ARKit notes

ARSCNView

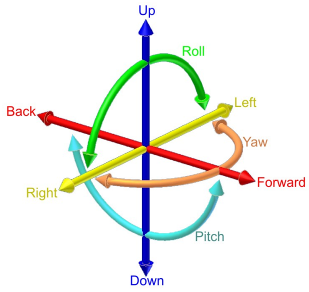
A view for displaying AR experiences that augment the camera view with 3D SceneKit content.

- The world **coordinate system** of the view's SceneKit scene directly **responds** to the **AR world coordinate system** established by the session configuration.
- The view automatically moves its SceneKit camera to match the real-world movement of the device.

=> placing object to real world requires only SceneKit position

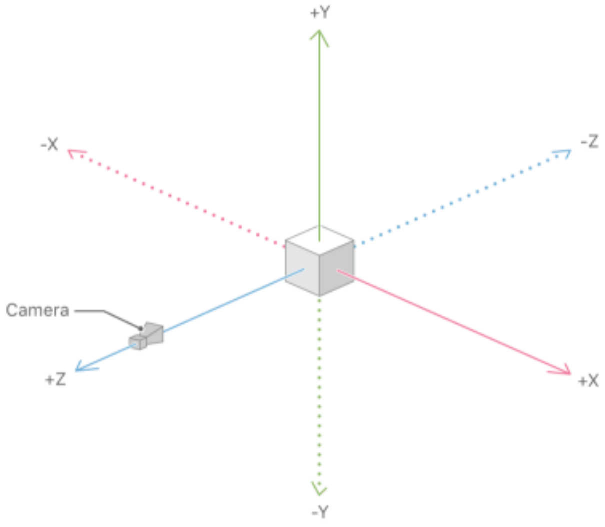
ARWorldTrackingSessionConfiguration

- tells ARSession we want **six degrees of freedom**



- (ARSessionConfiguration if user still)

- ARKit and SceneKit coordinate system
  - camera faces in the negative Z direction



SCNScene

A scene graph—a hierarchy of nodes with attached geometries, lights, cameras and other attributes that together form a displayable 3D scene.

Lights

`var lightingEnvironment: SCNMaterialProperty`

A **cube map texture** that depicts the environment surrounding the scene’s contents, used for advanced lighting effects.

- official tops
  - For realistic results, reuse the same contents for both the lighting environment and the `background` property.

Fog

- could be useful for simulating different environment
- all of them are **Animatable**

```
var fogStartDistance: CGFloat
var fogEndDistance: CGFloat
var fogDensityExponent: CGFloat
var fogColor: Any
```

Particle Systems

A **particle system** is a technique in game physics, motion graphics, and computer graphics that uses a large number of very small sprites, 3D models, or other graphic objects to simulate certain kinds of "fuzzy" phenomena

- **Physics**
- **Casts Shadow**

SCNNode

- important class for interposing objects into the scene

CI Filters

- tons of difital image processing tools

https://developer.apple.com/library/content/documentation/GraphicsImaging/Reference/CoreImageFilterReference/index.html

```
CIBoxBlur
CIDiscBlur
CIGaussianBlur
CIMaskedVariableBlur
CIMedianFilter
CIMotionBlur
CINoiseReduction
CIZoomBlur
```

Plane Detection

:tldr: SIFT (Scale Invariant Feature transform)

Problems

1. Poor lightning
2. Lack of texture
3. Fast movement
    - in terms of blurred images

- is neabled with `ARWorldTrackingConfiguration()` `planeDetection` flag
    - after we start getting callbacks to delegate methods for the ARSCNViewDelegate protocol
    - `func renderer(_ renderer: SCNSceneRenderer, didAdd | didUpdate node: SCNNode, for anchor: ARAnchor) {`
    - in these functions we handle planes

Development notes

- Storyboards have Dynamic cells by default therefor not visible anything after build
    - Set to Static

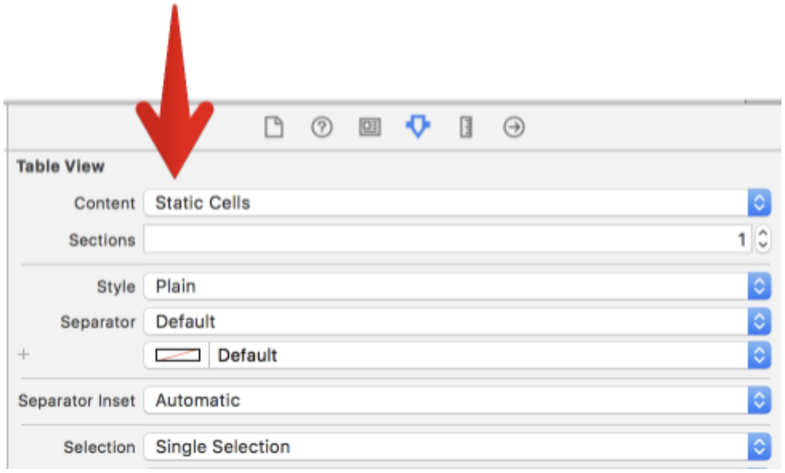


Table View

Content: Static Cells

Sections: 1

Style: Plain

Separator: Default

Default

Separator Inset: Automatic

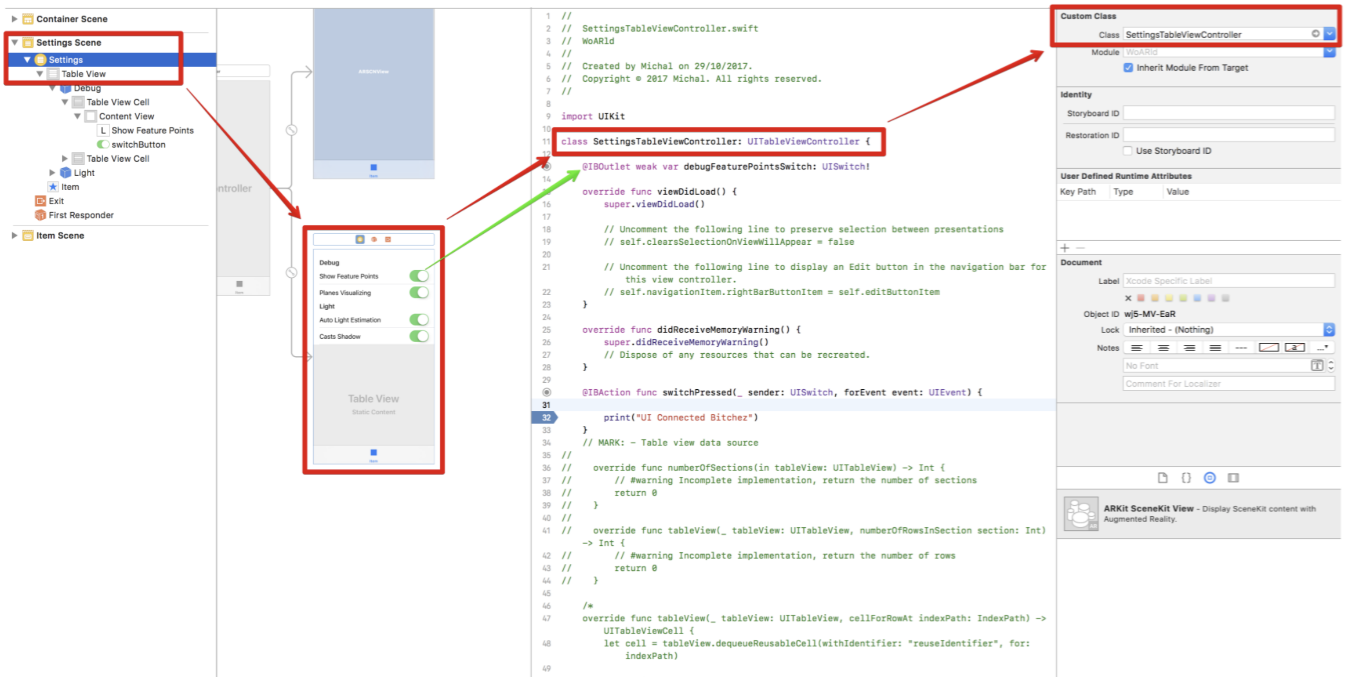
Selection: Single Selection

Data Management

1. Each scene should have own Controller

- keep in mind that `CustomClass` could be set only for “compatible” superclasses

- e.g. `UITabController` could these Custom Class which extends `UITableViewController`
- ❗ Only `ViewController` is not enough



```
//
//  SettingsTableViewController.swift
//  WoARld
//
//  Created by Michal on 29/10/2017.
//  Copyright © 2017 Michal. All rights reserved.
//

import UIKit

class SettingsTableViewController: UITableViewController {

    @IBOutlet weak var debugFeaturePointsSwitch: UISwitch!

    override func viewDidLoad() {
        super.viewDidLoad()

        // Uncomment the following line to preserve selection between presentations
        // self.clearsSelectionOnViewWillAppear = false

        // Uncomment the following line to display an Edit button in the navigation bar for this view controller.
        // self.navigationItem.rightBarButtonItem = self.editButtonItem
    }

    override func didReceiveMemoryWarning() {
        super.didReceiveMemoryWarning()
        // Dispose of any resources that can be recreated.
    }

    @IBAction func switchPressed(_ sender: UISwitch, forEvent event: UIEvent) {

        print("UI Connected Bitchez")
    }
    // MARK: - Table view data source
//
//    override func numberOfSections(in tableView: UITableView) -> Int {
//        // #warning Incomplete implementation, return the number of sections
//        return 0
//    }
//
//    override func tableView(_ tableView: UITableView, numberOfRowsInSection section: Int) -> Int {
//        // #warning Incomplete implementation, return the number of rows
//        return 0
//    }

    /*
    override func tableView(_ tableView: UITableView, cellForRowAt indexPath: IndexPath) -> UITableViewCell {
        let cell = tableView.dequeueReusableCell(withIdentifier: "reuseIdentifier", for: indexPath)

```

Custom Class

Class SettingsTableViewController

Module WoARld

☑ Inherit Module From Target

Identity

Storyboard ID

Restoration ID

□ Use Storyboard ID

User Defined Runtime Attributes

Key Path	Type	Value

Document

Label Xcode Specific Label

Object ID wj5-MV-EaR

Lock Inherited - (Nothing)

Notes

No Font

Comment For Localizer

ARKit SceneKit View - Display SceneKit content with Augmented Reality.

2. How to handle global state

- **global** struct is not such a bad idea
- in controllers other controllers could be references

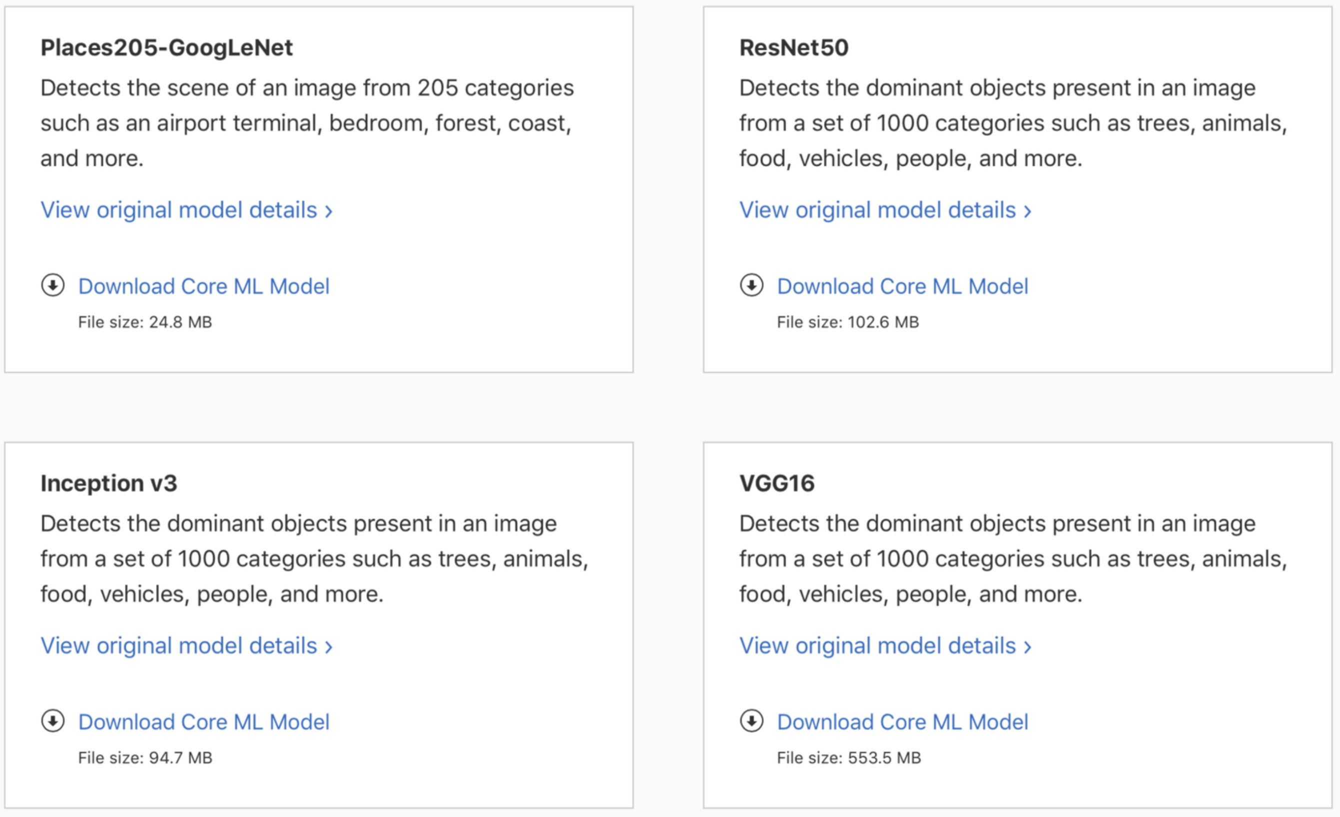
Machine Learning & Vision

https://developer.apple.com/documentation/vision

Vision framework

Apply high-performance image analysis and computer vision techniques to identify faces, detect features, and classify scenes in images and video.

- provides Models of pretrained sets
  - dominant objects recognition
    - Inception v3
    - ResNet
    - VGG16
  - places
    - places205-GoogLeNet



Places205-GoogLeNet

Detects the scene of an image from 205 categories such as an airport terminal, bedroom, forest, coast, and more.

View original model details ›

Download Core ML Model

File size: 24.8 MB

ResNet50

Detects the dominant objects present in an image from a set of 1000 categories such as trees, animals, food, vehicles, people, and more.

View original model details ›

Download Core ML Model

File size: 102.6 MB

Inception v3

Detects the dominant objects present in an image from a set of 1000 categories such as trees, animals, food, vehicles, people, and more.

View original model details ›

Download Core ML Model

File size: 94.7 MB

VGG16

Detects the dominant objects present in an image from a set of 1000 categories such as trees, animals, food, vehicles, people, and more.

View original model details ›

Download Core ML Model

File size: 553.5 MB

Labeling objects in scene

https://youtu.be/Sno-r2xQeRQ

Libraries coopeartion

Vuforia

- not supported yet
- according to official Vuforia docs in version 7 will come integration to ARKit
    - framework **Vuforia Fusion** *(a new capability designed to provide the best possible AR experience on a wide range of devices)*
    - source: https://www.vuforia.com/press-releases/ptc-announces-major-new-release-to-vuforia-augmented-reality-platform.html
- **developer licence?**

Kudan

- not so perspective future with ARKit

2017-10-30

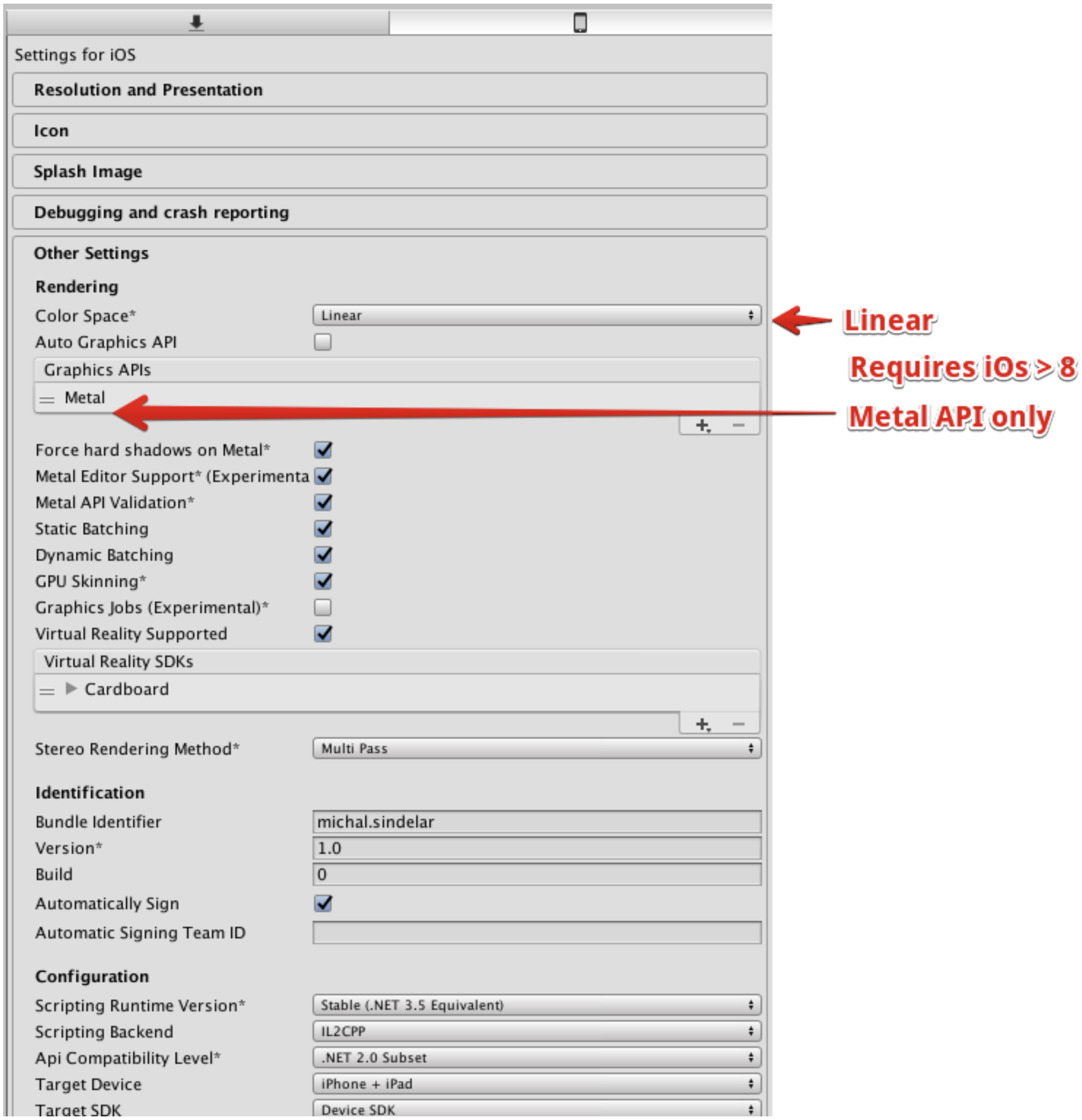
Future Notes

- orientation of planes investigate
- other libraries **(?)**
    - ...
- in case libraries not possible to use
    - detection of **markers**
        - https://github.com/likedan/Awesome-CoreML-Models
    - based on 4 corners based on perspective -> estimate position in scene
    - try opencv methods for position
        - compare with apple inside — calibration inside ARKit
- **aruco**
- light map
    - how to create?

Running extings Unity on iOS

Compilation problems 😡 -> Scene Ammends

Linear vs Gamma Color space



Settings for iOS

Resolution and Presentation

Icon

Splash Image

Debugging and crash reporting

Other Settings

Rendering

Color Space* Linear

Auto Graphics API ☐

Graphics APIs

Metal

Force hard shadows on Metal* ☑

Metal Editor Support* (Experimenta ☑

Metal API Validation* ☑

Static Batching ☑

Dynamic Batching ☑

GPU Skinning* ☑

Graphics Jobs (Experimental)* ☐

Virtual Reality Supported ☑

Virtual Reality SDKs

Cardboard

Stereo Rendering Method* Multi Pass

Identification

Bundle Identifier michal.sindelar

Version* 1.0

Build 0

Automatically Sign ☑

Automatic Signing Team ID

Configuration

Scripting Runtime Version* Stable (.NET 3.5 Equivalent)

Scripting Backend IL2CPP

Api Compatibility Level* .NET 2.0 Subset

Target Device iPhone + iPad

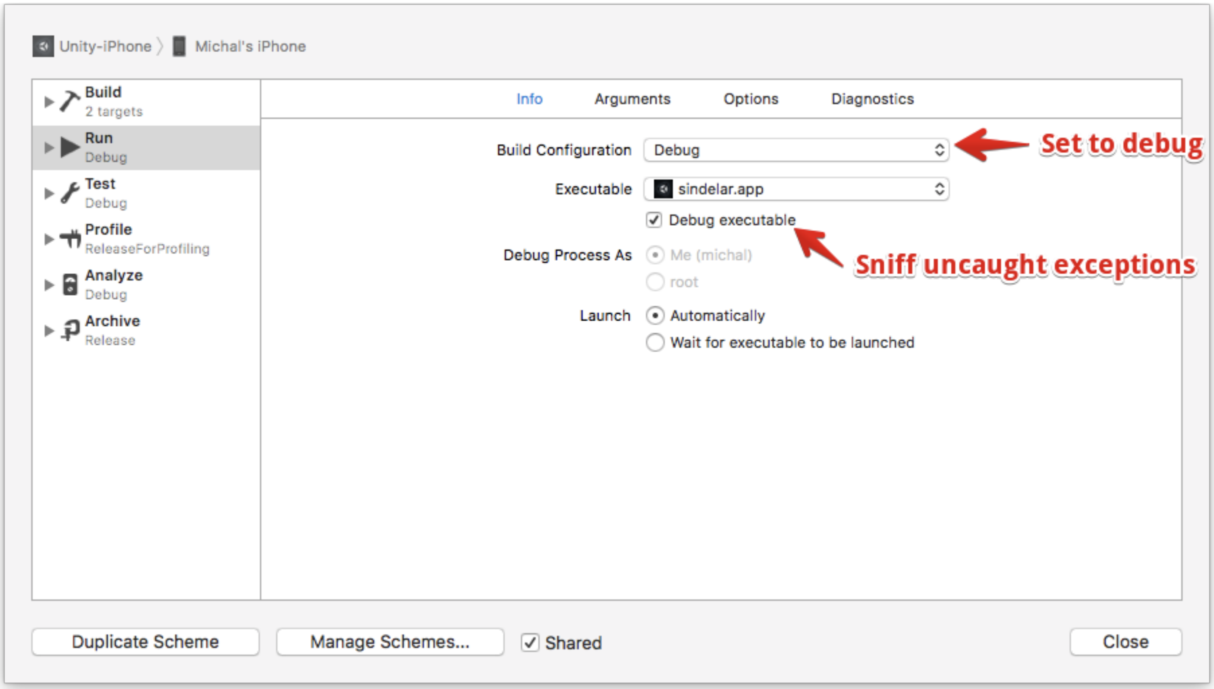
Target SDK Device SDK

Linear

Requires iOs > 8

Metal API only

Memory Issues



Build Configuration: Debug

Executable: sindelar.app

☑ Debug executable

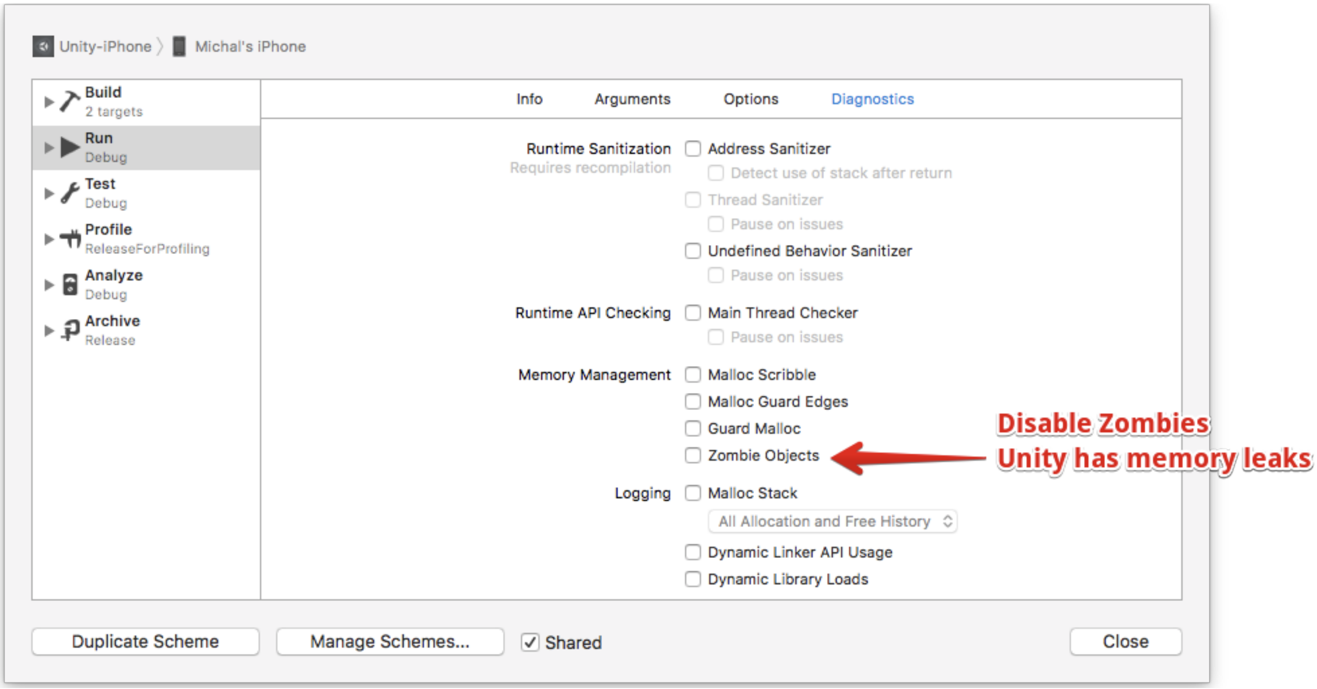
Debug Process As: ● Me (michal) ○ root

Launch: ● Automatically ○ Wait for executable to be launched

☑ Shared

Set to debug

Sniff uncaught exceptions



Runtime Sanitization (Requires recompilation): □ Address Sanitizer, □ Detect use of stack after return, □ Thread Sanitizer, □ Pause on issues, □ Undefined Behavior Sanitizer, □ Pause on issues

Runtime API Checking: □ Main Thread Checker, □ Pause on issues

Memory Management: □ Malloc Scribble, □ Malloc Guard Edges, □ Guard Malloc, □ Zombie Objects

Logging: □ Malloc Stack (All Allocation and Free History), □ Dynamic Linker API Usage, □ Dynamic Library Loads

☑ Shared

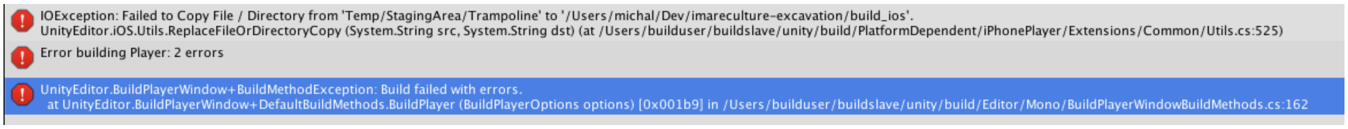
Disable Zombies
Unity has memory leaks

BuildPlayerWindowBuildMethods Exceptions in Unity

- try to reimport all Assets takes about an hour
- restart unity
- restart mac

IOExceptions

- flush all built files and create new folder 🤦‍♂️
- Player 2 Error without explanation



```
IOException: Failed to Copy File / Directory from 'Temp/StagingArea/Trampoline' to '/Users/michal/Dev/imareculture-excavation/build_ios'.
UnityEditor.iOS.Utils.ReplaceFileOrDirectoryCopy (System.String src, System.String dst) (at /Users/builduser/buildslave/unity/build/PlatformDependent/iPhonePlayer/Extensions/Common/Utils.cs:525)
Error building Player: 2 errors
UnityEditor.BuildPlayerWindow+BuildMethodException: Build failed with errors.
 at UnityEditor.BuildPlayerWindow+DefaultBuildMethods.BuildPlayer (BuildPlayerOptions options) [0x001b9] in /Users/builduser/buildslave/unity/build/Editor/Mono/BuildPlayerWindowBuildMethods.cs:162
```

Could not write to device

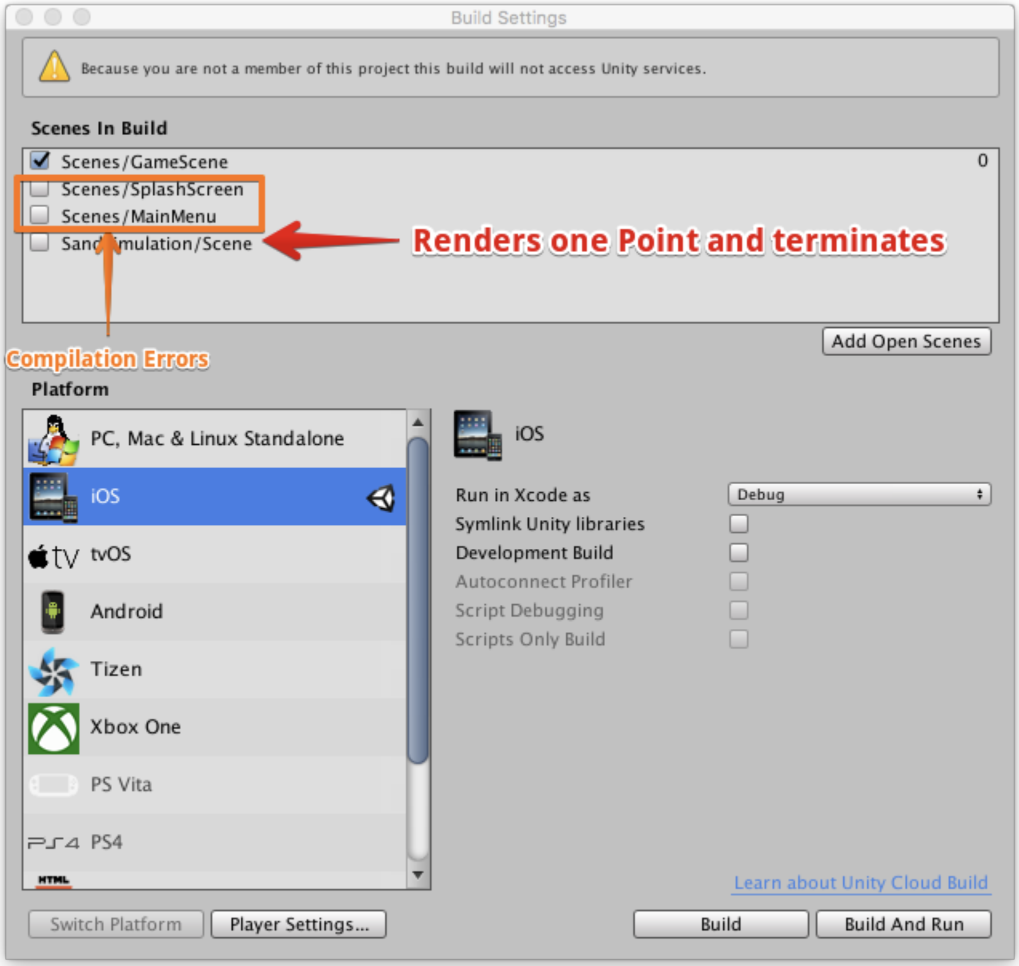
- restart XCode & Unity

Memory Issues

> *Message from debugger: Terminated due to memory issue*

- this is critical — terminates app
- possible causes
  - infinite loop internal while recompiling from Unity to C++
  - used too much memory which iOS cannot handle

Limit only to GameScene



Build Settings

Because you are not a member of this project this build will not access Unity services.

Scenes In Build

- ☑ Scenes/GameScene 0
- □ Scenes/SplashScreen
- □ Scenes/MainMenu
- □ SandSimulation/Scene

Renders one Point and terminates

Compilation Errors

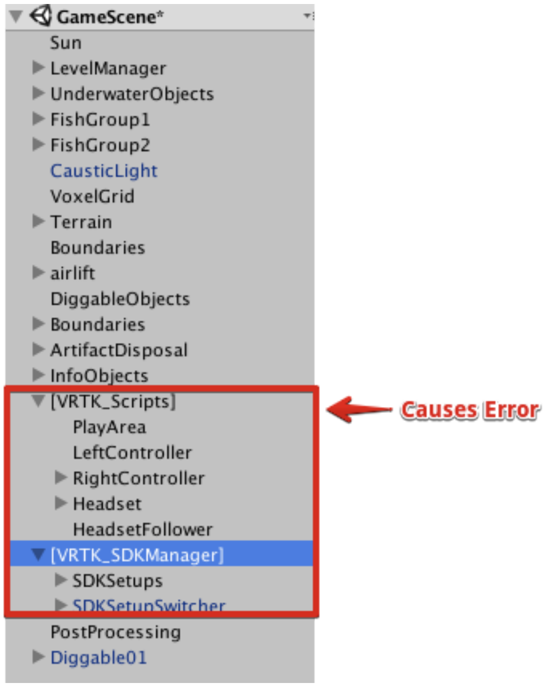
Platform

iOS

Run in Xcode as: Debug

- □ Symlink Unity libraries
- □ Development Build
- □ Autoconnect Profiler
- □ Script Debugging
- □ Scripts Only Build

Scene related



- GameScene*
  - Sun
  - LevelManager
  - UnderwaterObjects
  - FishGroup1
  - FishGroup2
  - CausticLight
  - VoxelGrid
  - Terrain
  - Boundaries
  - airlift
  - DiggableObjects
  - Boundaries
  - ArtifactDisposal
  - InfoObjects
  - [VRTK_Scripts]
    - PlayArea
    - LeftController
    - RightController
    - Headset
    - HeadsetFollower
  - [VRTK_SDKManager]
    - SDKSetups
    - SDKSetupSwitcher
  - PostProcessing
  - Diggable01

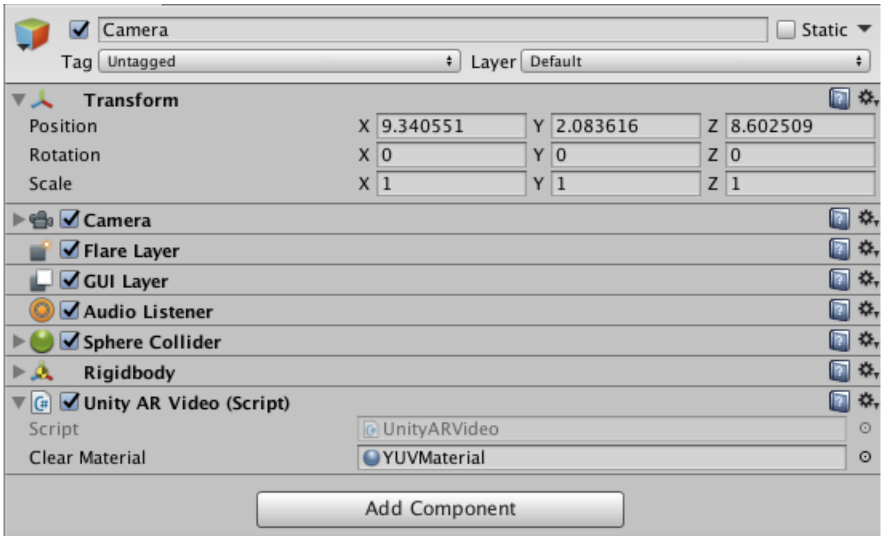
Causes Error

ARKit plugin settings

Camera

Main Camera

- main camera should load camera stream from the device and interpose scene after
  - sphere collider
  - rigid body
  - connect with `UnityARVideo` script



☑ Camera □ Static

Tag Untagged Layer Default

Transform

Position	X	9.340551	Y	2.083616	Z	8.602509
Rotation	X	0	Y	0	Z	0
Scale	X	1	Y	1	Z	1

☑ Camera

☑ Flare Layer

☑ GUI Layer

☑ Audio Listener

☑ Sphere Collider

Rigidbody

☑ Unity AR Video (Script)

Script UnityARVideo

Clear Material YUVMaterial

Add Component

Advanced Unity & ARKit Cooperation

imareculture-excavation

- placing the scene even with the rendering scripts into the real world

- simple support for cardboard virtual reality

Gesture recognition

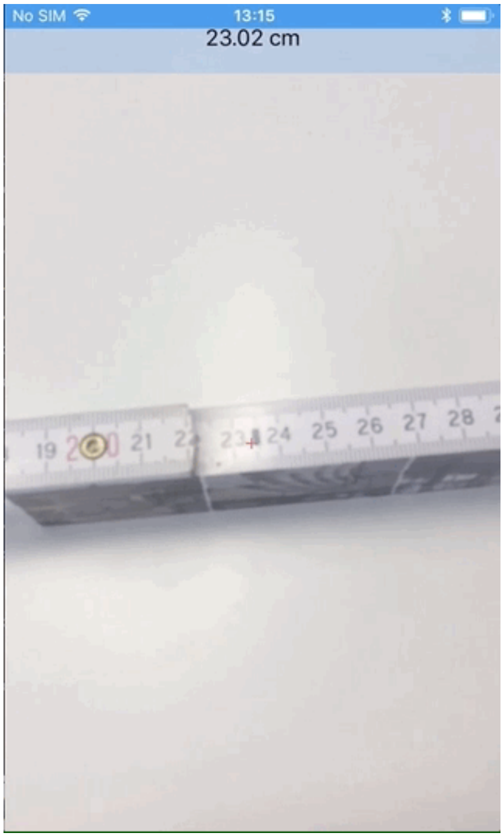
- simple example based on Core ML https://github.com/hanleyweng/Gesture-Recognition-101-CoreML-ARKit
  - powered by super simple model with only few test images (< 100) — intended to work only as an example
  - could be easily extended to work much more robust

- gesture recognition directly in unity
  - commercial https://www.assetstore.unity3d.com/en/#!/content/14458

- touch gesture recognizer
  - https://developer.apple.com/documentation/uikit/uigesturerecognizer

Measurement

- https://github.com/DroidsOnRoids/MeasureARKit
- simple app - choosing closest feature point to the center



https://youtu.be/KcWByTLTqlo

Measurement

- seems as a combination of computer vision + accelerometer sensors

- steps
  - image 1
    - detection of feature points
  - image 2
    - detection of feature points
  - image 1 and image 2
    - **compared** distance between the **position** of the camera where image 1 and image 2 are acquired using **accelerometer sensors**
    - compares **all** shared **feature points**
    - *(like eyes distance)*

Error

https://www.dropbox.com/s/vet0y1kzhbegzpr/ScreenRecording_12-03-2017%2020-21-28.m4v?dl=0

- hypothesis - storing the initial anchor
  - try

“Marker” detection

- possible using the Vision Framework — powered by Core ML training set
- tracking is done in 2D and then transformed to 3D position
- done by postprocessing of image
  - delay could be visible

=> marker like detection is possible via **postprocessing of images**

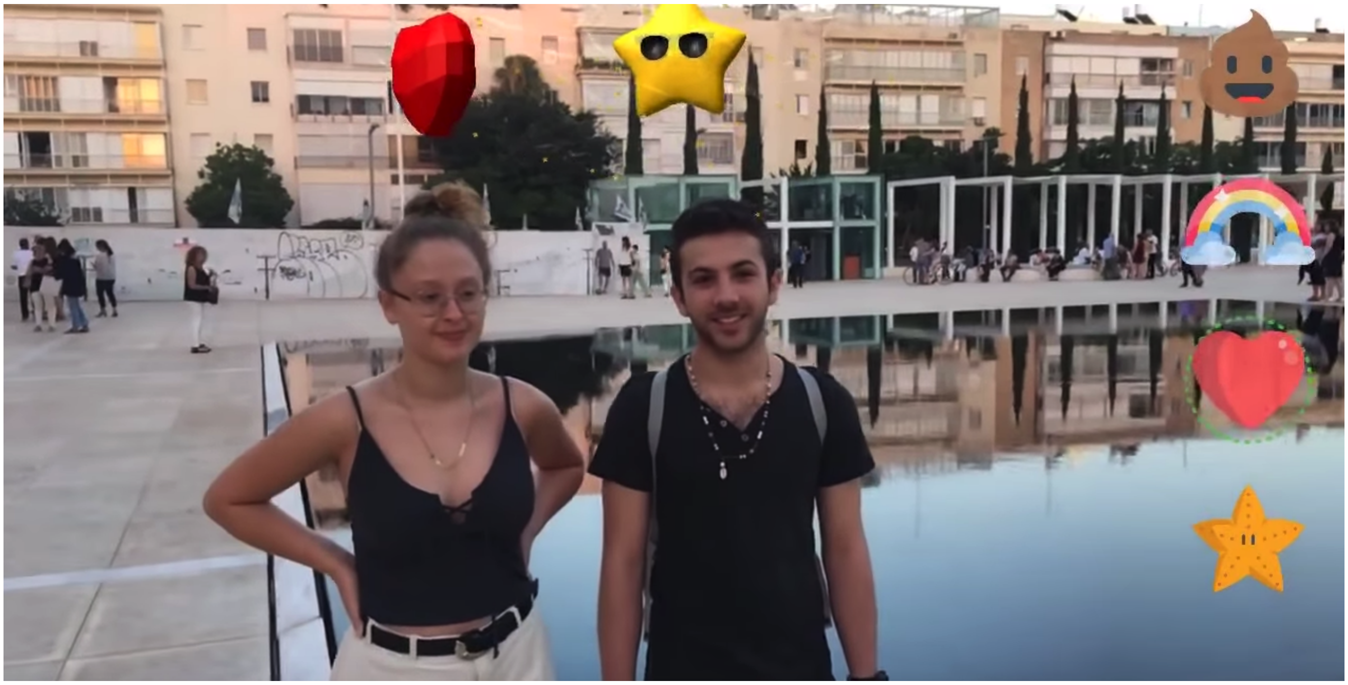
- ML data models
  - depends on model quality & robustness
- 3rd party libraries - not many

Applications

⬆️ **Labeling objects in scene**

- video from Core ML block

Face Detection



https://youtu.be/RdAqD4uIbX0

- jak vypocita hloubku pozici ve 3D
  - seems as a fake
    - 2 possible solution
      - working with true depth front iPhone X camera
      - same distances from people

🔲 **Simple QR codes detection**

- placing 3D objects to the scene
- demo app live

- sample video

https://www.dropbox.com/s/z3dlrxt81rur7cj/ScreenRecording_12-03-2017%2019-22-17.m4v?dl=0
https://github.com/CocoaHeadsDetroit/CocoaHeadsDetroit.github.io/raw/master/arkit%2B2dtrack-1.gif

📰 Based on Text detection

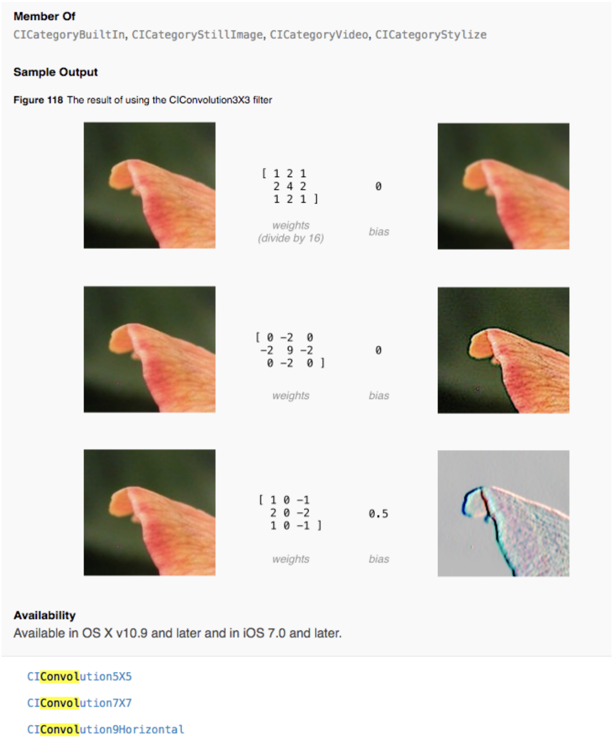
https://www.dropbox.com/s/lhlkuw3h1on1zdr/ScreenRecording_12-04-2017%2015-58-54.m4v?dl=0

Last Week

- try to reveal how the 3D position is obtained — especially with face detection / text
- examples with **OpenCV** app
  - calibration - squares
  - cooperation Arkit & OpenCV
- uncompressed video app
- DIP notes links

DIP powered by Apple

- docs
  - https://developer.apple.com/library/content/documentation/GraphicsImaging/Reference/CoreImageFilterReference/index.html#//apple_ref/doc/uid/TP30000136-SW29



Member Of
CICategoryBuiltIn, CICategoryStillImage, CICategoryVideo, CICategoryStylize

Sample Output

Figure 118 The result of using the CIConvolution3X3 filter

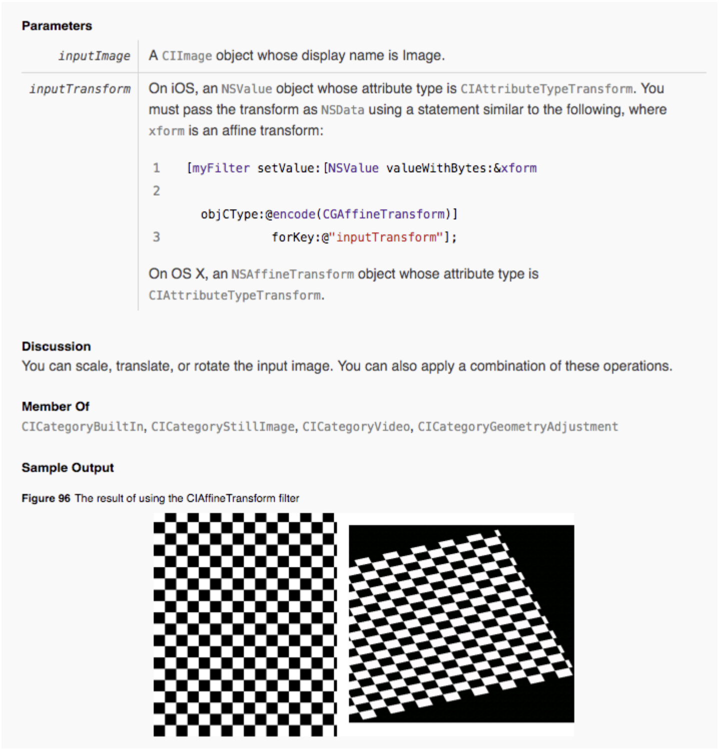
```
[ 1 2 1
  2 4 2
  1 2 1 ]          0

  weights         bias
(divide by 16)

[ 0 -2  0
 -2  9 -2
  0 -2  0 ]        0

  weights         bias

[ 1 0 -1
  2 0 -2
  1 0 -1 ]        0.5

  weights         bias
```

Availability
Available in OS X v10.9 and later and in iOS 7.0 and later.

CIConvolution5X5

CIConvolution7X7

CIConvolution9Horizontal



Parameters

inputImage	A CIImage object whose display name is Image.
inputTransform	On iOS, an NSValue object whose attribute type is CIAttributeTypeTransform. You must pass the transform as NSData using a statement similar to the following, where xform is an affine transform: `[myFilter setValue:[NSValue valueWithBytes:&xform objCType:@encode(CGAffineTransform)] forKey:@"inputTransform"];` On OS X, an NSAffineTransform object whose attribute type is CIAttributeTypeTransform.

Discussion
You can scale, translate, or rotate the input image. You can also apply a combination of these operations.

Member Of
CICategoryBuiltIn, CICategoryStillImage, CICategoryVideo, CICategoryGeometryAdjustment

Sample Output

Figure 96 The result of using the CIAffineTransform filter

```
CICategoryBlur
- blur filters

CICategoryColorAdjustment

- CIColorClamp, CIColorControls, CIColorMatrix, CIColorPolynomial, CIExposureAdjust, CIGammaAdjust

CICategoryColorEffect
- CIColorPosterize, CIFalseColor, CIMaskToAlpha, CIMaximumComponent, CIMinimumComponent

```

```
CICategoryCompositeOperation
- blend modes,  darken, difference, max / min composition, blend

CICategoryDistortionEffect
- distortion, wrapping, stretching

CICategoryGenerator
- Aztec generator, QR generator


CICategoryGeometryAdjustment
- affine transform, crop, straighten


CICategoryGradient
- gaussian gradient, linear, radial

CICategoryHalftoneEffect

CICategoryReduction
- CIAreaAverage, CIAreaHistogram


CICategorySharpen
- sharpenning


CICategoryStylize
- CIBlendWithAlphaMask, CIBlendWithMask, CIBloom, CIComicEffect, CIConvolution

CICategoryTileEffect

CICategoryTransition

```

- tons of features — sufficient to omit other libraries

Revealing 3D anchor from 2D position

ARHitTestResult

- all of the demonstrated apps uses this class
- doc
  - https://developer.apple.com/documentation/arkit/arhittestresult
- raycasting and checking intersection with detected planes
  - method returns an array of sorted intersection by distance (the floor is the last == farthest one)
  - => the video with the emojis above the faces was took by the true-depth iPhone X camera whic creates accurate depth map

https://youtu.be/YhnwBx3Tr3w

- another example detecting objects in scen 2D -> 3D raycast to planes
  - https://github.com/hanleyweng/CoreML-in-ARKit

- some applications uses only fake transformation to 3D -> place the anchor `x metres` in fron of the camera

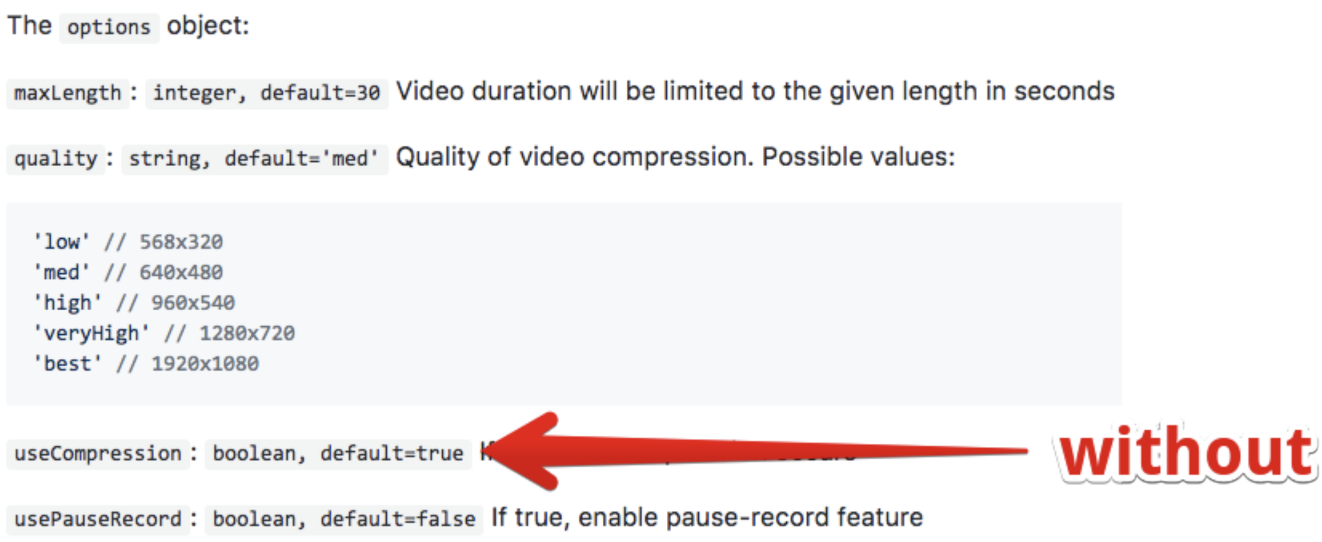
Face

- great features with the fron true-depth camera
- doc
  - https://developer.apple.com/documentation/arkit/creating_face_based_ar_experiences
  - https://developer.apple.com/documentation/arkit/arfacetrackingconfiguration
  - https://developer.apple.com/documentation/arkit/arfaceanchor

Video without Compression

Go Game Custom Video Module

- github: https://github.com/thegogame/native_video_module



The `options` object:

`maxLength` : `integer, default=30` Video duration will be limited to the given length in seconds

`quality` : `string, default='med'` Quality of video compression. Possible values:

```
'low' // 568x320
'med' // 640x480
'high' // 960x540
'veryHigh' // 1280x720
'best' // 1920x1080
```

`useCompression` : `boolean, default=true`

`usePauseRecord` : `boolean, default=false` If true, enable pause-record feature

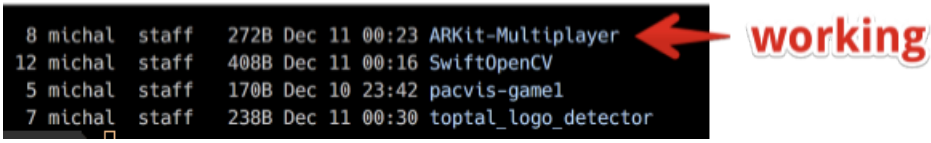
OpenCv & ARkit

- more combinations - **Unity & OpenCV & ARKit**

https://youtu.be/v6x6Aa9qLXE

- for native cooperation iOS & OpenCV
  - tutorials for creating OpenCVWrapper
  - https://docs.opencv.org/2.4/doc/tutorials/ios/video_processing/video_processing.html#including-opencv-library-in-your-ios-project

- I tried several applications, all of them outdated / impossible to compile
  - only one implementation working



```
 8 michal  staff   272B Dec 11 00:23 ARKit-Multiplayer
12 michal  staff   408B Dec 11 00:16 SwiftOpenCV
 5 michal  staff   170B Dec 10 23:42 pacvis-game1
 7 michal  staff   238B Dec 11 00:30 toptal_logo_detector
```

working

- resumé
  - support of OpenCV for iOS + ARKit exists but a way more common way how to use OpenCV in cooperation with iOS seems to be connected with Unity

---

Resources
https://developer.apple.com/arkit/
https://blog.markdaws.net/arkit-by-example-part1-7830677ef84d