Affordable Off-The-Shelf Augmented Reality in Python

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http://thp.io/2013/europython/

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About Me

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Hardware

- **PS Move Motion Controller**
  - USB (pairing, charging) and Bluetooth
  - Accelerometer, Gyroscope, Magnetometer
  - Glowing RGB ball, 8 digital buttons, 1 analog trigger

- **PS Eye Camera**
  - USB 2.0, 4 microphones (not used here)
  - 640x480 @ 60 FPS, 320x240 @ 120 FPS

6DoF (six degrees of freedom)

- **3-axis position**
  - tracked with OpenCV via camera, sphere
- **3-axis rotation**
  - tracked with AHRS algorithm via inertial sensors

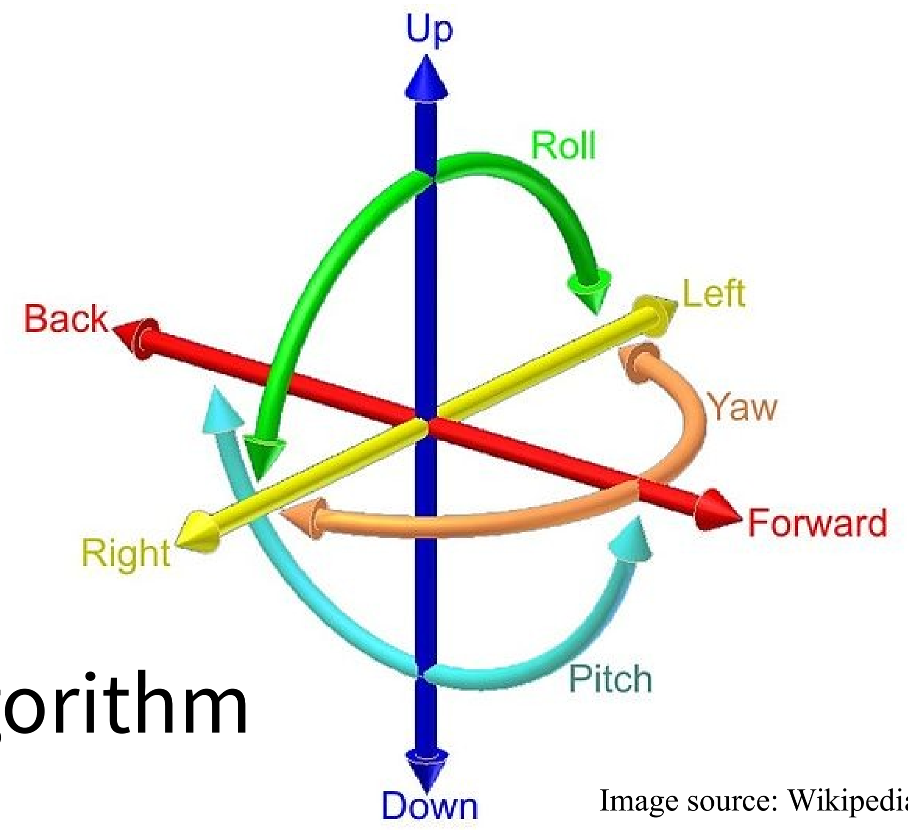
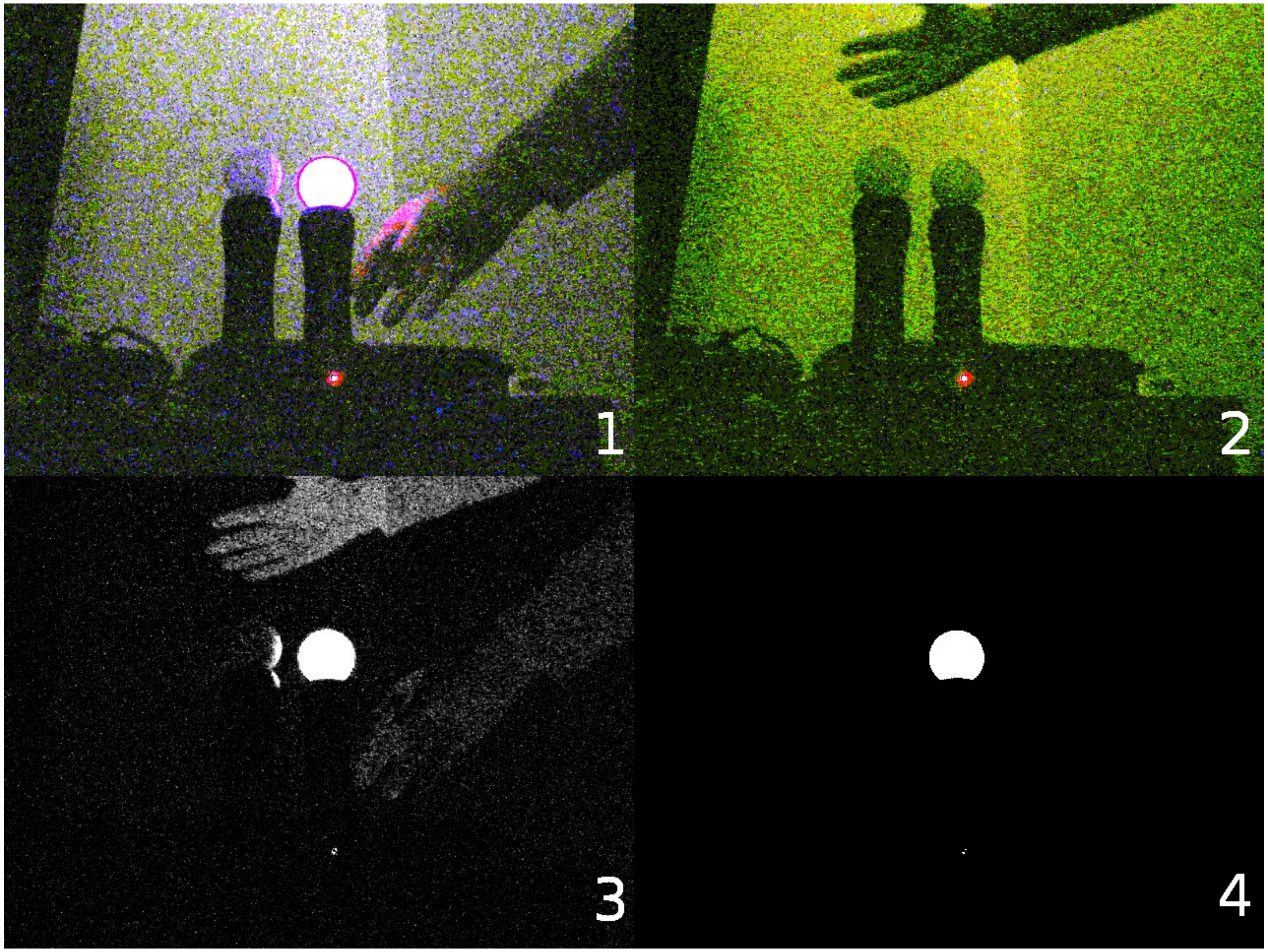


Image source: Wikipedia

Tracking Algorithm (1/2)



“Blinking Calibration”

1: LEDs on

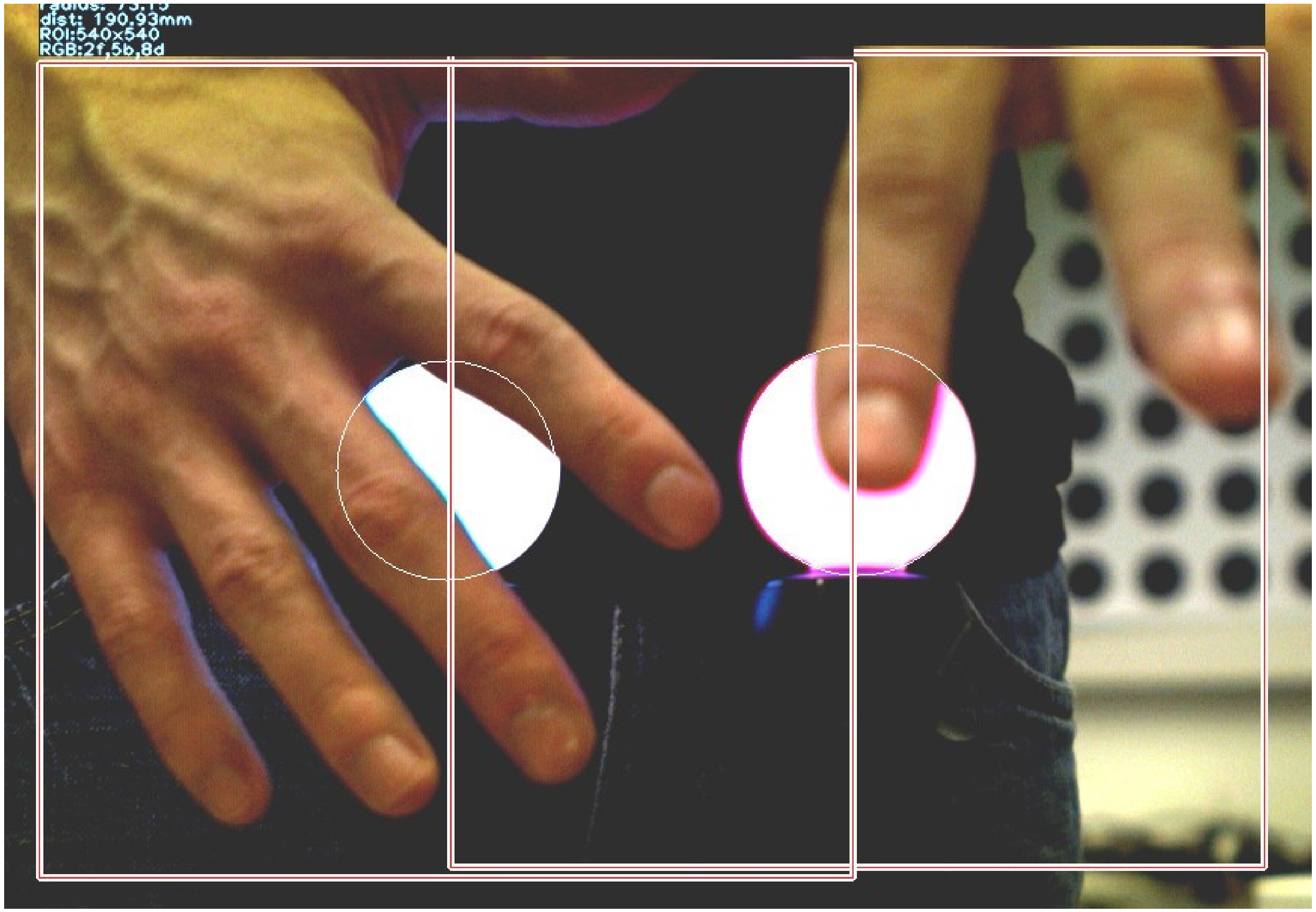
2: LEDs off

3: Difference image

4: Thresholded diff

Use 4 as mask for 1, average color of biggest blob = color of sphere in camera

Tracking Algorithm (2/2)



Sphere Size Calculation

Find the two points A, B in the blob with the maximum distance

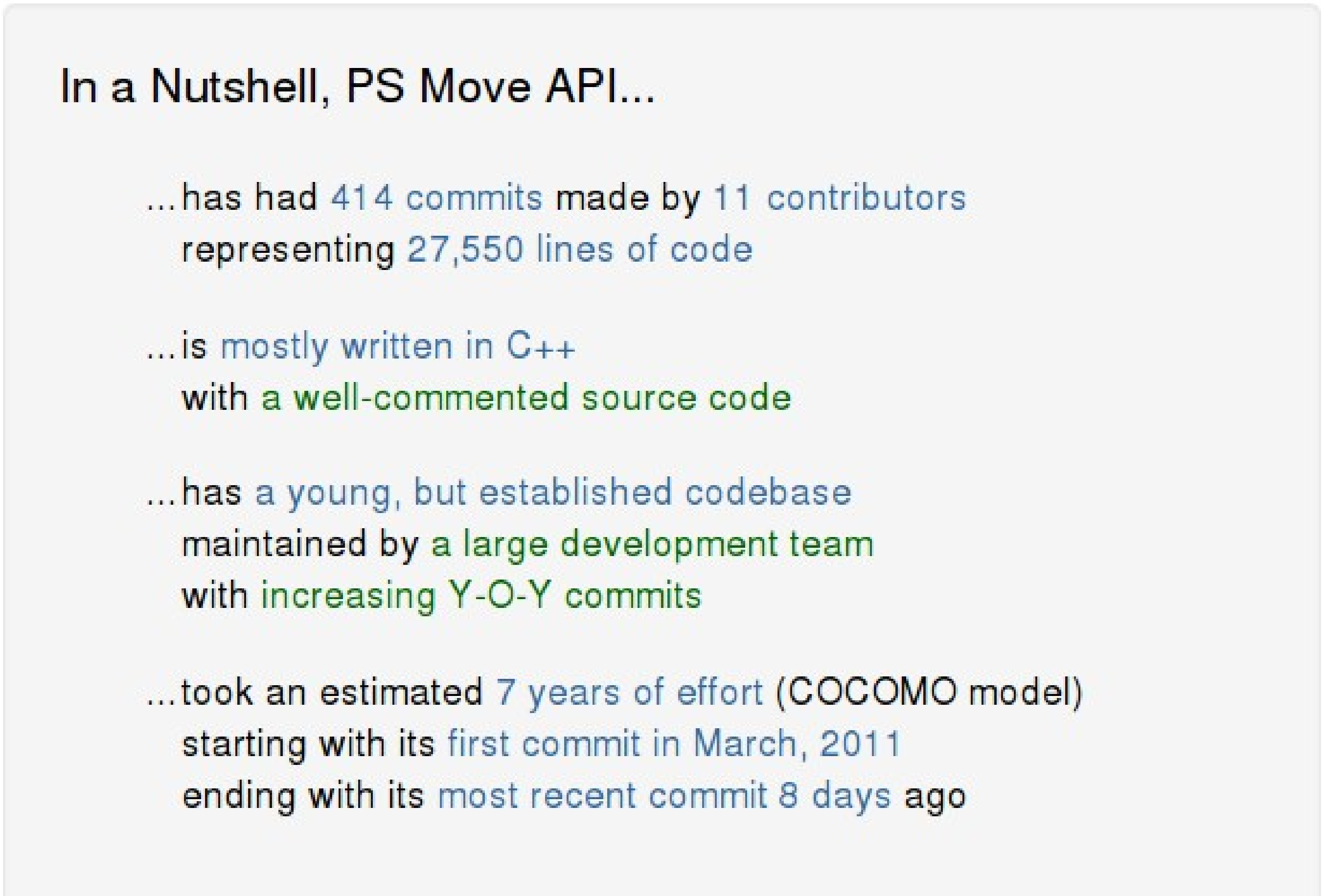
Line from A to B

Center of sphere: Center of Line

Diameter of sphere: Length of Line

Implementation

- **C library** (PS Move API) + **Bindings** (Python, ...)
- **Cross-platform** availability


In a Nutshell, PS Move API...

...has had 414 commits made by 11 contributors
representing 27,550 lines of code

...is mostly written in C++
with a well-commented source code

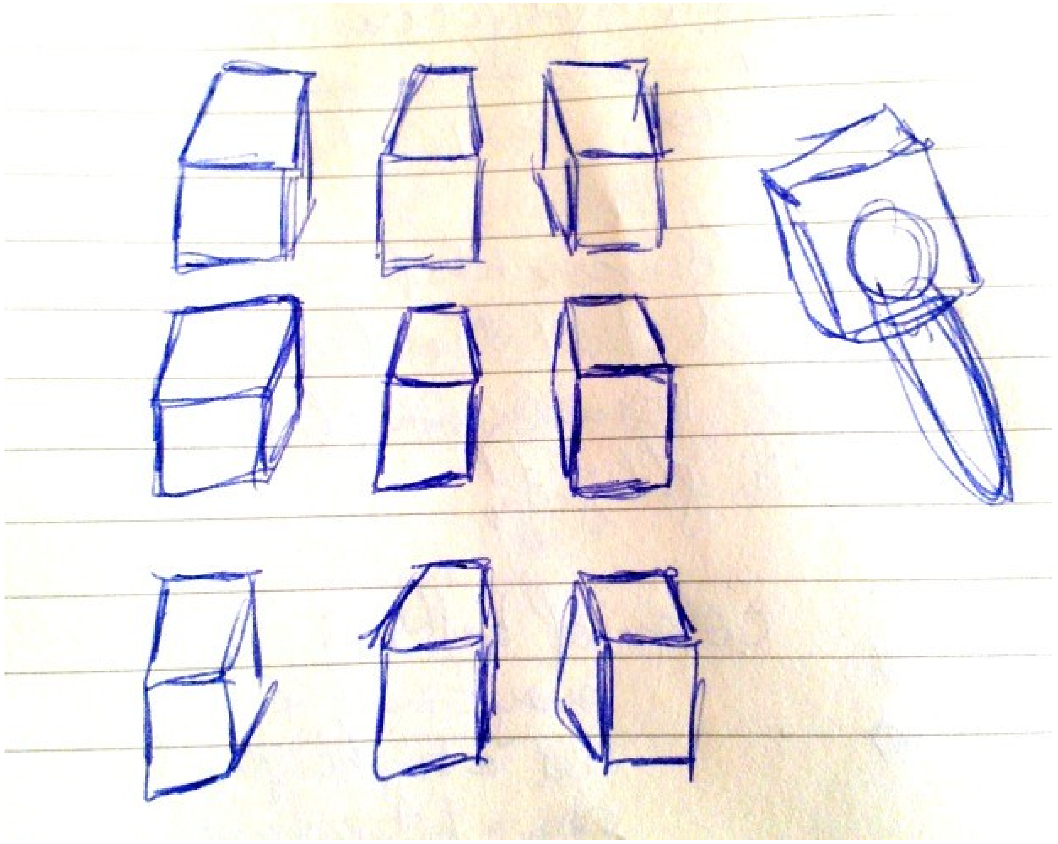
...has a young, but established codebase
maintained by a large development team
with increasing Y-O-Y commits

...took an estimated 7 years of effort (COCOMO model)
starting with its first commit in March, 2011
ending with its most recent commit 8 days ago

Hands-On

How to use the API in Python

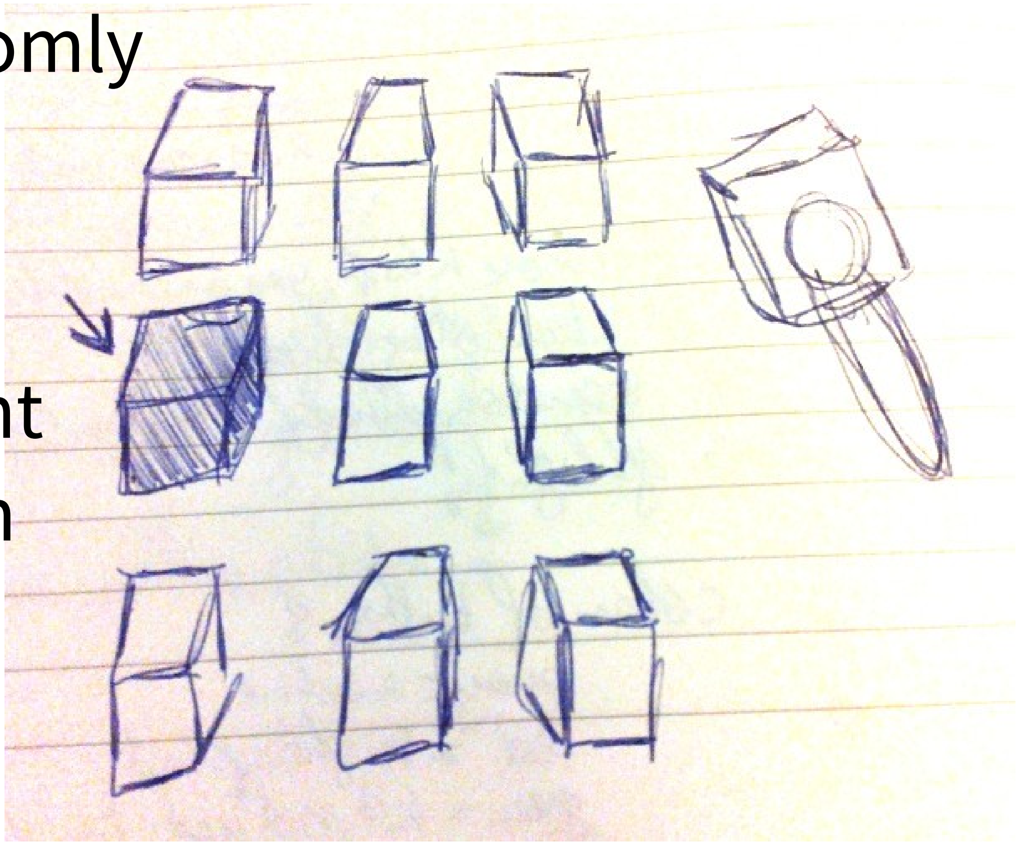
Let's write an AR game in Python



- **“Whack a cube”**
  - Grid of 3x3 cubes floating in space
  - Cubes light up randomly, hit to score

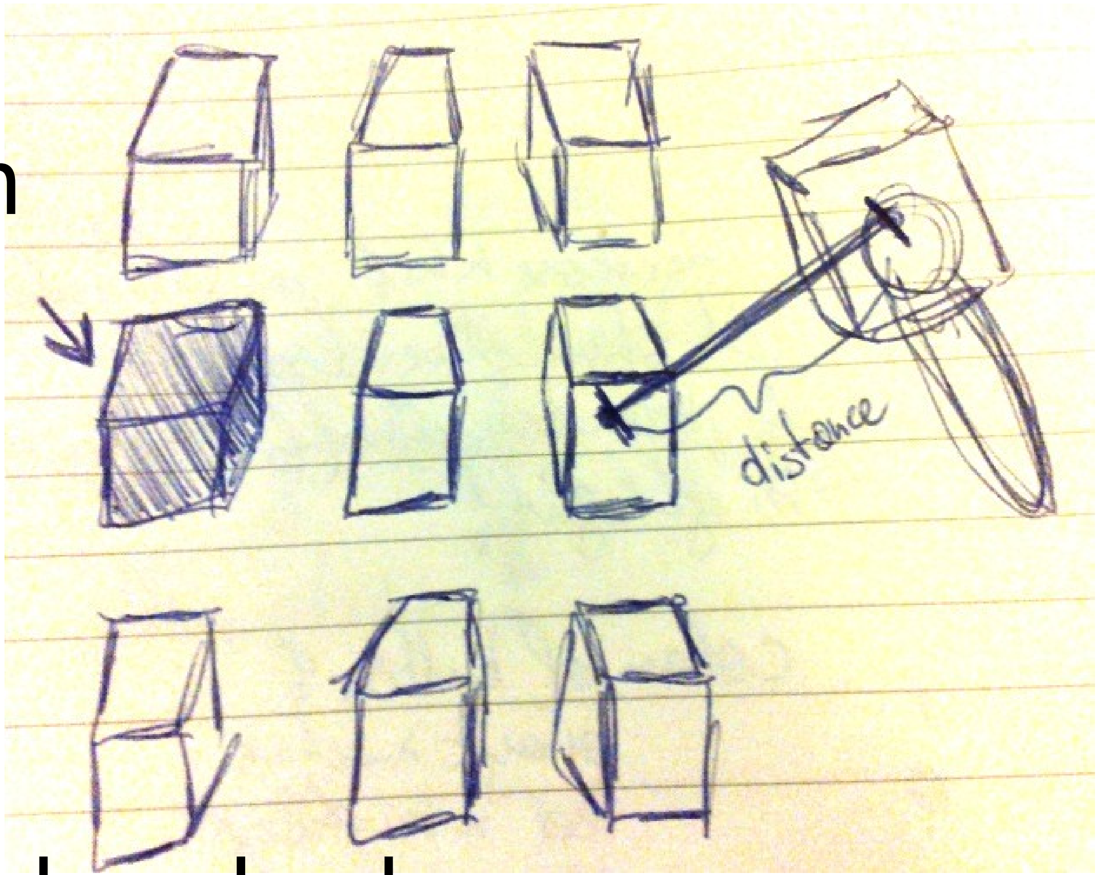
Whack a cube: Design (1/2)

- Highlight happens randomly
- Maximum number of highlighted cubes
- Timeout (before highlight disappears) also random
- Minimum time between two consecutive hits



Whack a cube: Design (2/2)

- Collision detection using distance
- Time split into "ticks" (20 ms)
- Rendering:
  Camera image + colored cube



Whack a cube: Implementation

- Focus on API usage and AR, not visuals
- **Button**: “Whackable cube”
  - Highlight state, position, hit handling
- **Highlighter**: Picks button for highlight
  - Also takes care of maximum highlights

3D Rendering

- Model-View Matrix: **Controller** (6DoF)
- Projection Matrix: **Camera** Projection

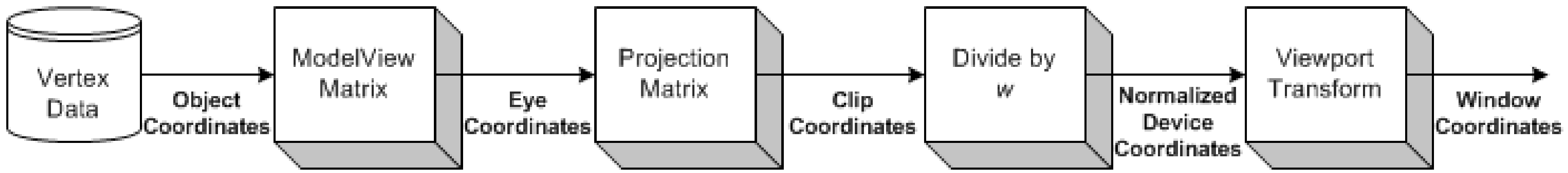


Image source: songho.ca

- Placing objects on the controller sphere
  - Object at origin (x=0, y=0, z=0)
  - Apply Model-View Matrix

OpenGL Shader Pipeline (1/2)

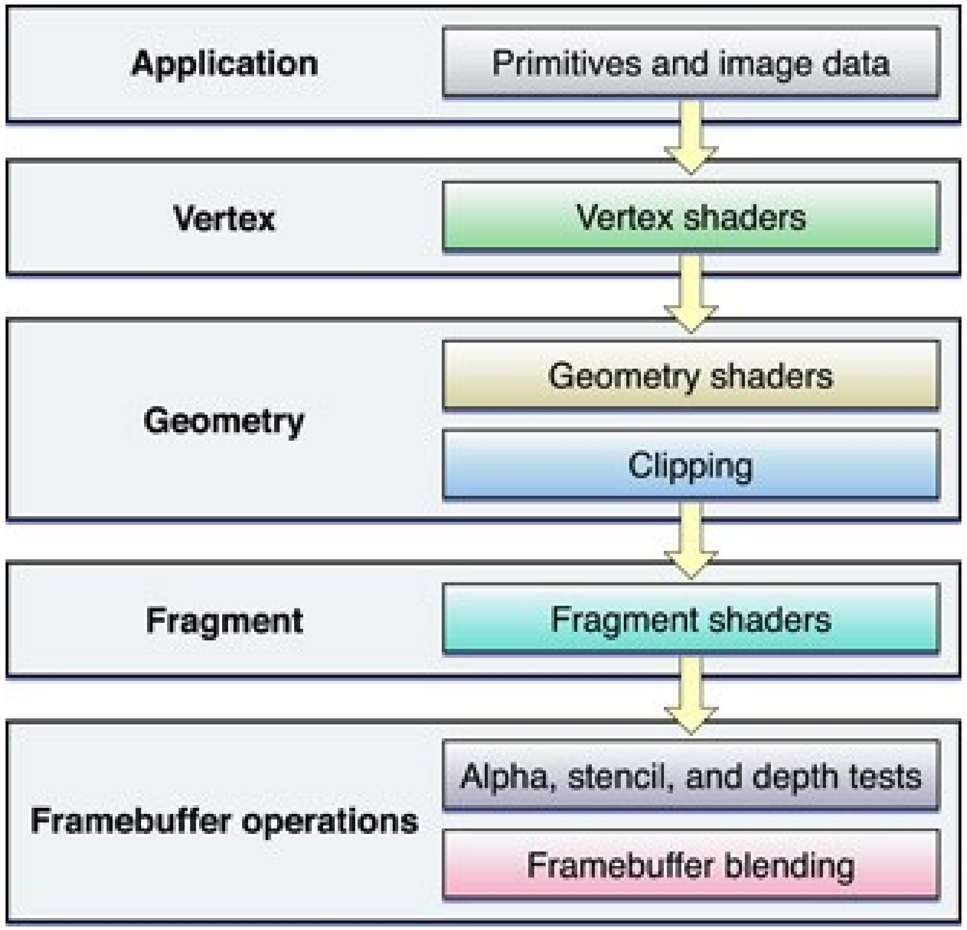


Image source: developer..apple.com

OpenGL Shader Pipeline (2/2)

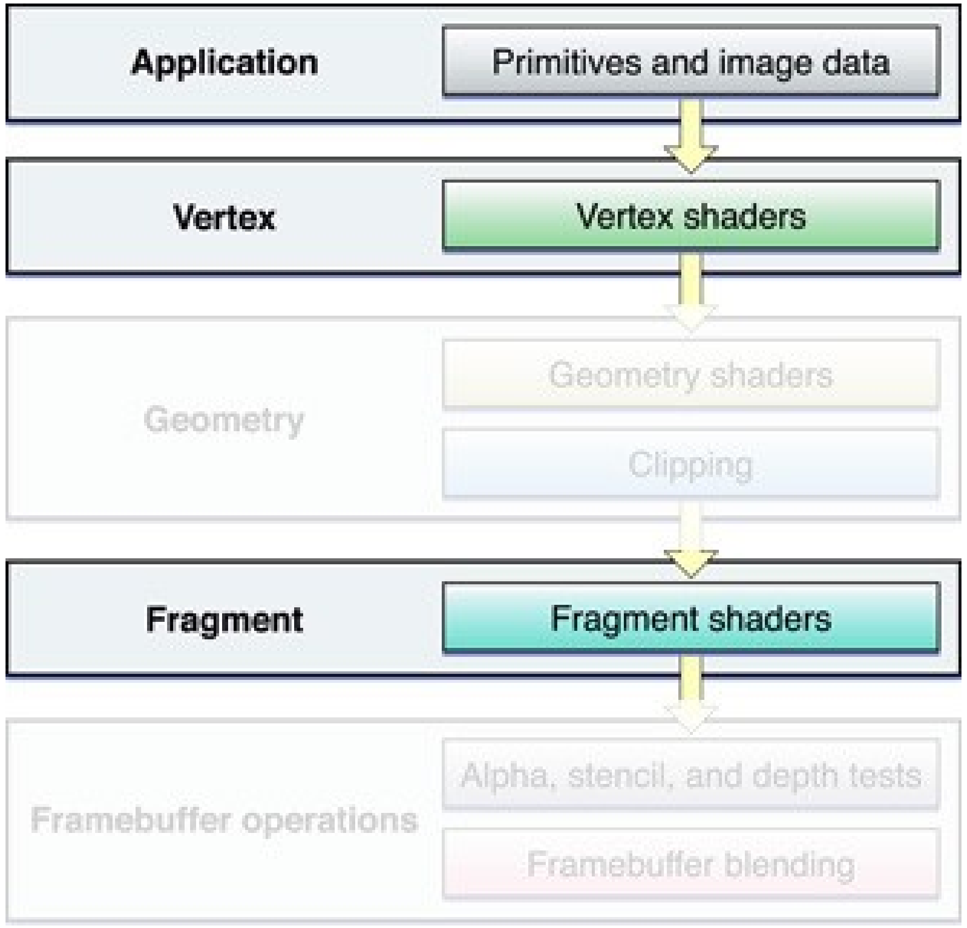


Image source: developer..apple.com

Hands-On

Whack a cube

Performance

- Vision Tracker Frame Rate (tracking 1 controller)
  - ~ **50 - 68 FPS**
- End-to-End System Latency
  - Initially: **60 ms (+/- 3 ms)**
  - While tracking is in progress: **~ 15 ms**
- Maximum Sensor Update Rate:
  - **~ 87 updates / second** (hardware limit)

More Info

http://thp.io/2013/europython/

Project

http://thp.io/2010/psmove/

http://code.google.com/p/moveonpc/

Thesis

http://thp.io/2012/thesis/

Google Summer of Code 2012