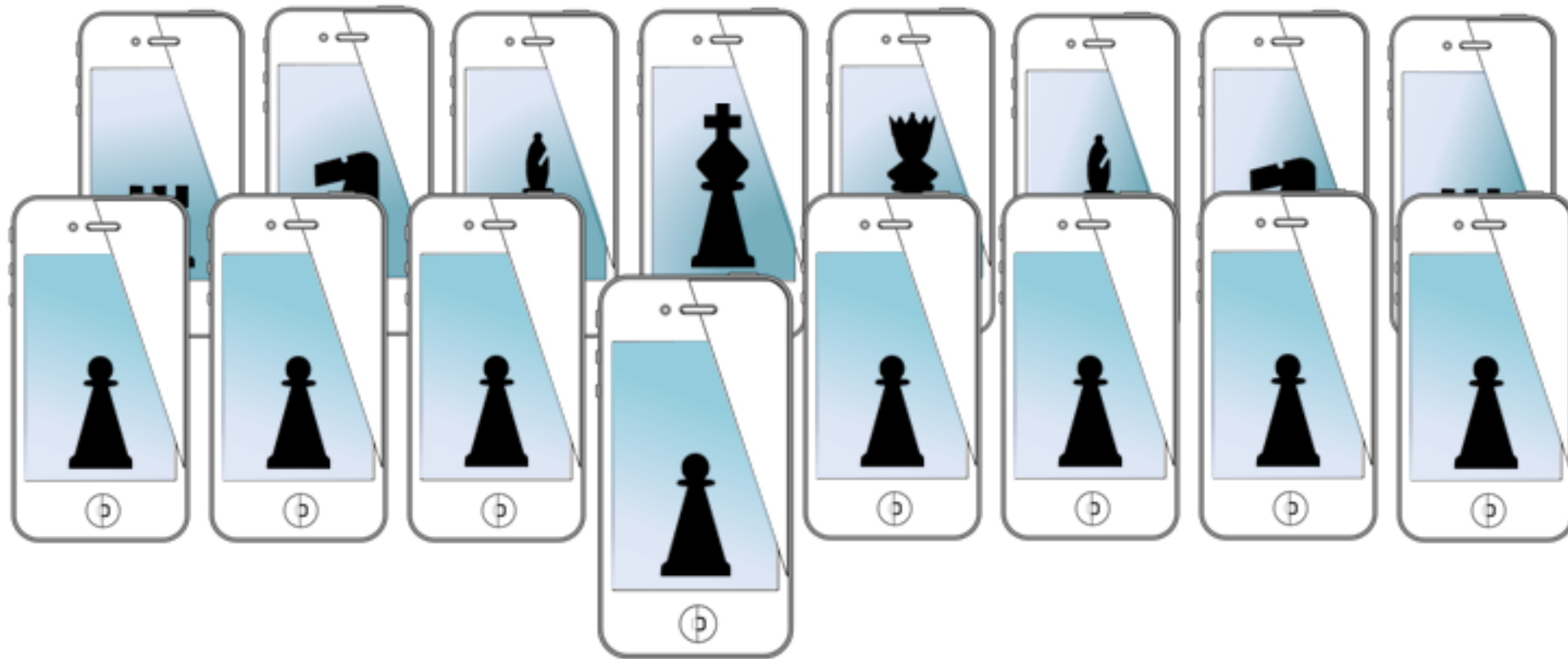


MOBILE SENSING LEARNING



CSE5323 & 7323

Mobile Sensing and Learning

week 6: computer vision with core image

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course logistics

- Grades are coming
- A3 is due Friday!
- A4 is due 2 weeks from Friday (week of Fall Break!)
 - A4 constraints on website
- **next lecture: in-class assignment, OpenCV**

agenda

- video processing
- computer vision
 - face detection
- heart physiology

updating filter parameters

- can be done on the fly, without performance loss

init

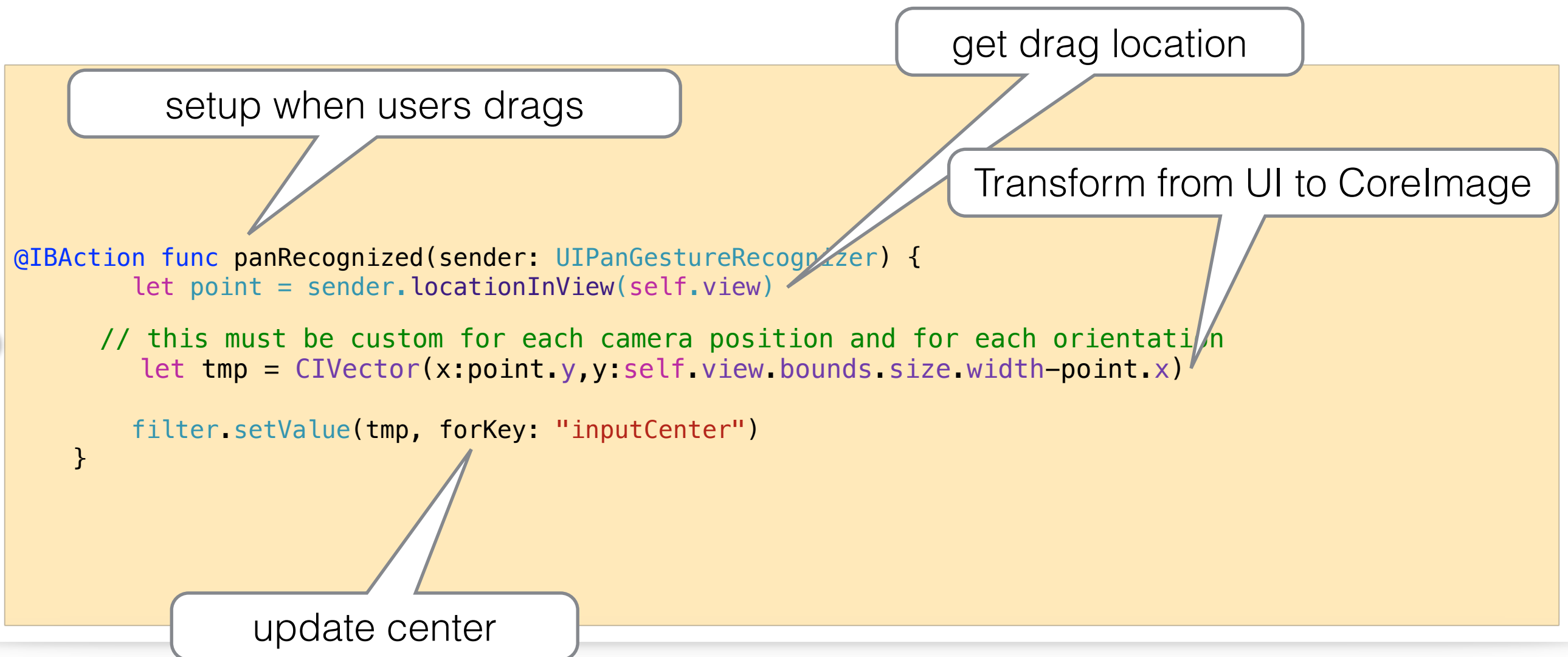
```
let filter:CIFilter = CIFilter(name: "CIBumpDistortion")
filter.setValue(-0.5, forKey: "inputScale")
filter.setValue(75, forKey: "inputRadius")
```

apply

```
self.videoAnalgesic.setProcessingBlock()
{(inputImage:CImage)->(CImage) in
    self.filter.setValue(inputImage, forKey: "inputImage")
    return self.filter.outputImage
}
```

updating filter parameters

- update from the UI



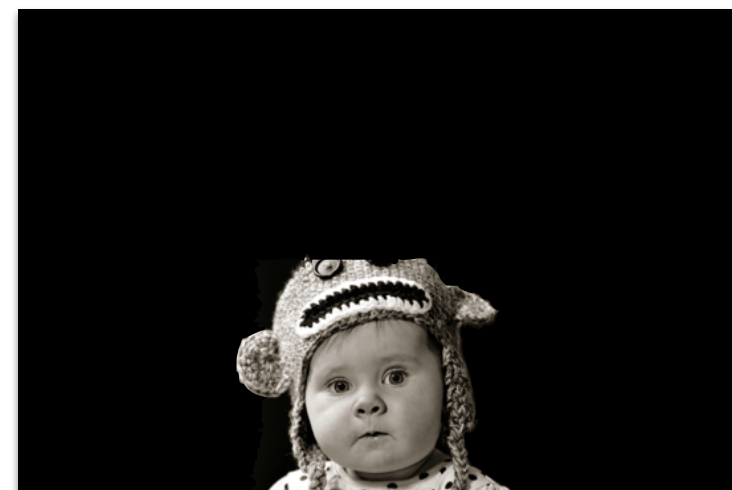
filter param demo

- PinchMe



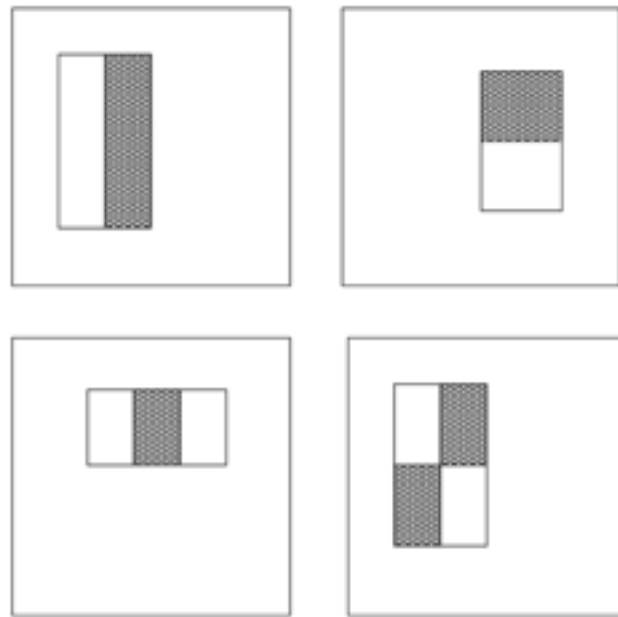
face detection

- is a face in the picture and where?
- algorithm is probably hardware accelerated variant of Viola Jones
- essentially, a “matching” filter is applied
 - only happens in one orientation
 - but multiple scales (which takes “some” time)



an intuition

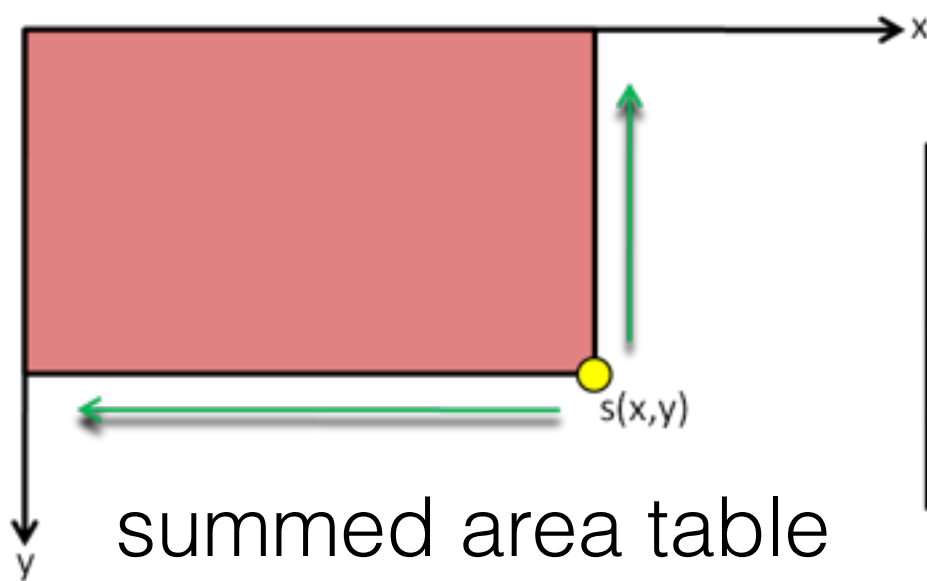
- face detection with “rectangle” features



feature value =
sum of pixels in white area -
sum of pixels in black area

“best” dark and light rectangles
already chosen for face
detection!

sum of any rectangle =
 $C - D - B + A$

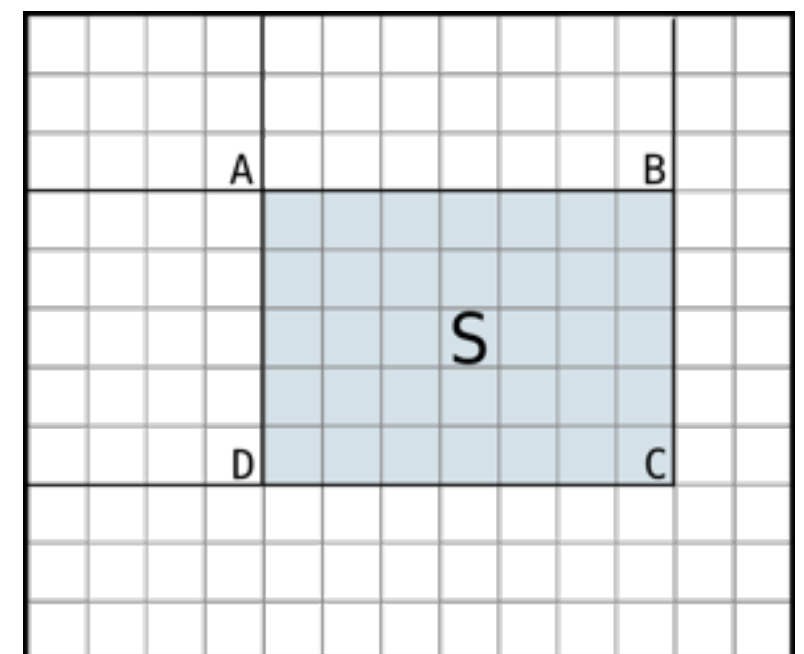


4	1	2	2
0	4	1	3
3	1	0	4
2	1	3	2

original

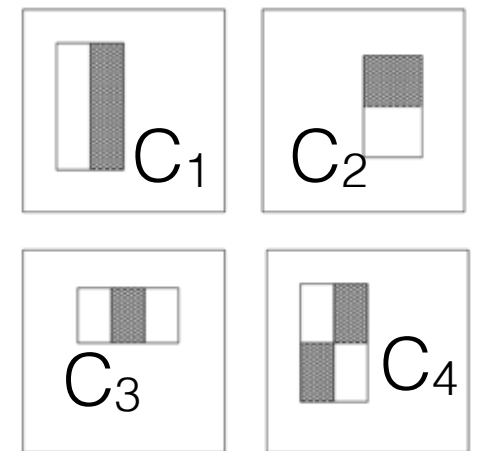
4	5	7	9
4	9	12	17
7	13	16	25
9	16	22	33

summed



learning

- train a bunch of “classifiers” with lots of examples



$$\underbrace{C_t(x)}_{\text{classifier}} = \underbrace{1, \text{ if } f_t > \theta_t}_{\text{feature above thresh}}$$

combine output of classifiers

cascade these

$$\underbrace{\underbrace{C(x)}_{\text{ensemble}}}_{\text{learned weights}} = 1, \text{ if } \underbrace{\sum_{t=0}^{T-1} \alpha_t C_t(x)}_{\text{learned weights}} > \frac{1}{2} \sum_{t=0}^{T-1} \alpha_t$$

learning

- tough to train
 - need examples in various lighting and illumination
 - different poses, glasses, with hair in face
 - different genders, races, and scales
 - **what made this easier?**
- easy to use once trained
 - just getting integral image
 - then getting relevant “features”
 - multiply with learned weights!
- iOS already has done the training for you

face detection iOS

- similar pipeline to applying a filter

specify options

the CIDetector class

- specify where the processing should occur

detector type: face,
rectangle, QRCode,
Text

```
let optsDetector = [CIDetectorAccuracy: CIDetectorAccuracyHigh]
```

```
let detector = CIDetector(ofType: CIDetectorTypeFace,  
    context: self.videoAnalgesic.getCiContext(),  
    options: optsDetector)
```

context

```
var optsFace =  
[CIDetectorImageOrientation: self.videoAnalgesic.getImageOrientationFromUIOrientation(UIApp  
lication.sharedApplication().statusBarOrientation)]
```

orientation

for each face

```
var features = detector.featuresInImage(inputImage, options: optsFace)
```

```
for f in features as [CIFaceFeature]{  
    NSLog("%@", f)  
}
```

do this

options specific to
"run"

face demonstration

- PinchMe++



face detection

- many tracking mechanisms are supported
- eye location
- mouth location
- smile detection
- blink / wink detection for each eye
- all use a variant of the Haar Wavelet method (probably)

computer vision

- face detection is just the beginning
 - could use tracking method for any object
- could also do “recognition”
 - typically done with eigen-faces or fisher-faces
 - would take (slightly) too much time in this class to implement
- more than just tracking
 - edge detection
 - finding lines and shapes
 - color space transformations
- extract “knowledge” from a scene

computer vision in iOS

- mobile camera is a rich medium for:

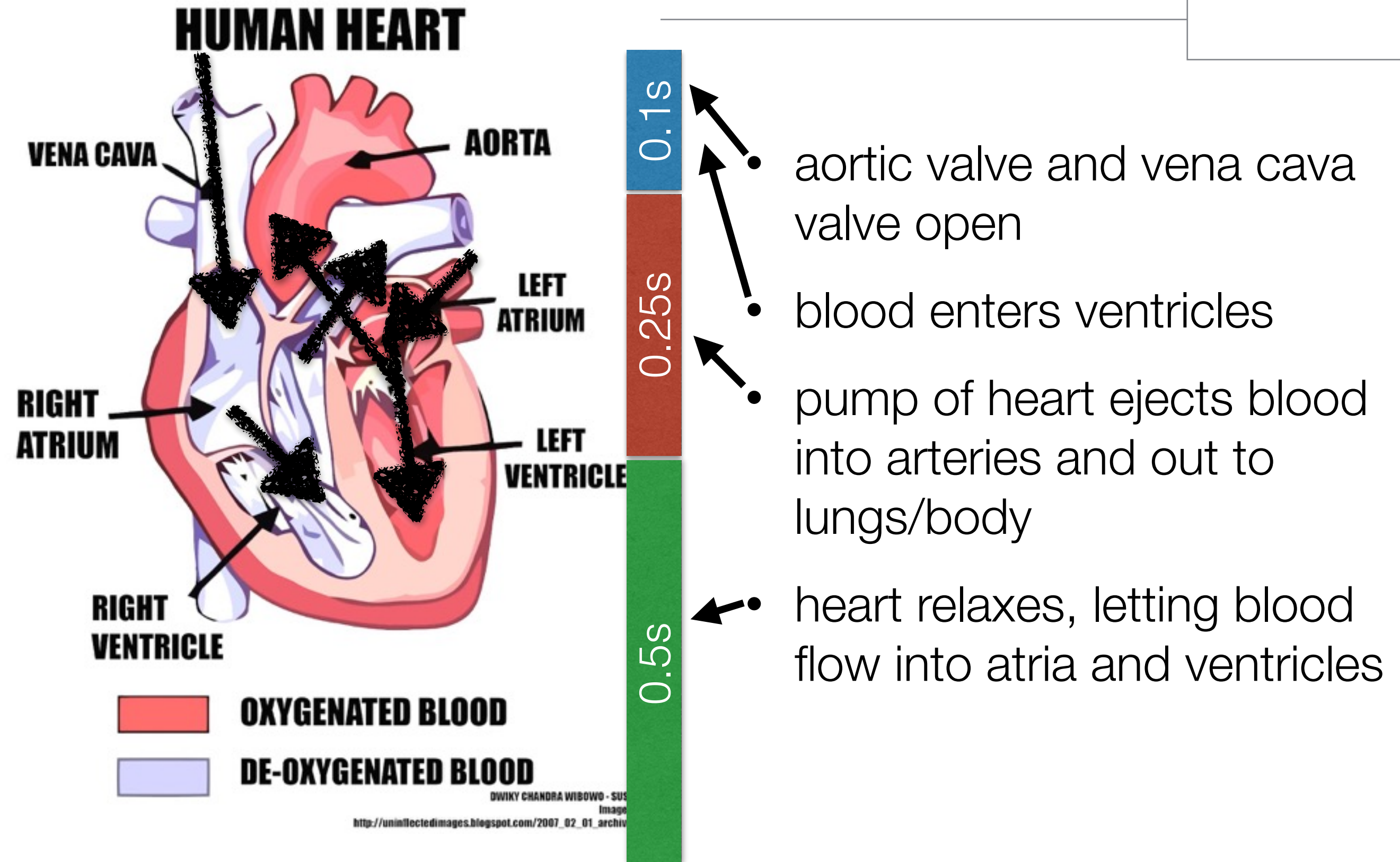
- enhancement
- interaction
- augmented reality
 - gaming
 - tracking
- health

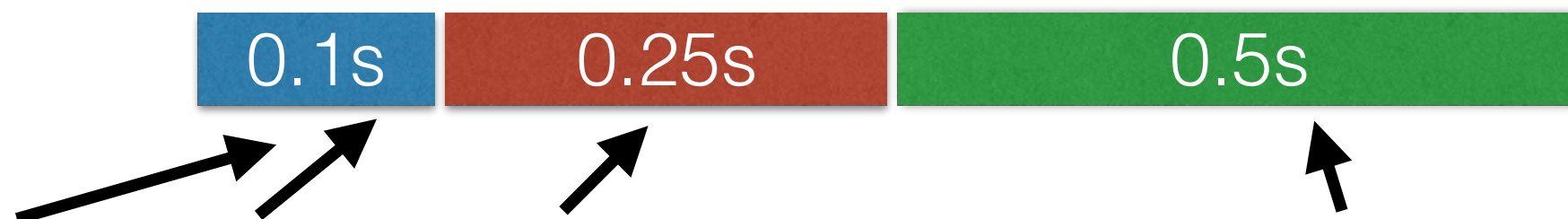


health?

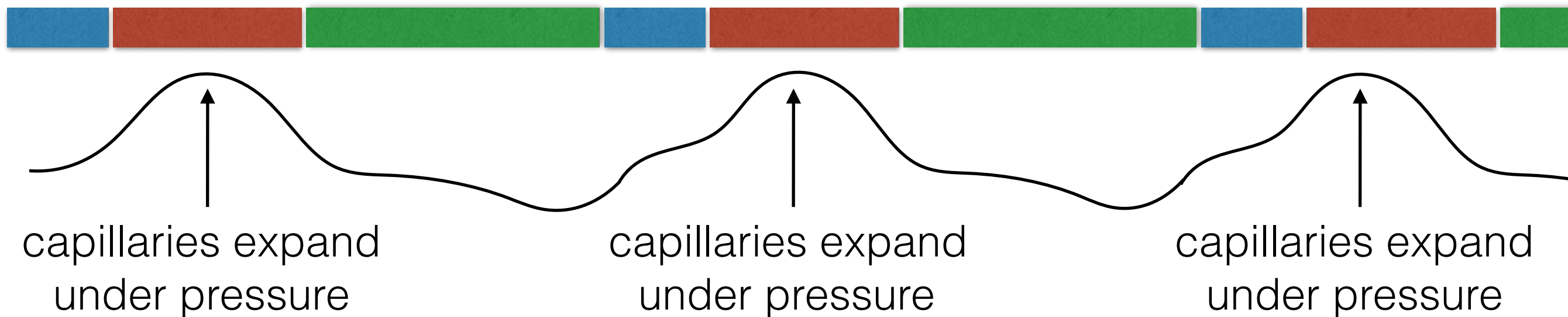
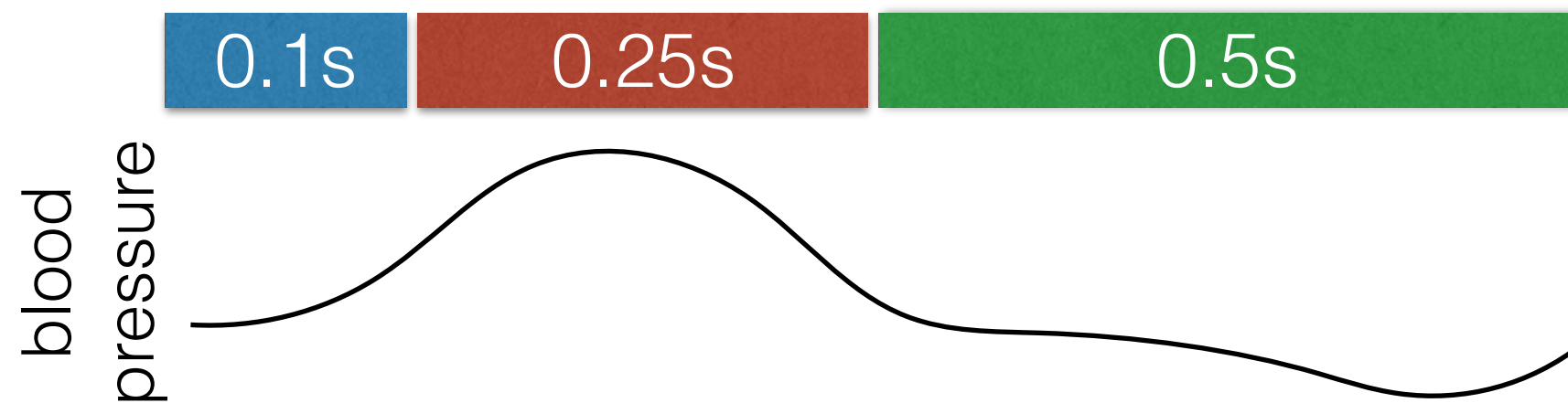
- detecting heart rate from the camera
- what is the function of the heart?
 - pump oxygenated blood from lungs to the rest of the body
 - bring back de-oxygenated blood
- a pump maintains pressure and flow
 - no pump works continuously
 - series of pressure buildup, release, buildup, release
 - cycles in the heart is the **heart beat**

the cardiac cycle

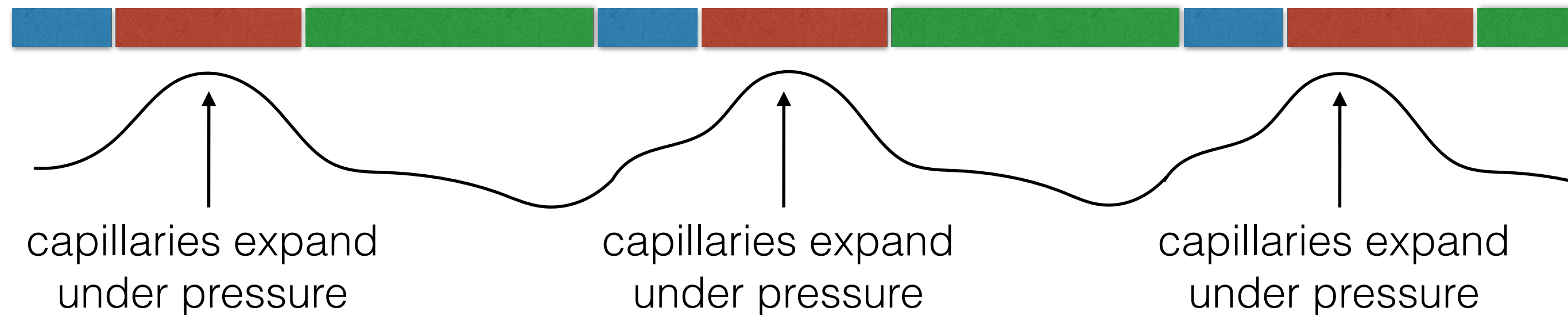




a signal from the heart



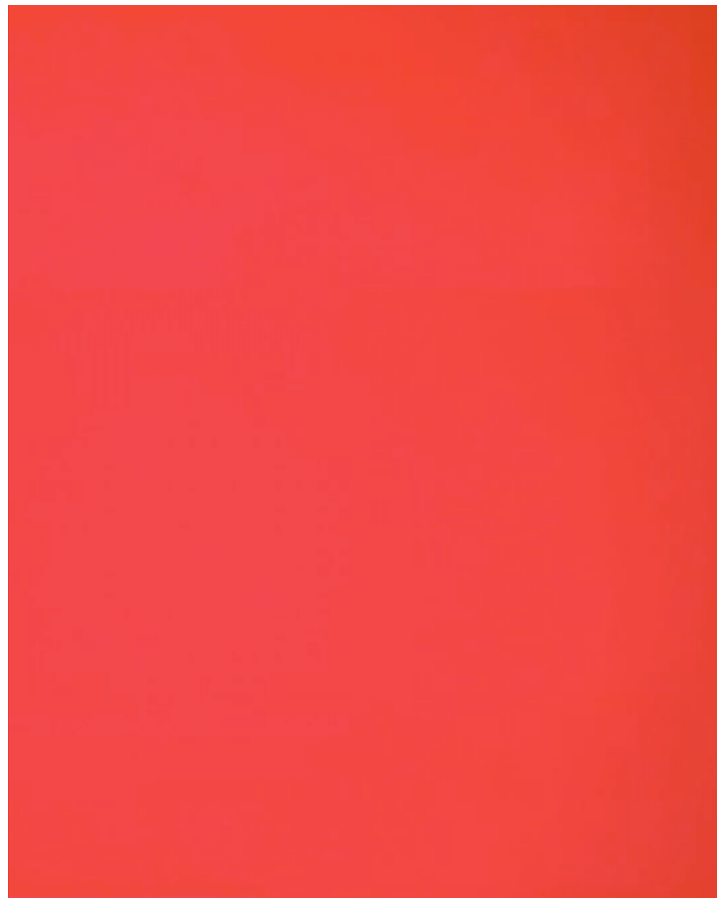
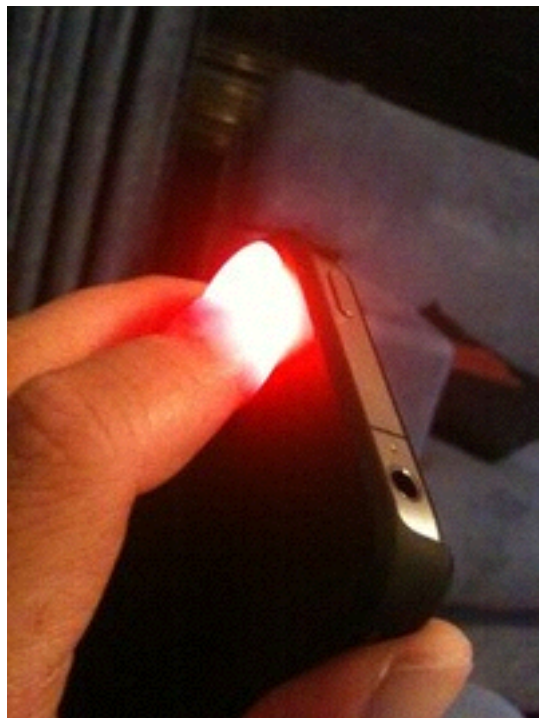
a signal from the heart



- capillary expansion means more blood under skin
 - shift in redness from oxygenated blood
 - shift in blueness from deoxygenated blood
 - more blood molecules for light to reflect from

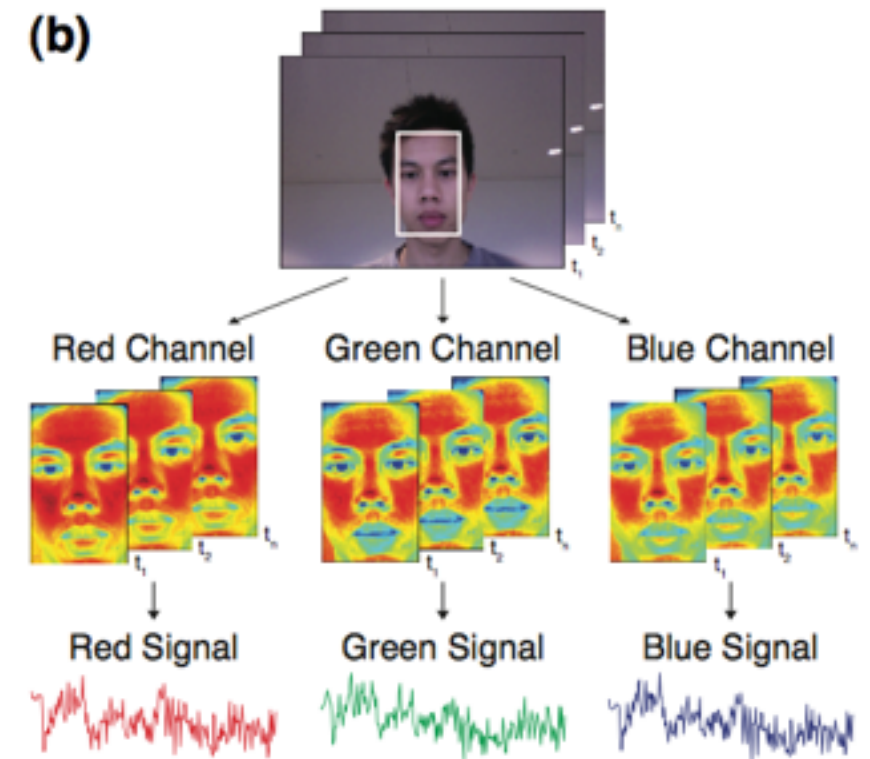
a signal from the heart

- hold finger over
 - camera
 - torch (always on flash)



photoplethysmography (PPG)

exemplary work



caveats

- do not press too hard on camera
- vasoconstriction and vasodilation
- bigger surface areas are better
- don't move around too much
- the heart is not the only organ that increases pressure
 - what else could cause the capillaries to expand/contract?
- what method might you use to measure PPG from the camera?

a cool example

September 7, 2016

HemaApp screens for anemia, blood conditions without needle sticks

Jennifer Langston

News and Information

In the developing world, [anemia](#) — a blood condition exacerbated by malnutrition or parasitic disease — is a staggeringly common health problem that often goes undiagnosed.

In hospitals everywhere, children and adults with leukemia and other disorders require frequent blood draws to determine if they need blood transfusions.

In both cases, doctors are interested in measuring hemoglobin, a protein found in



HemaApp measures hemoglobin levels and screens for anemia non-invasively by illuminating the patient's finger with a smartphone's camera flash. **Dennis Wise/University of Washington**

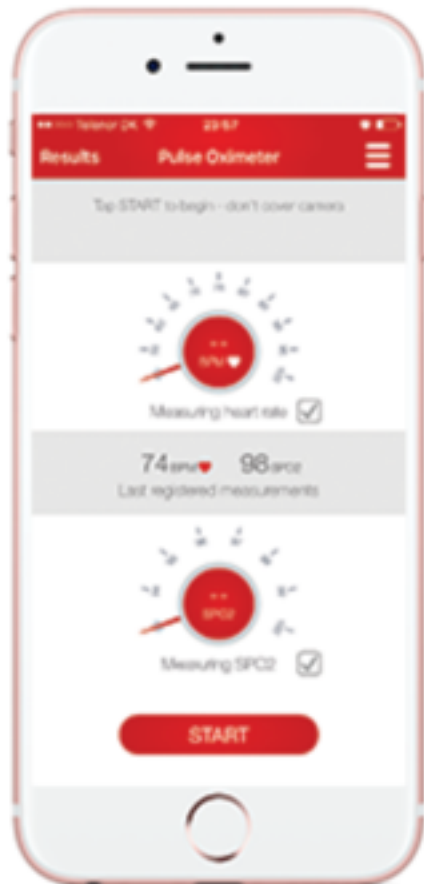
another cool example

digiDoc Technologies

Home

Products

The World's Only Digital Solution



The Pulse Oximeter app measures both Heart Rate and Oxygen Saturation. The app integrates with Apple Health. There's no need for an external device. *Your iPhone is all you need.*

INTENDED USE

The Pulse Oximeter app is for use by sports users who are interested in knowing their blood oxygenation level (SpO2) and Heart Rate. The Pulse Oximeter app is NOT INTENDED FOR MEDICAL USE. The Pulse Oximeter app can be used in a wide range of settings, including between exercises, running, hiking, and in relaxation management.

Pulse Oximeter uses your iPhone's camera to detect your pulse and oxygen levels from your fingertip. Track and

record heartbeat and blood oxygen levels. Instant results, easy to use, simple charts to save your progress.

Features

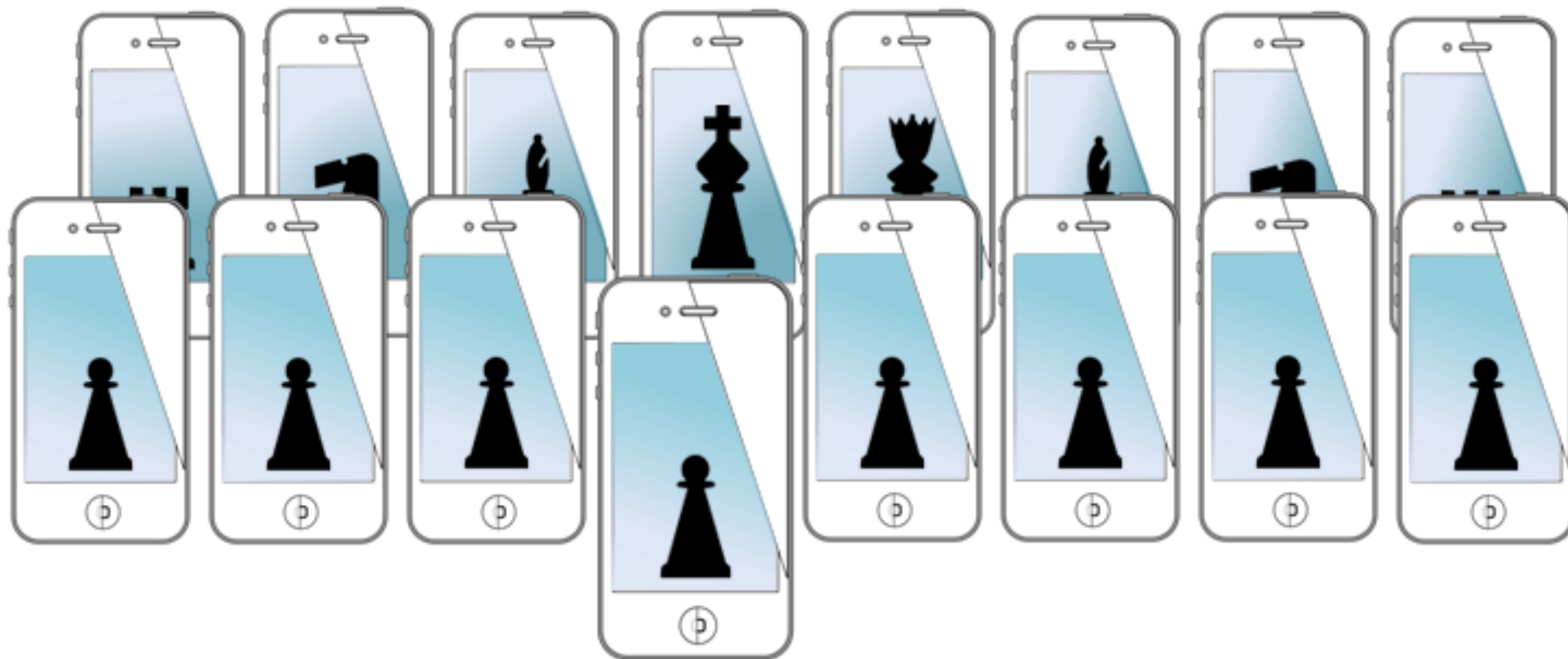
- ✓ Measure pulse and blood oxygen saturation
- ✓ Pulse Oximeter range 93-100%
- ✓ Record and store history of data
- ✓ Real-time PPG graph for immediate accuracy
- ✓ Apple HealthKit integration
- ✓ Label selection



for next time...

- computer vision with OpenCV
 - watch video lecture for OpenCV
 - fun operations in imaging
 - come ready to use OpenCV next time

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