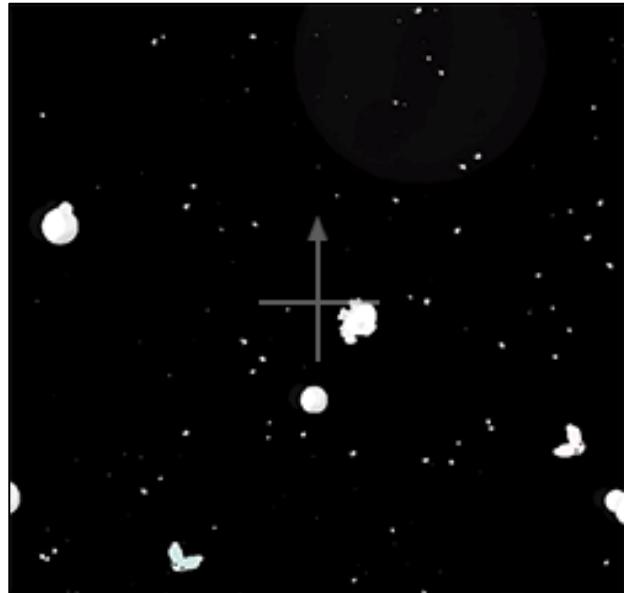
projected-focus

target-focus

physics-smoothing

Double-Ring attractors





Aether © 2008 Armor Games
(Edmund McMillen, Tyler Glaiel)

cue-focus*

* Camera orientation shifts with gravity

position-locking

lerp-smoothing



Limbo © 2010 Playdead

region-based-anchors*

* Zoom, position (and exposure)

position-locking*

* Changes per region

cue-focus*

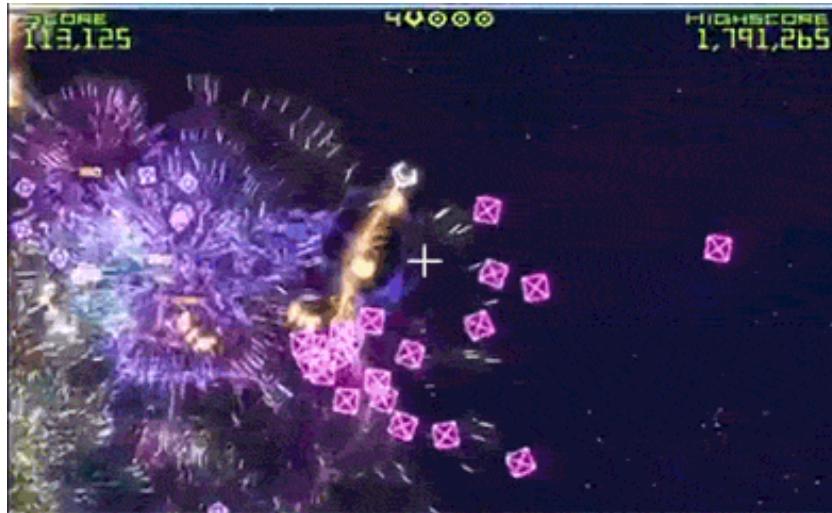
* Certain actions trigger cues, e.g.
enemy attack, etc.

physics-smoothing



region-focus

Focus on a region anchor (e.g. center of region), combined with player's position



Geometry Wars © 2003 Bizarre Creations

region-focus*

* Camera position is the average of the ship and the center of the field



Vessel © 2012 Strange Loop Games

region-focus*

* Camera position is based mostly on the region anchor point, but shifts slightly as the player moves

region-based-anchors*

* Different regions provide different anchor positions and zoom factors

cue-focus

physics-smoothing
cinematic-paths

gesture-cues

Certain gameplay behaviors cue camera gestures



Tomba! © 1997 Whoopee Camp

gesture-cues*

* Camera shifts to positions reflecting gestures and states

dual-forward-focus (horiz.)

platform-snapping

camera-window (vert.)



Aztez © [Release TBA] Team Colorblind

gesture-cues*

* Zooming and tilting

position-locking (vert.)

lerp-smoothing

zoom-to-fit



cinematic-paths

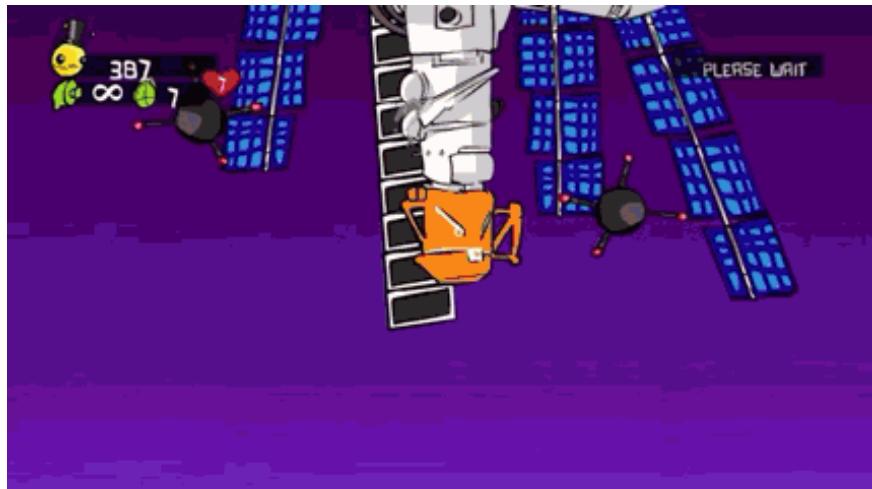
Using game camera to provide an out-of-screen narrative context



Streets of Rage © 1991 Sega

***region-based-anchors
cinematic-paths
camera-window****

* Standard brawler behavior: One-sided camera-window, effective between fights only



Alien Hominid © 2004 The Behemoth

***region-based-anchors
cinematic-paths
camera-window****

* Standard brawler behavior: One-sided camera-window, effective between fights only



Multi-focal Camera

Focusing on multiple objects





position-averaging

Focus on the average position



Gauntlet © 1985 Atari Games

position-averaging



Samurai Gunn © 2013 Teknopants

***position-averaging
lerp-smoothing***



Street Fighter © 1987 Capcom

camera-window

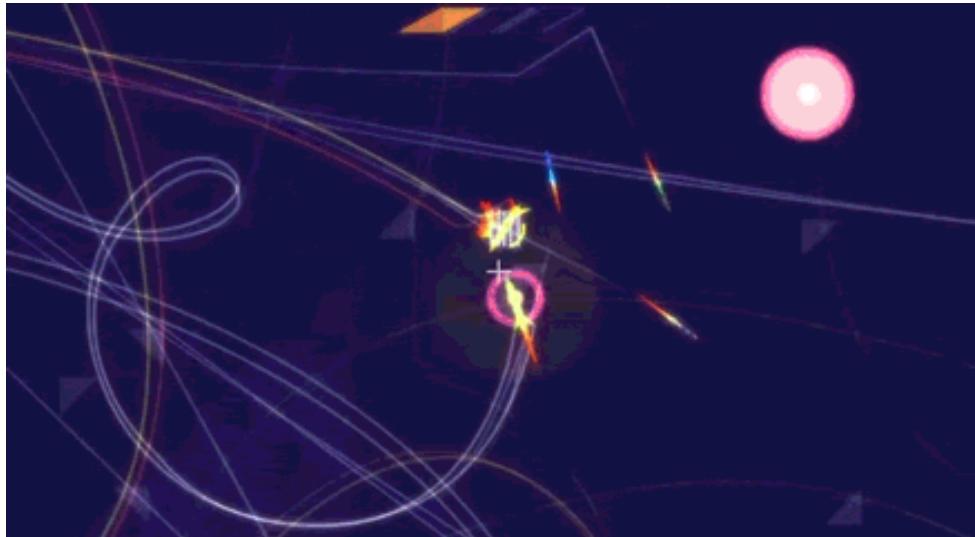
zoom-to-fit

Change zoom (between min-max values) to provide a close-up view of relevant elements



Super Smash Bros. © 1999 Nintendo (HAL Laboratory)

zoom-to-fit
position-averaging*
* Technically look-to position
lerp-smoothing



ROCKETSROCKETSROCKETS © 2014 Radial Games

zoom-to-fit*

* Encourage close encounters

position-averaging



Selected player focus

Solve opposing directions by focusing on one player at a time



***position-locking
lerp-smoothing
[manual-control*]***

* Up/Down for extended vert. look

Spelunky © 2008-2012
Mossmouth (Derek Yu)



Never Alone © 2014
Upper One Games

physics-smoothing
position-averaging
cinematic-paths
region-based-anchors
cue-focus



Manual Control

Providing additional camera control to the player





Super Mario World © 1990 Nintendo

camera-window (vert.)
platform-snapping**

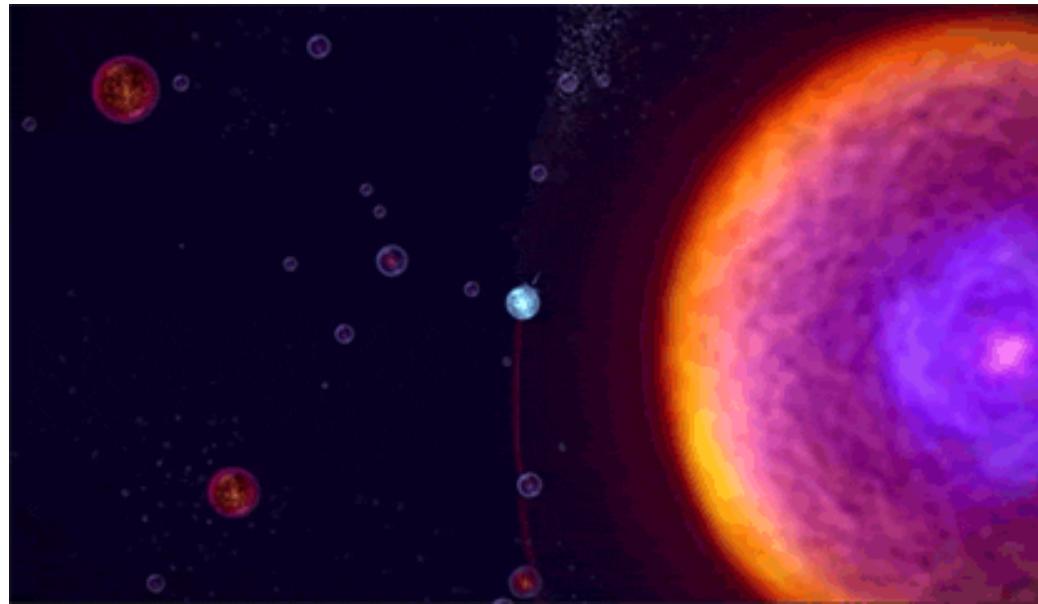
* Where applicable

***region-based-anchors
dual-forward-focus****

* Threshold triggered

manual-control*

* Controller provides extra panning



Osmos © 2009 Hemisphere Games

***position-locking
manual-control****

Mouse-wheel / multi-touch pinch to change zoom



Jazz Jackrabbit 2 © 1998 Epic Games

lerp-smoothing (vert.)

target-focus*

* Stick/cursor-keys push the focus point in the desired direction

[manual-control*]

* Manual extended look = *target-focus*



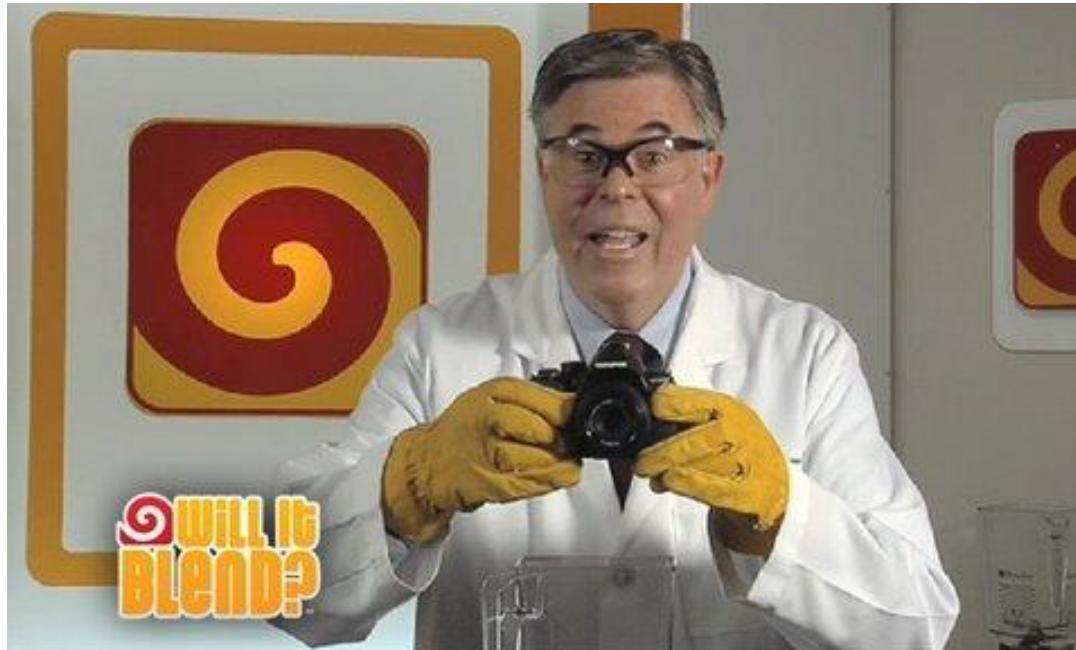
Spelunky © 2008-2012
Mossmouth (Derek Yu)

*position-locking
lerp-smoothing
[manual-control*]*
* Up/Down for extended vert. look



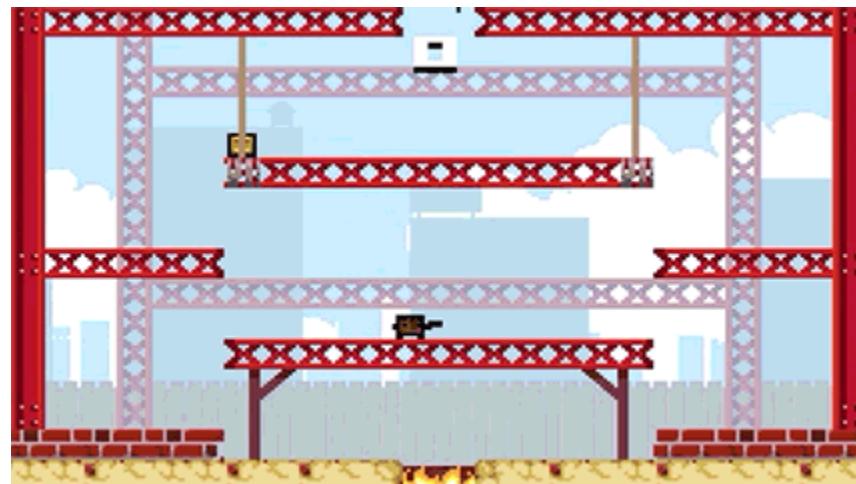
Camera Shake

All control is lost





Mario Bros. © 1983 Nintendo



Super Crate Box © 2010 Vlambeer



Custom-Made Camera

Putting it all together: Tailoring the camera to your game





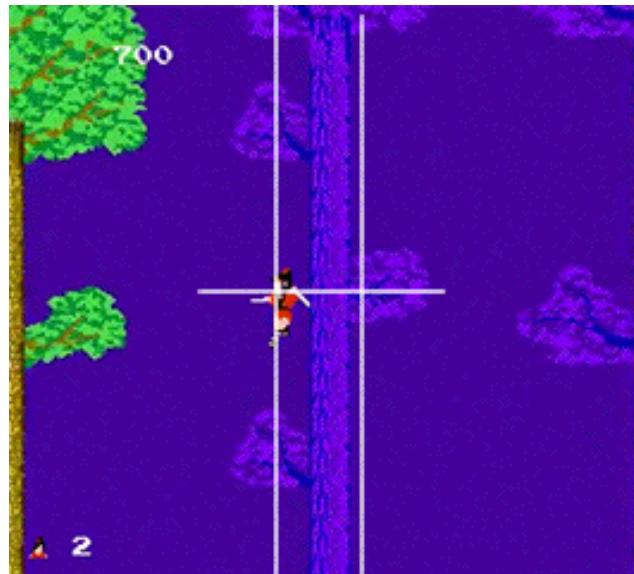
Better Camera

- Find the unique and significant characteristics of your game
- Get inspired by other games facing similar challenges
- Make it your own



Rapid direction changes?

Consider a horizontal camera window.



The Legend of Kage © 1985 Taito

position-locking (vert.)
camera-window* (horiz.)

* Window size based on gameplay features



Quick, high jumps?

Consider a vertical camera window + snapping / smoothing.



Shinobi © 1987 Sega

position-snapping (vert.)
camera-window (vert.)
position-locking (horiz.)
static-forward-focus

Multi-direction, fast moving character?

Consider centering it with a narrow window.



Sonic the Hedgehog © 1991 Sega

***platform-snapping
camera-window
static-forward-focus
manual-control***



... But ease-in the camera before hitting the edge.



Sonic the Hedgehog 2 © 1992 Sega

***platform-snapping
camera-window
speedup-push-zone****

* Each quadrant serves as a smoothing zone

***forward-focus
manual-control***



Long distance view required?

Consider a slow progressing dual-forward-focus.



position-locking (vert.)
dual-forward-focus
physics-smoothing
manual-control*

* Controller provides extra up/down panning



Where's the action?

Frame it using the appropriate camera technique.



Fez © 2012 Polytron Corporation

camera-window* (horiz.)

* Enforced even during dimension shifts

position-locking (vert.)

lerp-smoothing



Elaborate puzzle systems?

The character is just one piece in the puzzle - frame camera around all elements of importance



Vessel © 2012 Strange Loop Games

region-focus*

* Camera position is based mostly on the region anchor point, but shifts slightly as the player moves

region-based-anchors*

* Different regions provide different anchor positions and zoom factors

cue-focus

physics-smoothing
cinematic-paths



Telling a story?

Keep storytelling within the frame, providing context, direction and suspense.



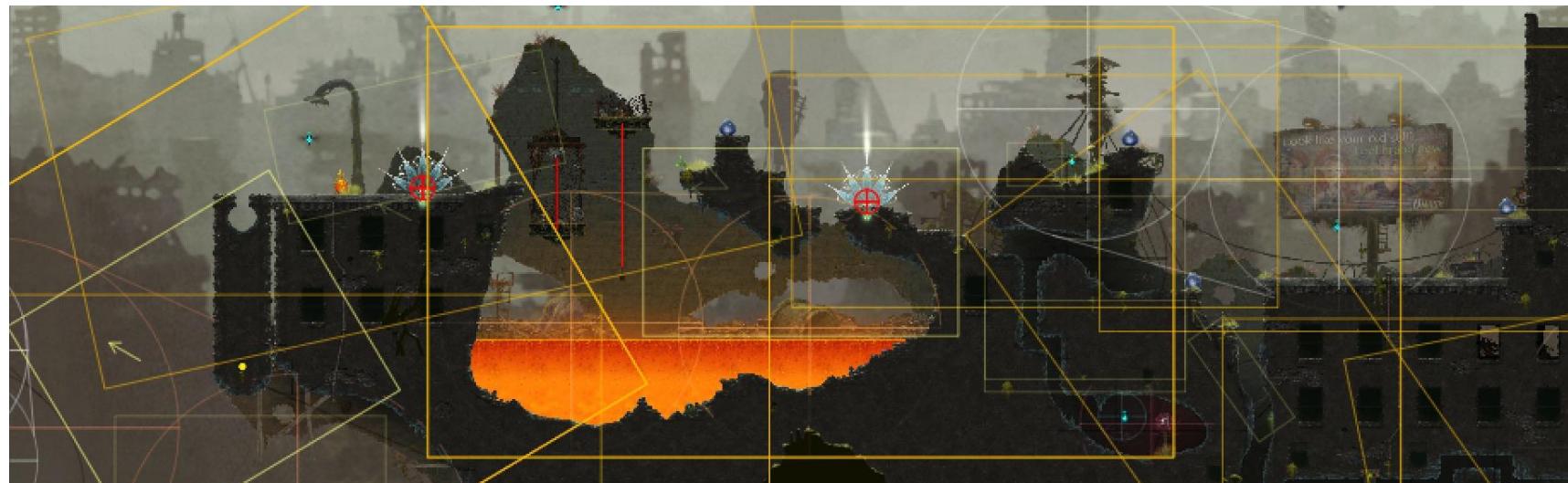
The Swapper © 2013 Facepalm Games

target-focus
physics-smoothing
region-based-anchors
cue-focus
cinematic-paths



GDC

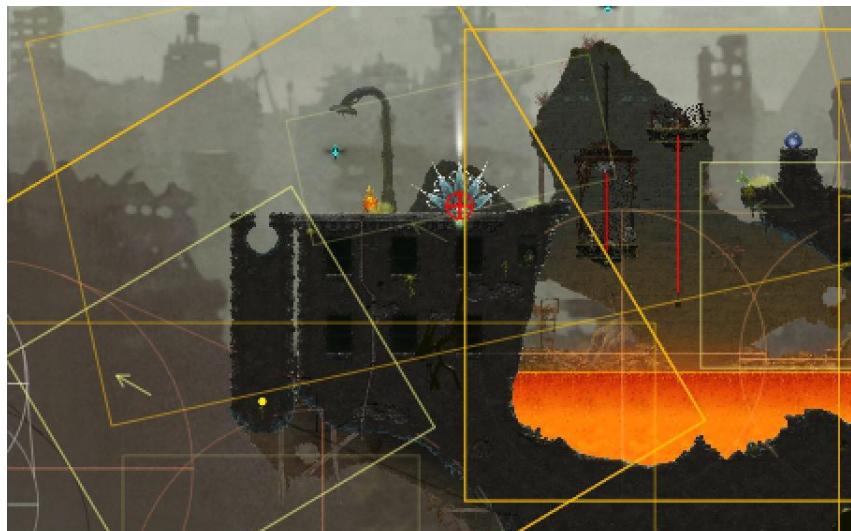
MUSHROOM 11



Mushroom 11 © [Release TBA] Untame

Multiple regions per level

Each region has a preset rectangular path and zoom factor (FOV)



region-based-anchors*

* Preset rectangular path and zoom per region

position-averaging*

static-forward-focus*

* In applicable regions only

cue-focus*

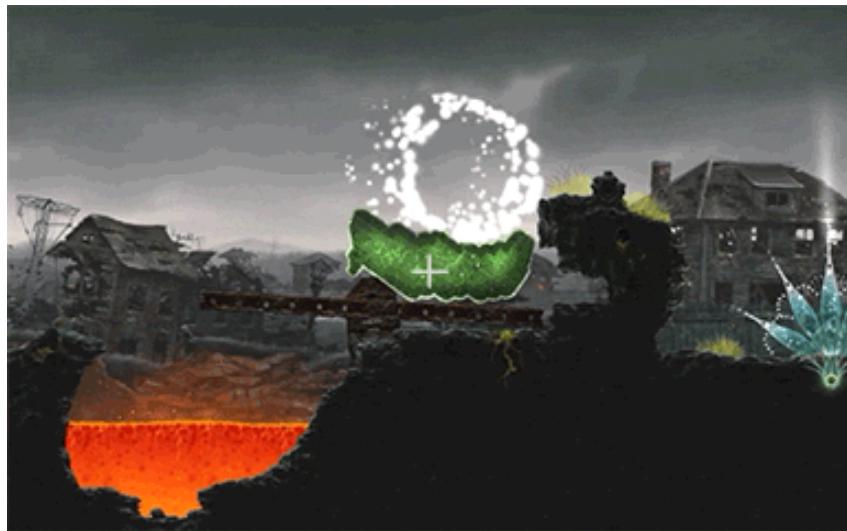
projected-focus

physics-smoothing*

* Speed based smoothing-factor

Regions are ordered

Camera is controlled by the mushroom piece(s)
in the highest numbered region



Mushroom 11 © [Release TBA] Untame

region-based-anchors*

* Preset rectangular path and zoom per region

position-averaging*

static-forward-focus*

* In applicable regions only

cue-focus*

projected-focus

physics-smoothing*

* Speed based smoothing-factor

[Active camera borders]

Region type 1: Center-oriented

Focus on the average position of *all cells* (weighted average of all center-of-mass positions)



region-based-anchors*

* Preset rectangular path and zoom per region

position-averaging*

static-forward-focus*

* In applicable regions only

cue-focus*

projected-focus

physics-smoothing*

* Speed based smoothing-factor

Region type 2: Progression-oriented

Focus on most progressed mushroom (according to the defined progression path), and add extra *static-forward-focus* distance



region-based-anchors*

* Preset rectangular path and zoom per region

position-averaging*

static-forward-focus*

* In applicable regions only

cue-focus*

projected-focus

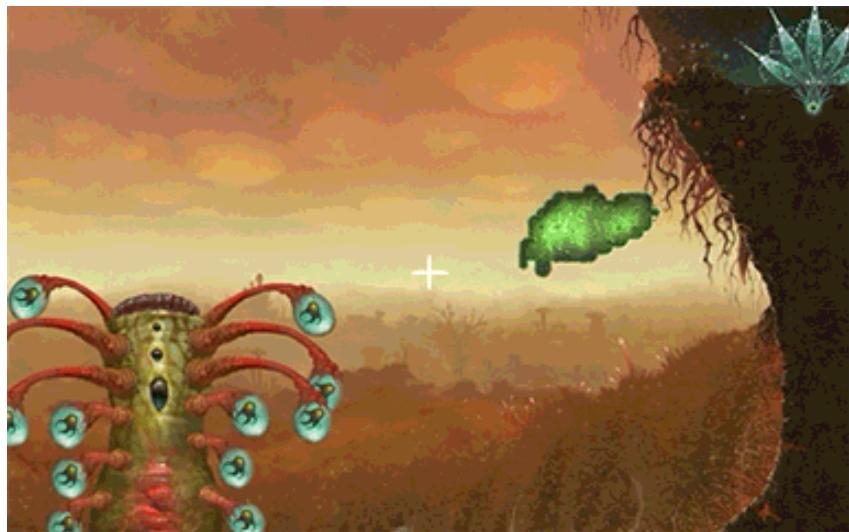
physics-smoothing*

* Speed based smoothing-factor

Mushroom 11 © [Release TBA] Untame

Cues

Certain objects and creatures serve as camera attractors, with specified/dynamic attraction factor



Mushroom 11 © [Release TBA] Untame

region-based-anchors*

* Preset rectangular path and zoom per region

position-averaging*

static-forward-focus*

* In applicable regions only

cue-focus*

projected-focus

physics-smoothing*

* Speed based smoothing-factor

Smoothing

physics-smoothing with smoothing factor based on the velocity of the mushroom, and *projected-focus* to anticipate its motion



region-based-anchors*

* Preset rectangular path and zoom per region

position-averaging*

static-forward-focus*

* In applicable regions only

cue-focus*

projected-focus

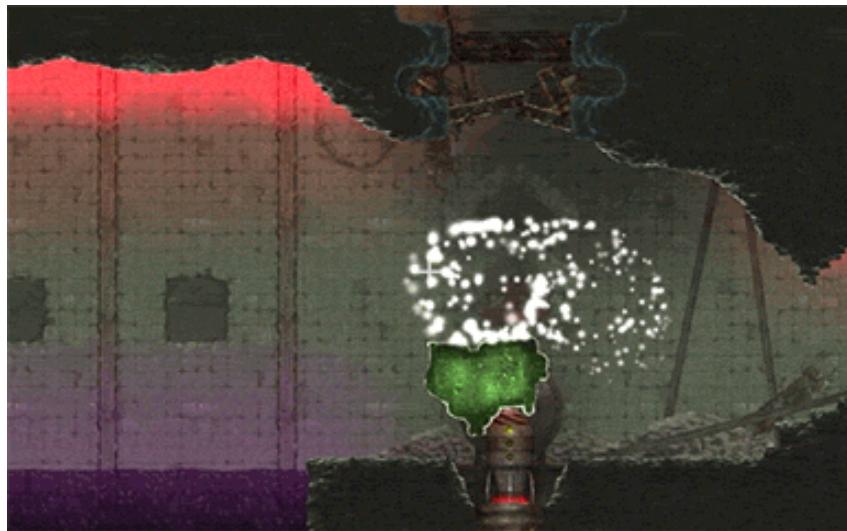
physics-smoothing*

* Speed based smoothing-factor

Mushroom 11 © [Release TBA] Untame

Putting it all together

Handle mushrooms in multiples sizes and velocities across multiple regions



region-based-anchors*

* Preset rectangular path and zoom per region

position-averaging*

static-forward-focus*

* In applicable regions only

cue-focus*

projected-focus

physics-smoothing*

* Speed based smoothing-factor

Mushroom 11 © [Release TBA] Untame

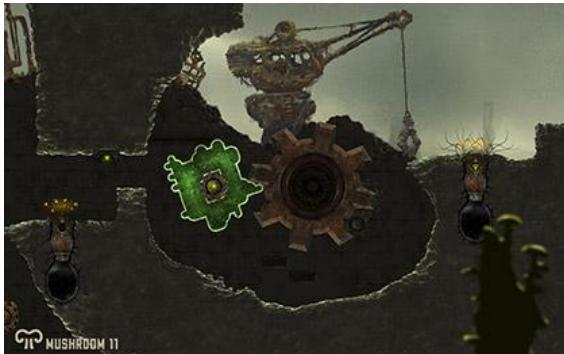


Thank You

Glossary, GIFs and source code will be posted on my blog: itaykeren.tumblr.com

Itay Keren

 itay@untame.com
 @itayke



mushroom11.com