



AUGMENTED REALITY FOR PROGRAMMERS

Andrew Bibichev
2010, September

AR

AR

AR

AR

AR

WTF?

AR

AR

AR

AR

AR

AR





[Link](#)

 **Washington St**
300 ft

then



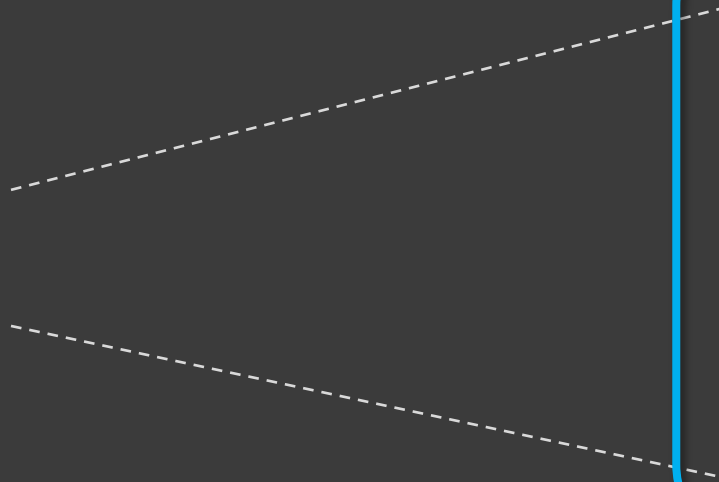

0 min

W **12th St**

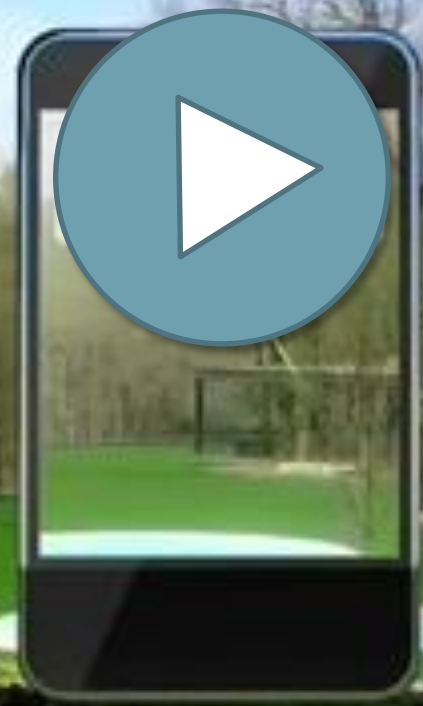
[Link](#)





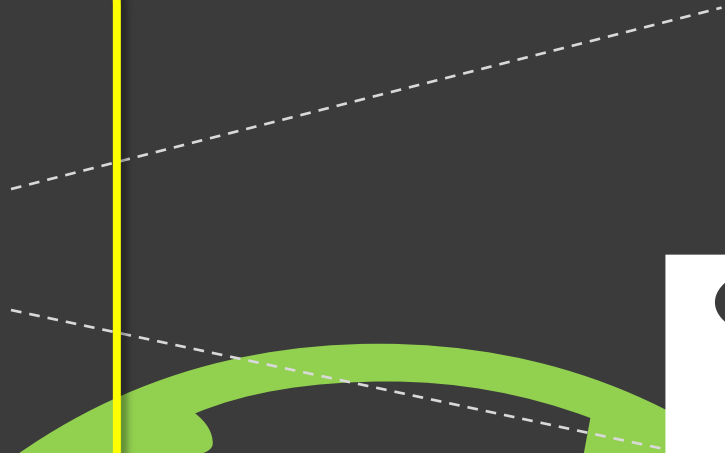
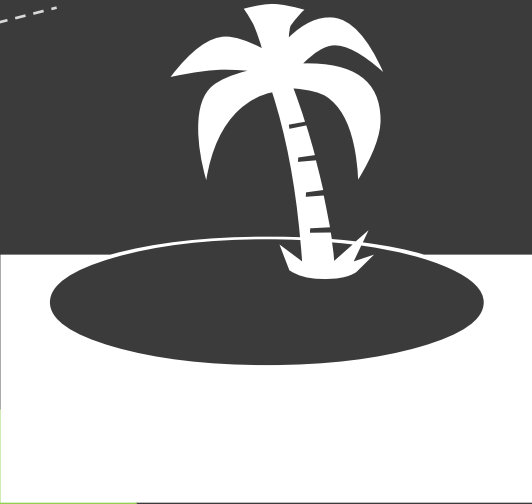
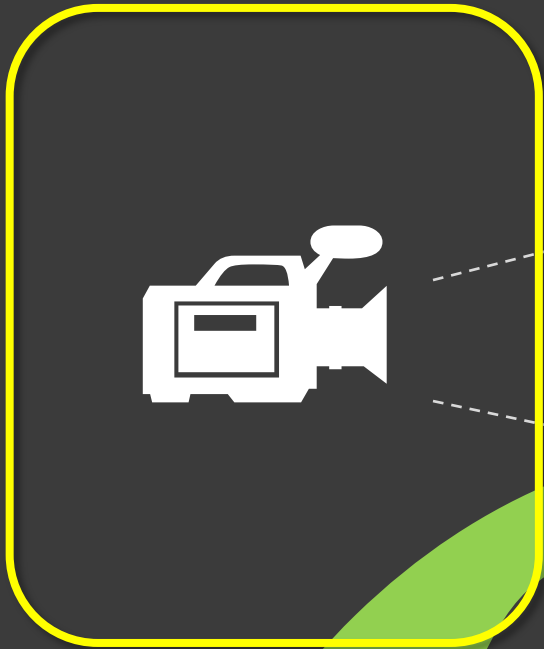


...and augment it.





[Link](#)



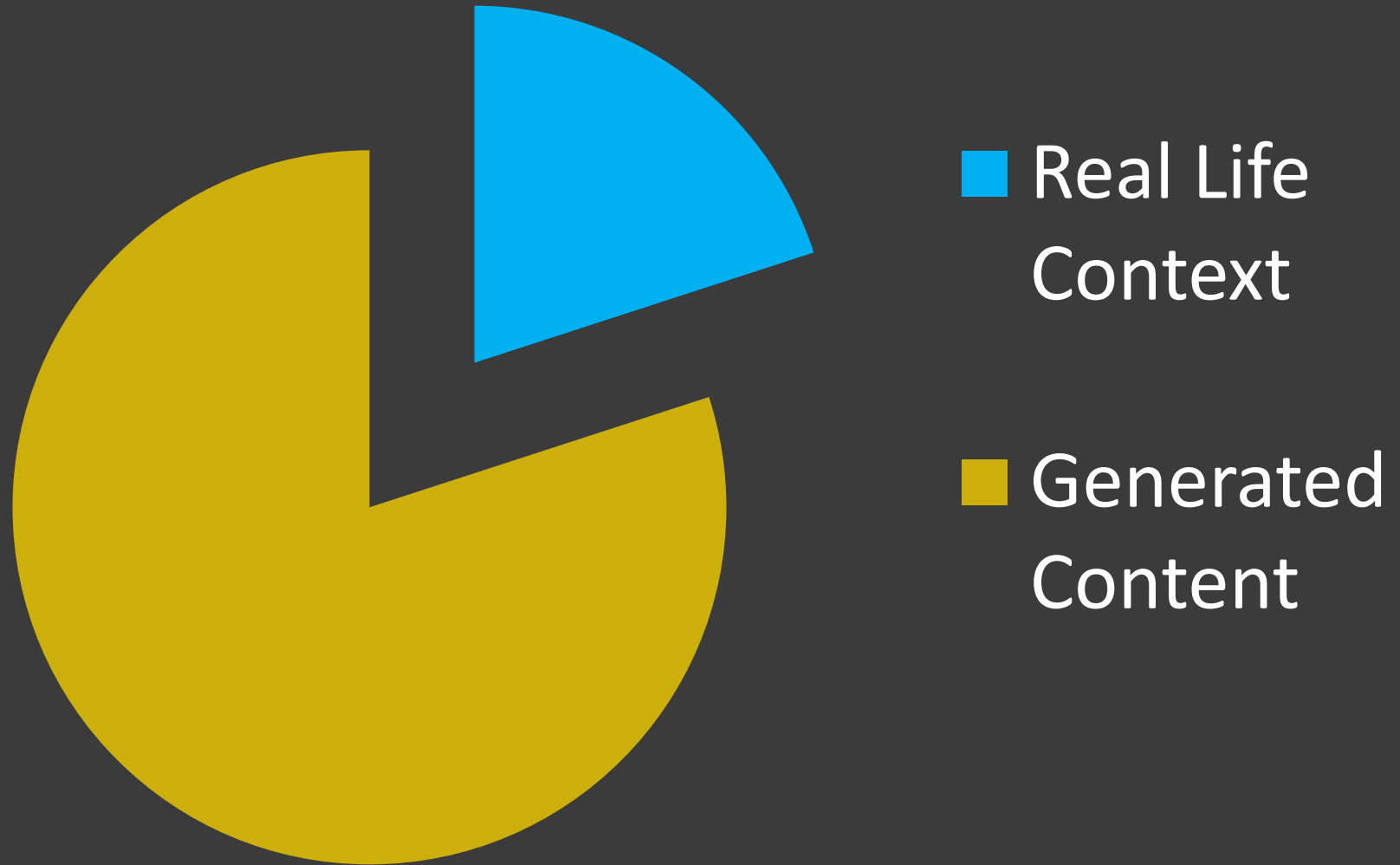
AR vs. VR

AR vs. VR

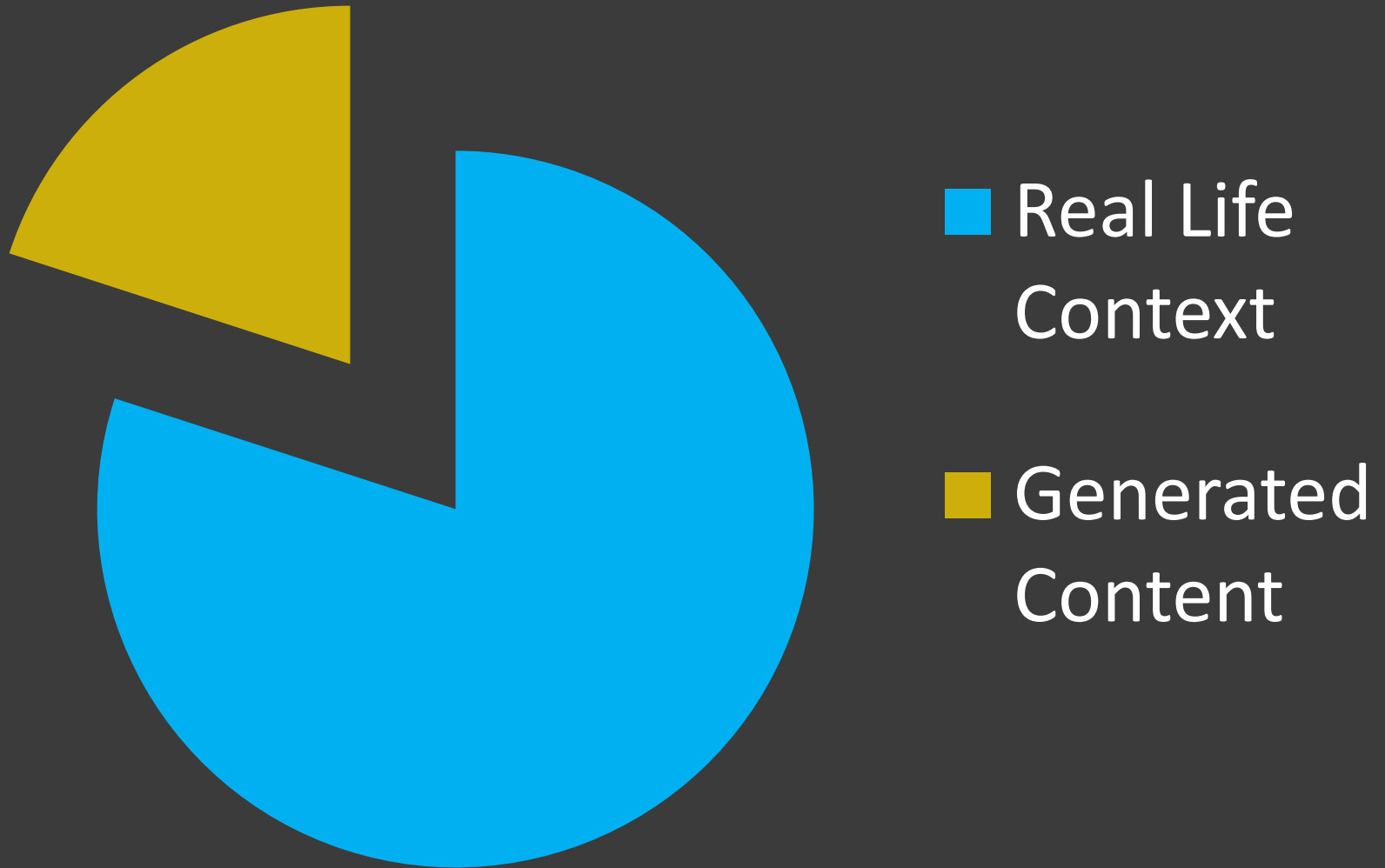




VIRTUAL REALITY



AUGMENTED REALITY



AR



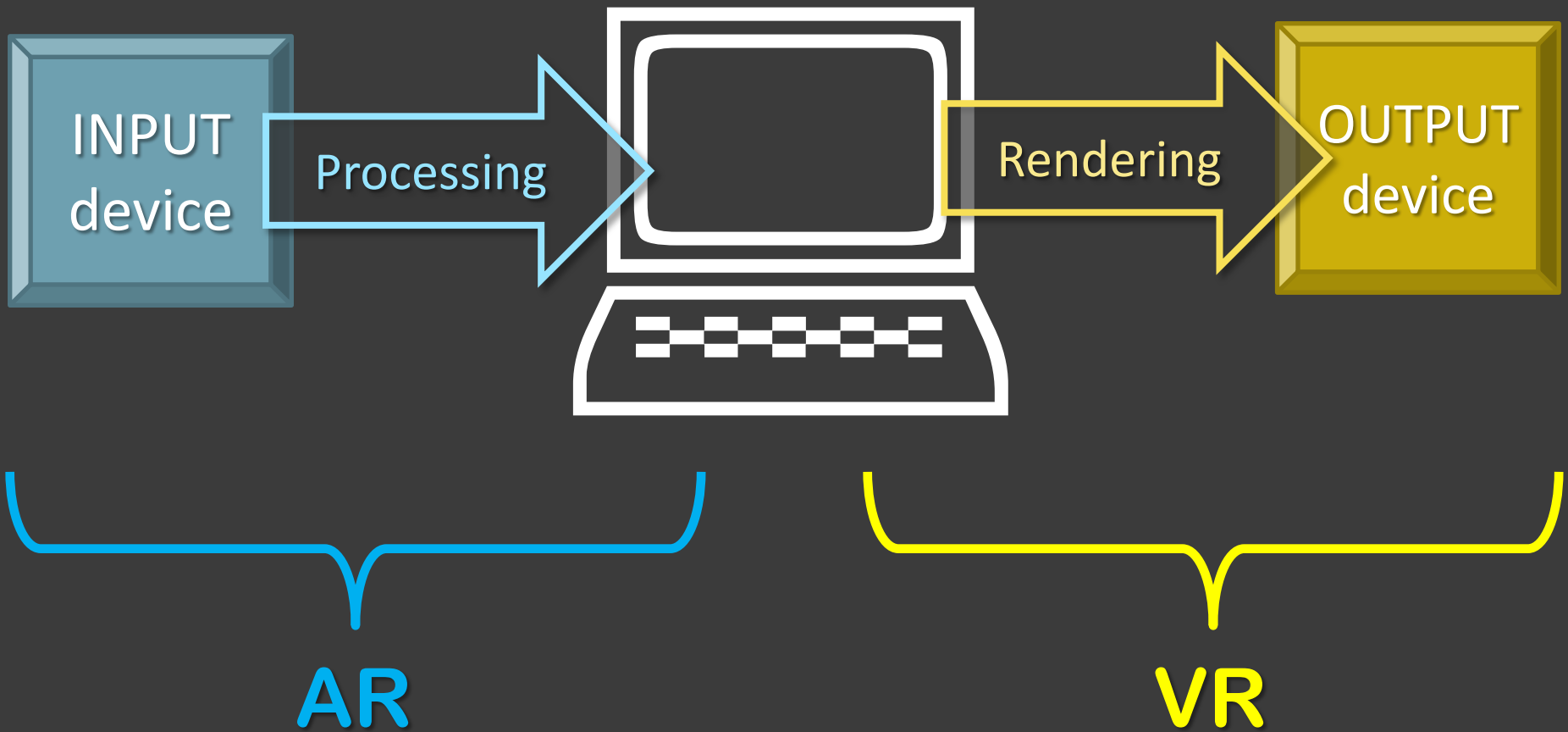
VR



■ Real Life
Context

■ Generated
Content

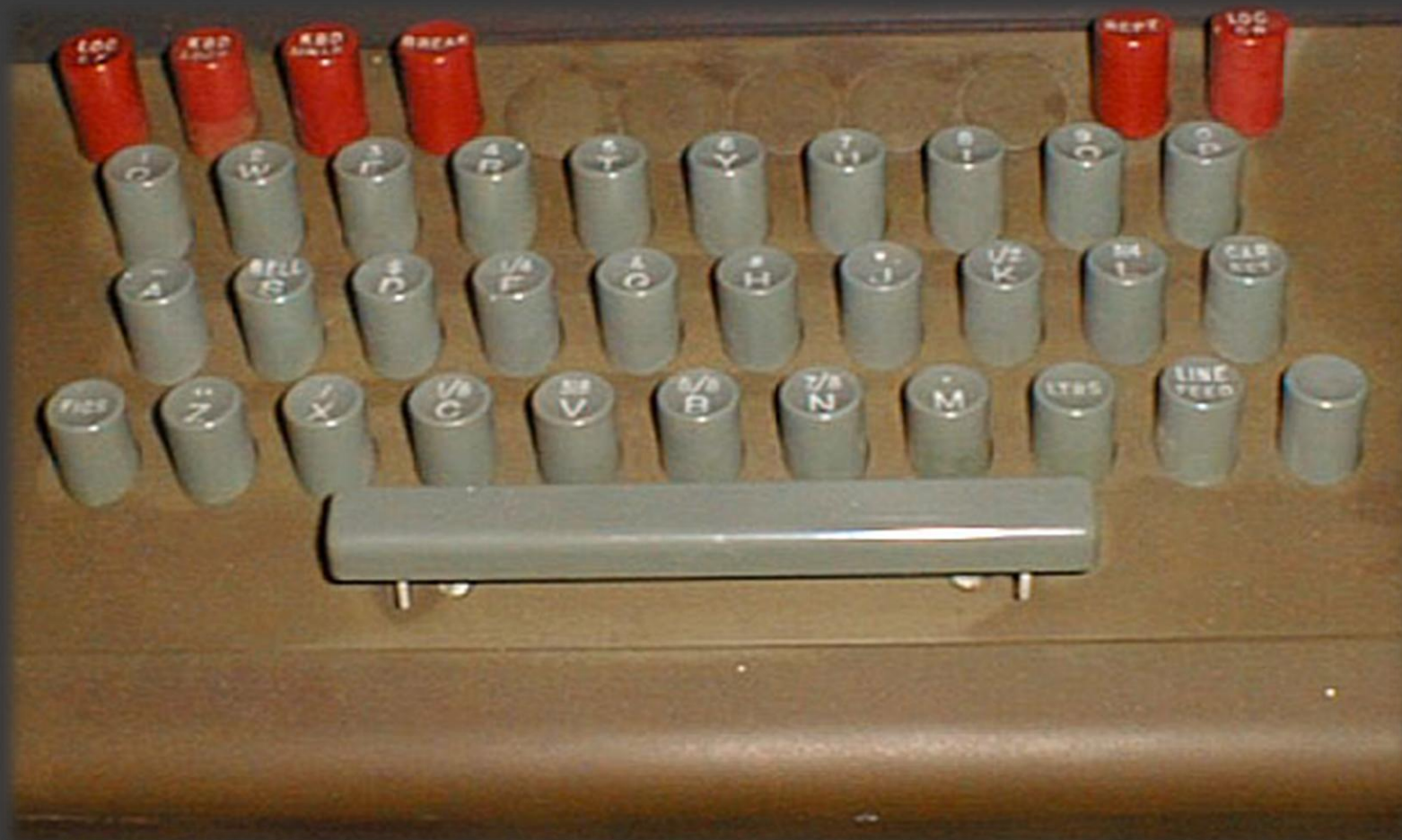
INNOVATIONS IN



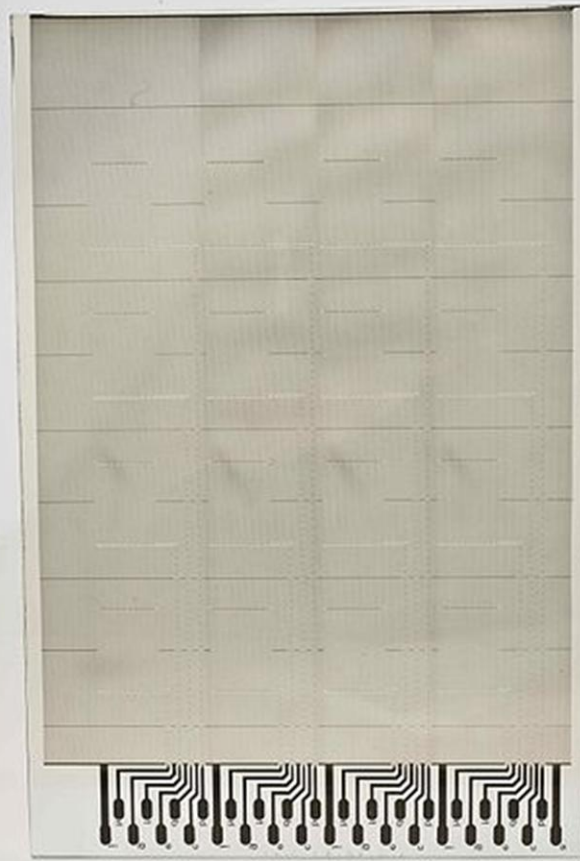
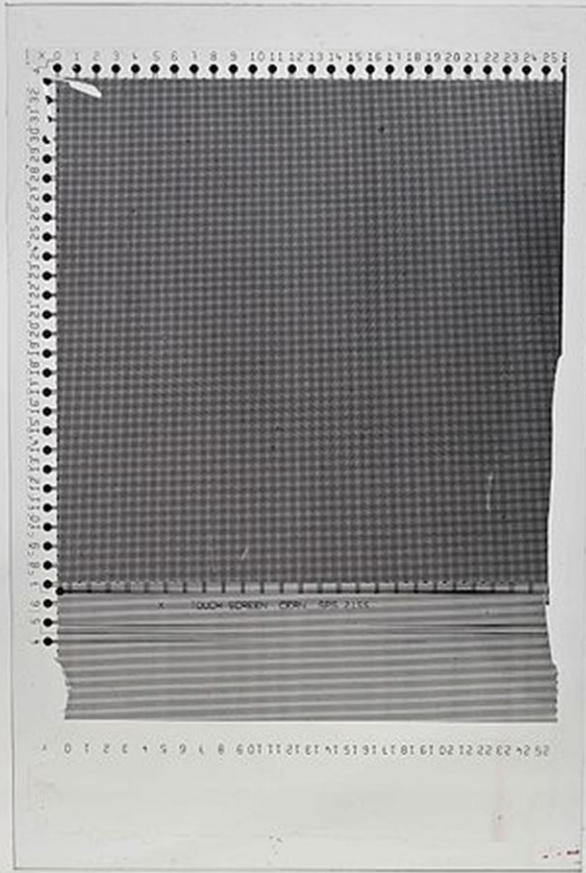
A LA HISTORY

A LA HISTORY

EARLY 1970s: FIRST ELECTRONIC KEYBOARD



1977: TOUCH SCREEN



1981: Xerox Star mouse



10+ YEARS

EARLY 1990s: WEBCAM



1995: Genius EasyScroll mouse



10+ YEARS

2007: multi touch (iPhone)



2007: WII REMOTE (accelerometer)




JUNE, 2009: WII MOTION+ (gyro)



2010: smart phones

with gyro, accel, GPS, video camera, ...



3-axis gyro (angular velocity)

Pitch, roll & yaw

Rotation about gravity

**Gyro + accelerometer provide
6-axis motion sensing**

New CoreMotion APIs

Perfect for gaming

gdygt



RIGHT NOW

SEP, 2010: SONY MOVE





=



HD

A woman in a tan shirt and dark pants is shown in a forest, aiming a bow. The bow is glowing orange and has a blue light on the arrow. A large blue play button is overlaid on the center of the image. The background is a lush green forest with tall trees and a grassy ground.

FEEL THE ACCURACY
Perform true-to-life movements

NOV, 2010: MS KINECT



KINECT™
for  XBOX 360.

for  XBOX 360™
KINECT

Color and Skeleton



Avatar



BGR



Start

2 Player - Default Policy

Exit Prev Next X Y A Pause

Firmware: 1.1-1737.0 | NUIView: 11513.0

FIRST TRUE AR

1984: Apache

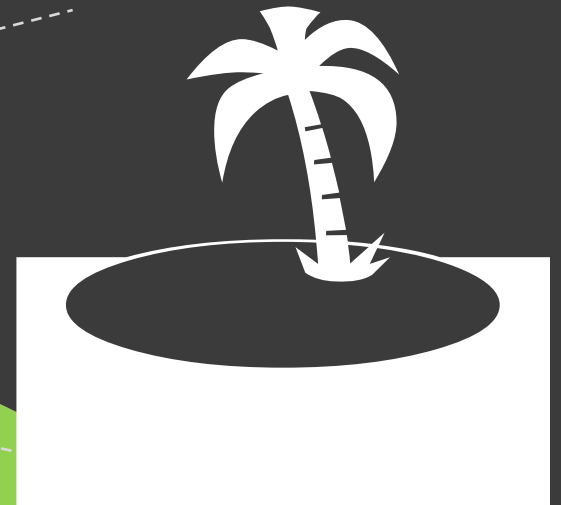
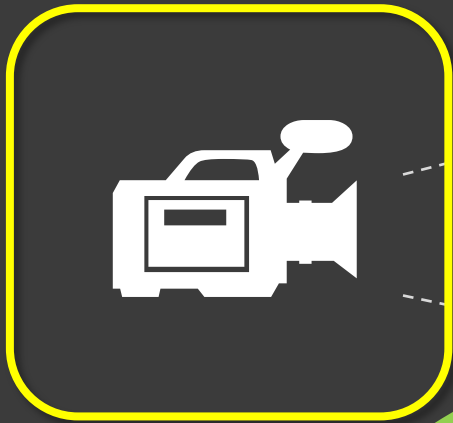


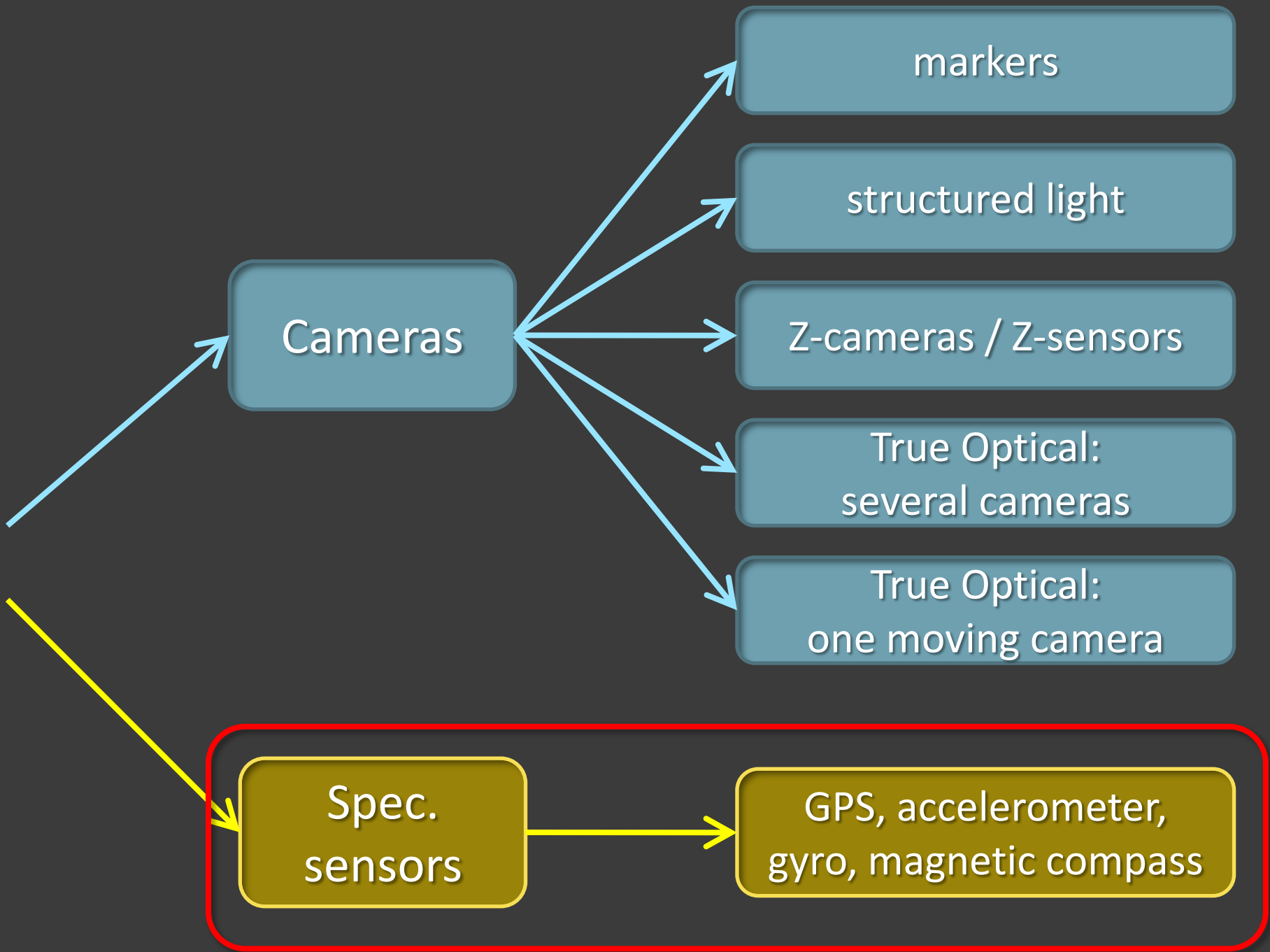


[Link](#)

HOW DOES IT WORK?

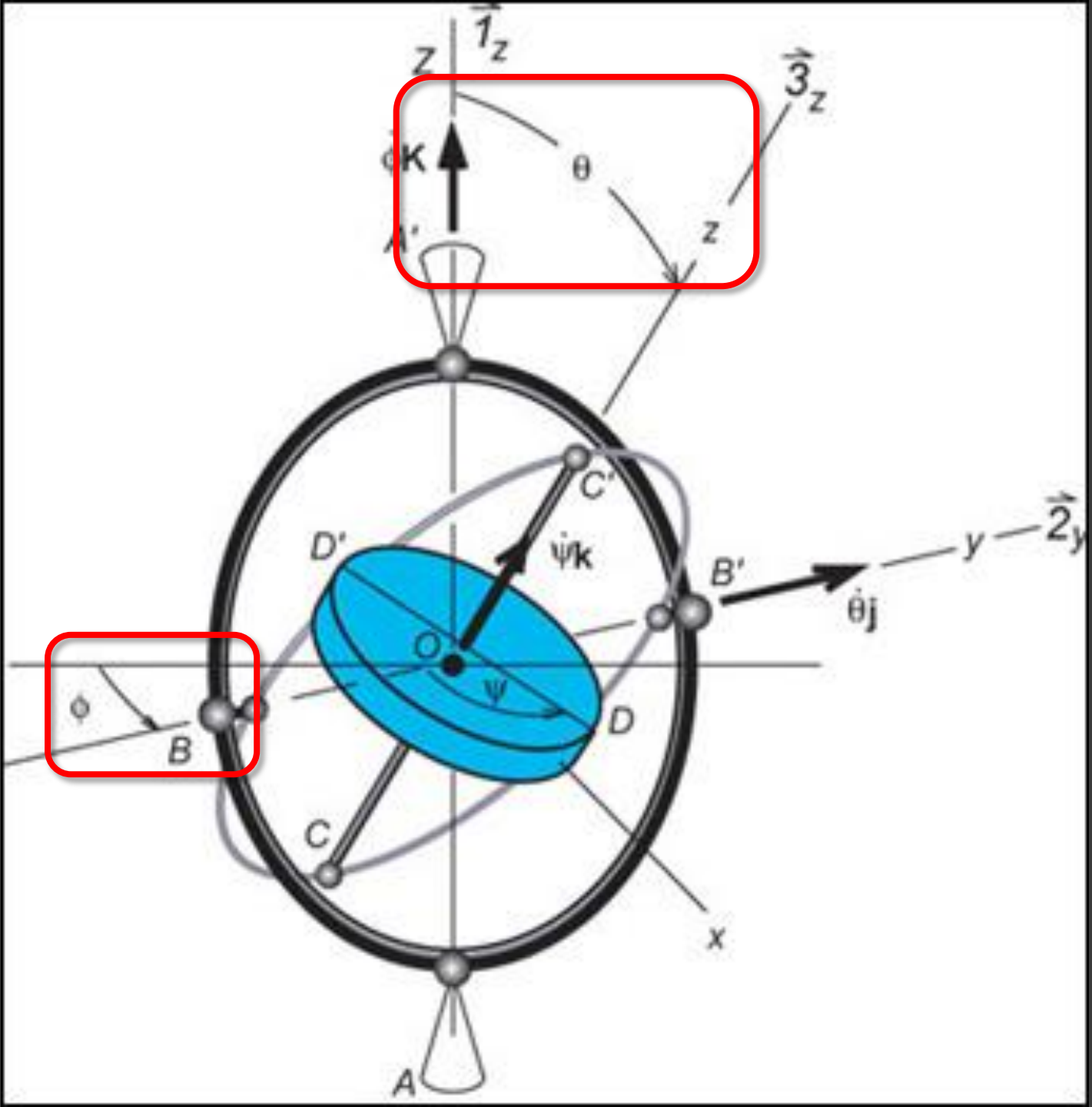
HOW DOES IT WORK?

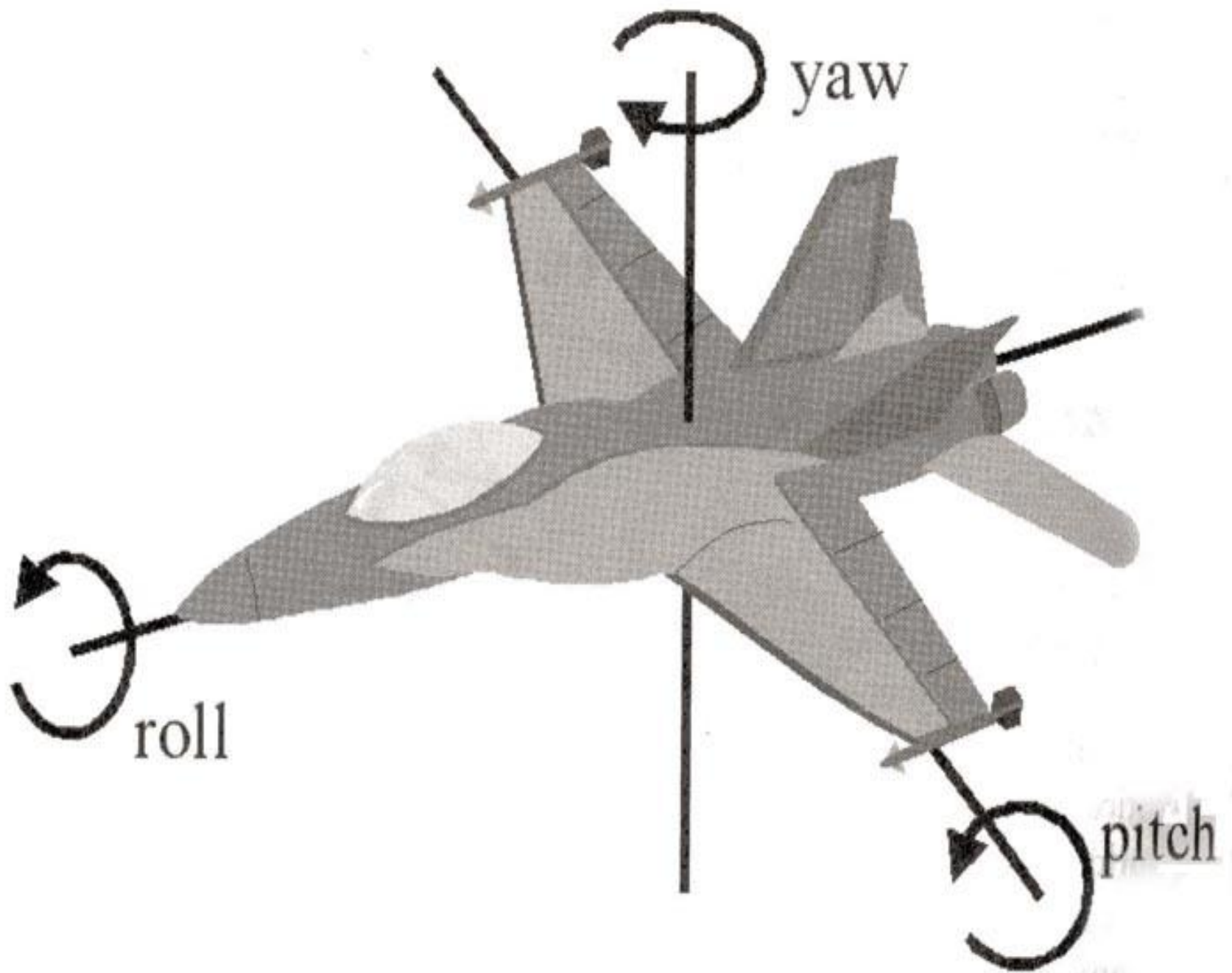




GYROSCOPE

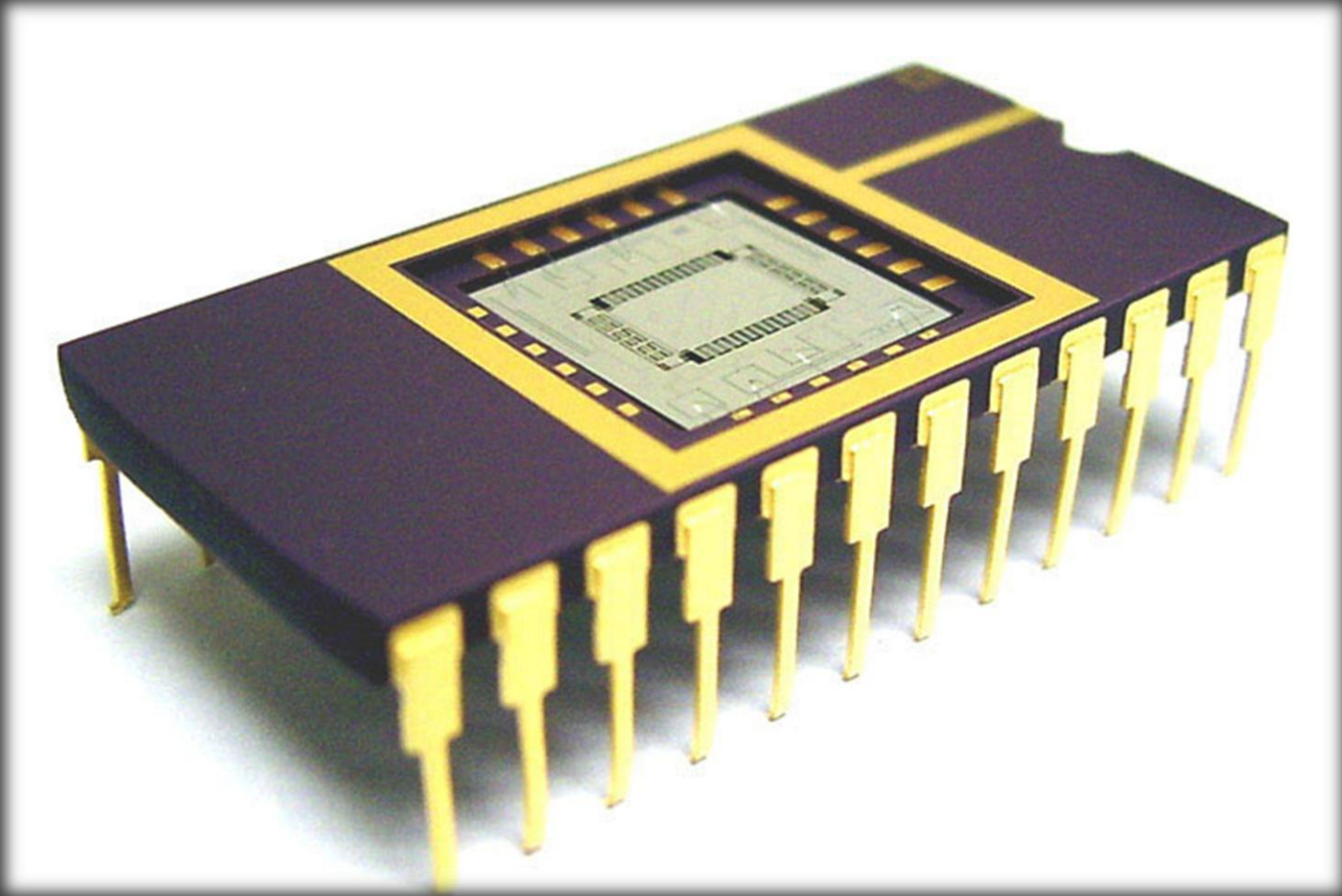


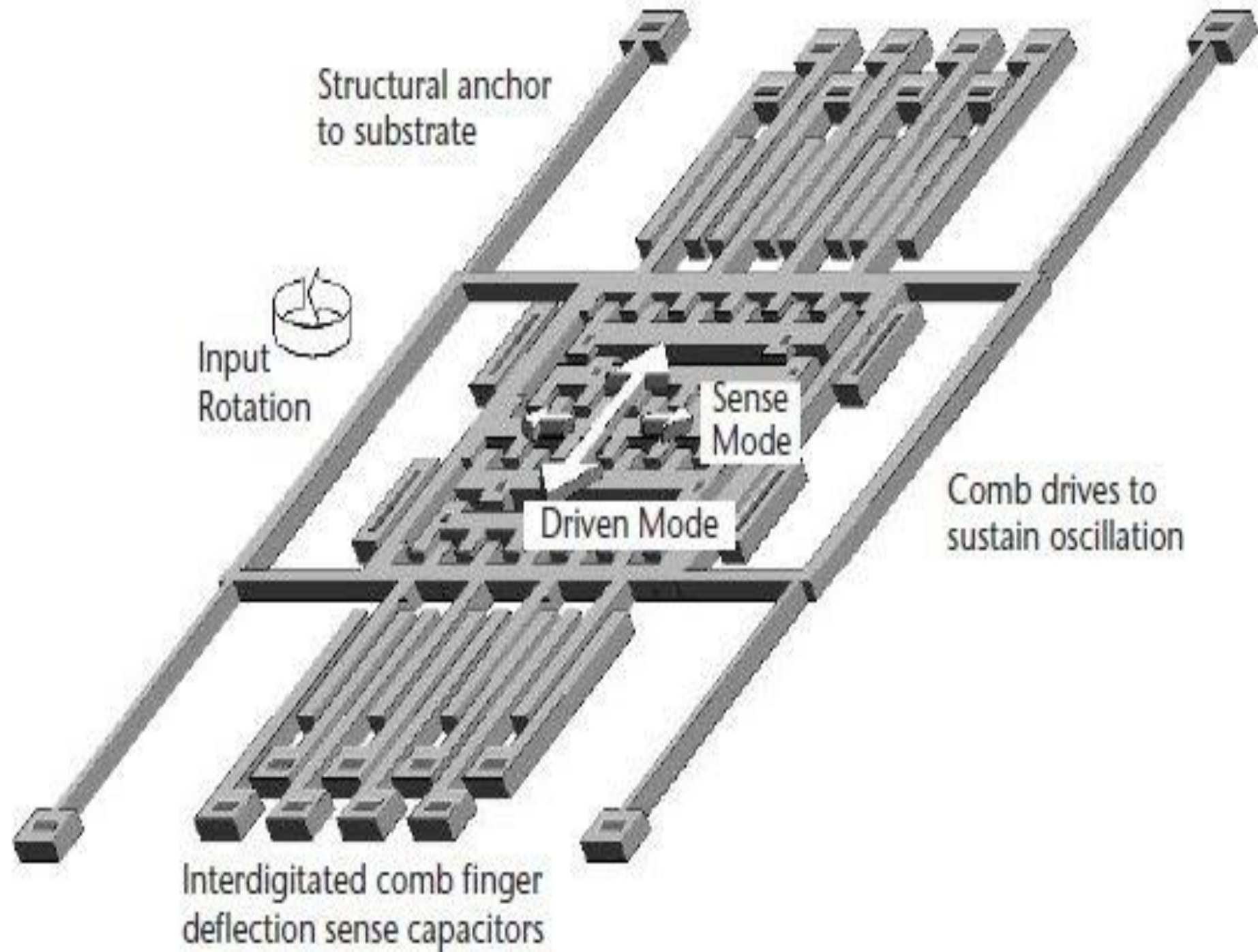


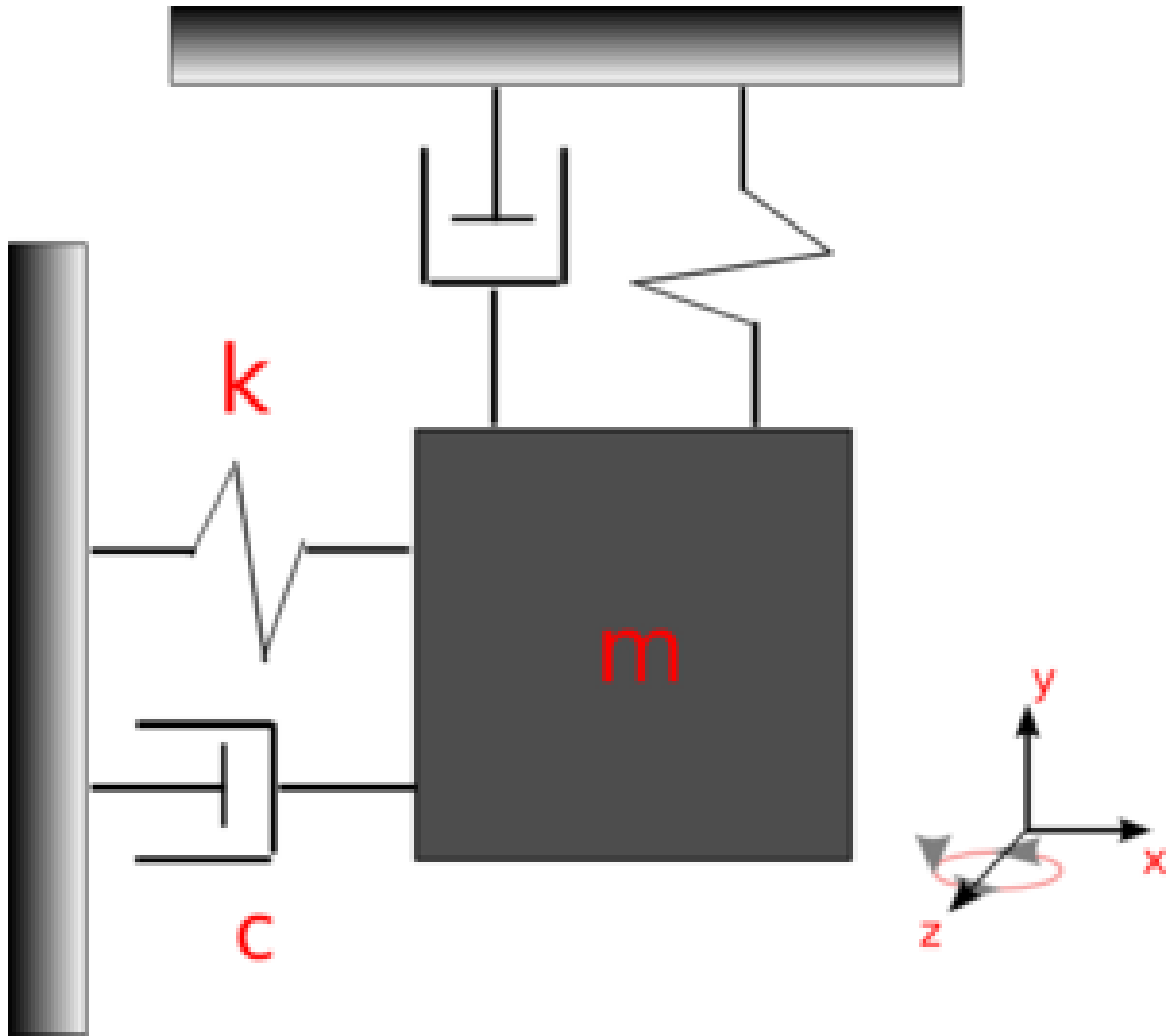


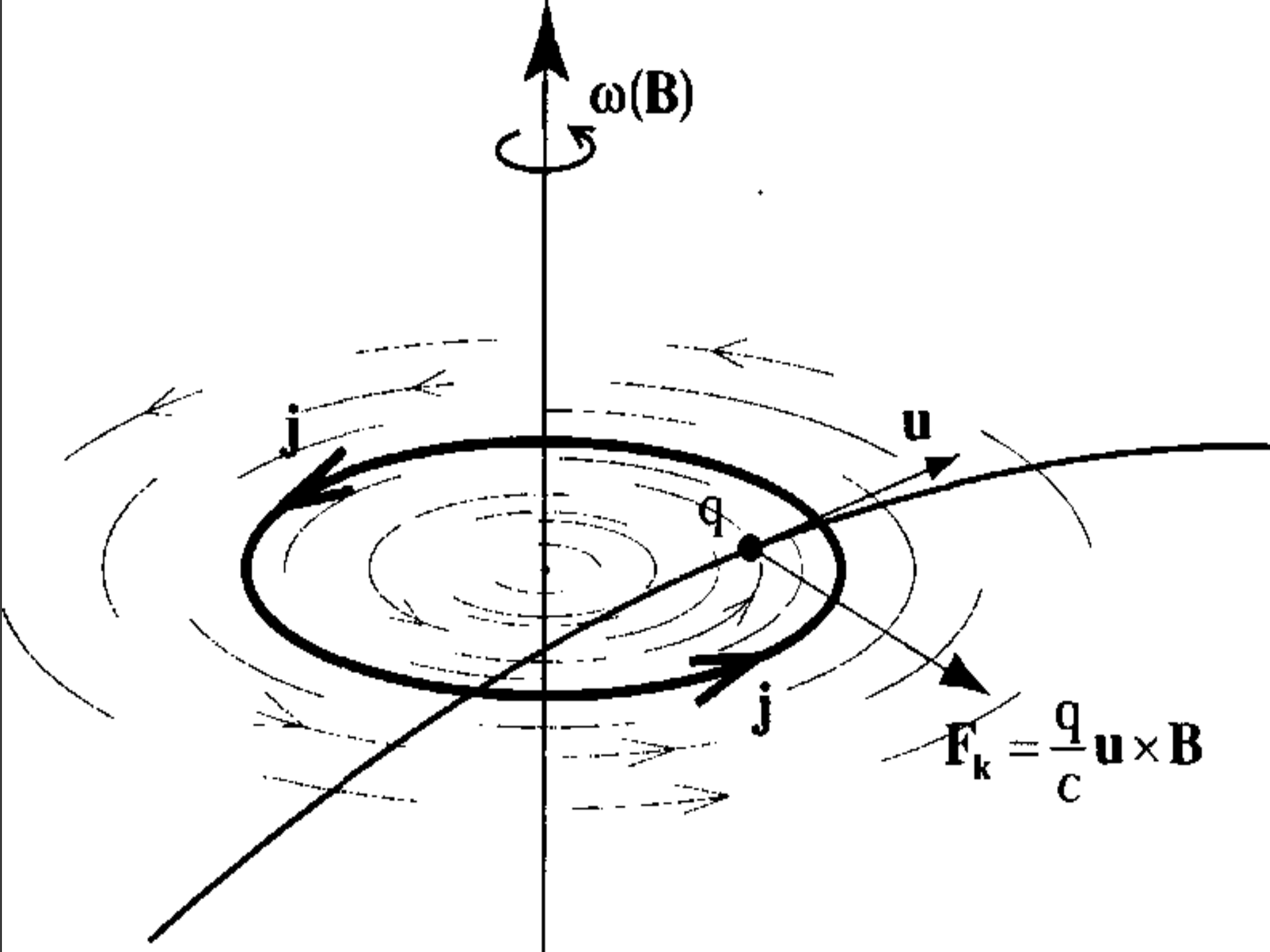


MICROMECHANICAL GYROSCOPE









1d:

$$\alpha(t) = \int_0^t \omega(\tau) d\tau$$

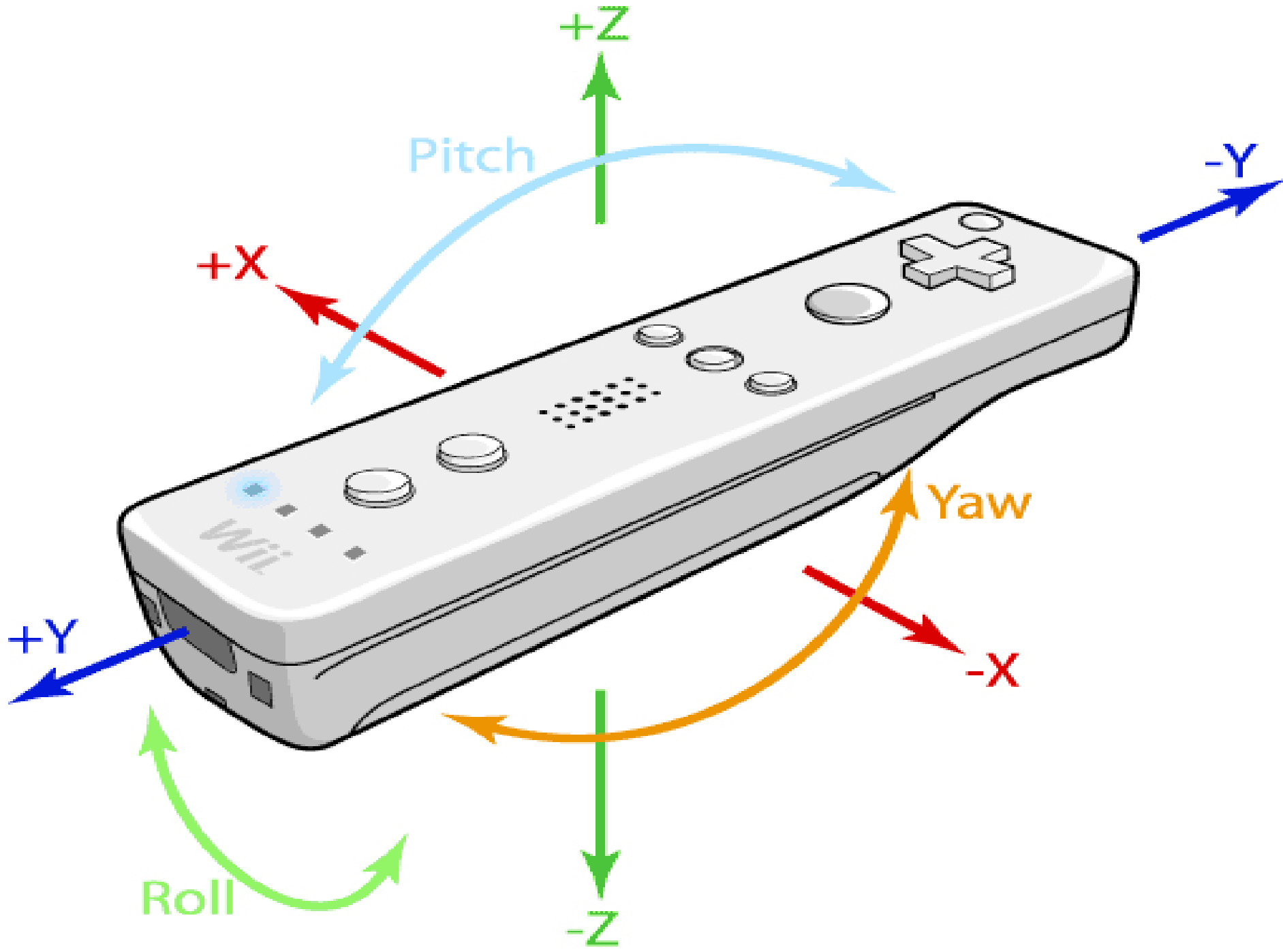
1d discrete:

$$\alpha_{i+1} = \alpha_i + \omega_i \Delta t$$

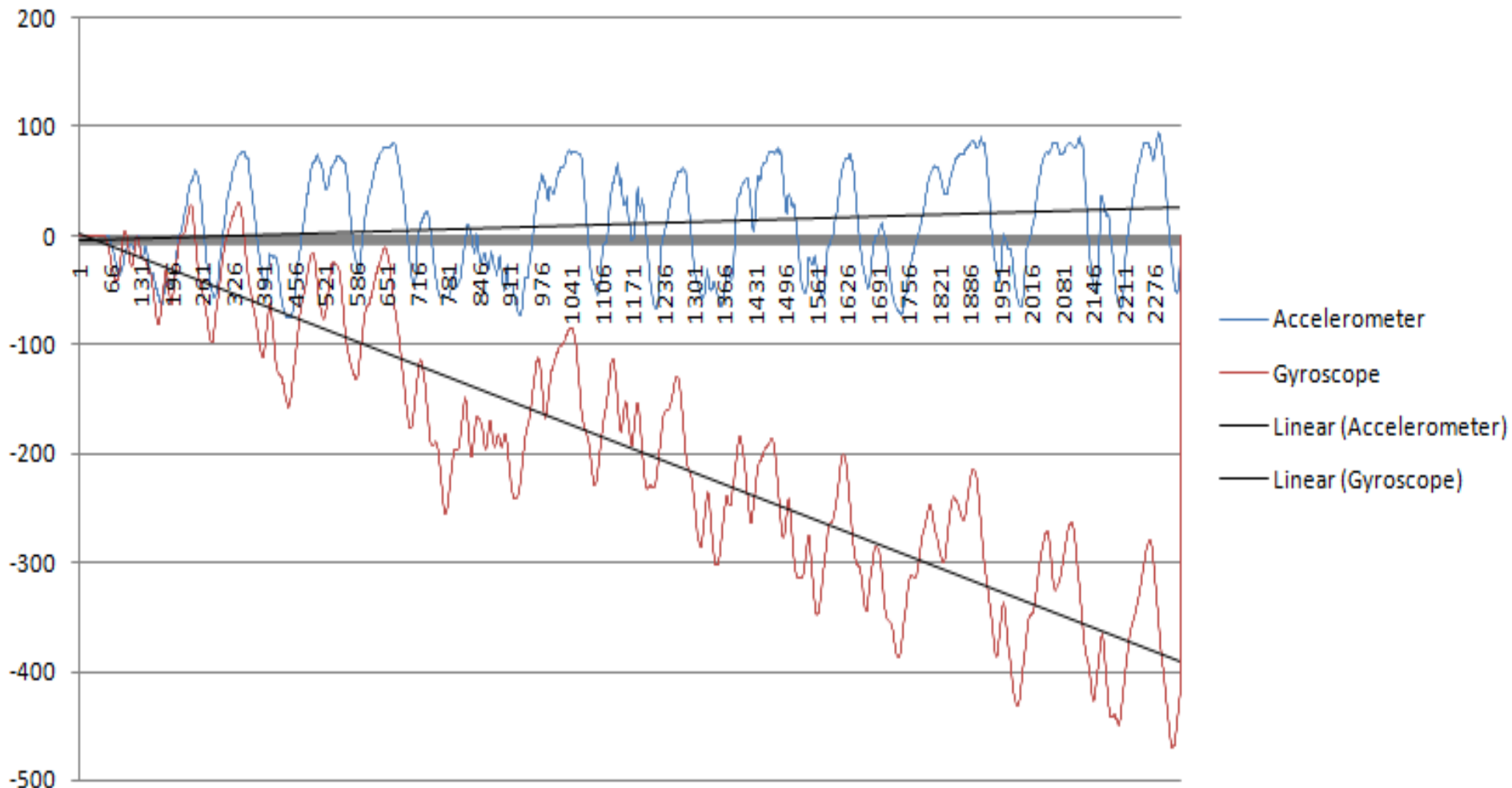
OUTPUT IS **ANGULAR VELOCITY**

3d discrete:

$$\mathbf{q}_{i+1} = \mathbf{q}_i \cdot \begin{pmatrix} \omega_i^x \Delta t \\ \omega_i^y \Delta t \\ \omega_i^z \Delta t \\ 0 \end{pmatrix}$$



ERROR ACCUMULATION =>
=> **DRIFT** == LOW-FREQUENCY NOISE

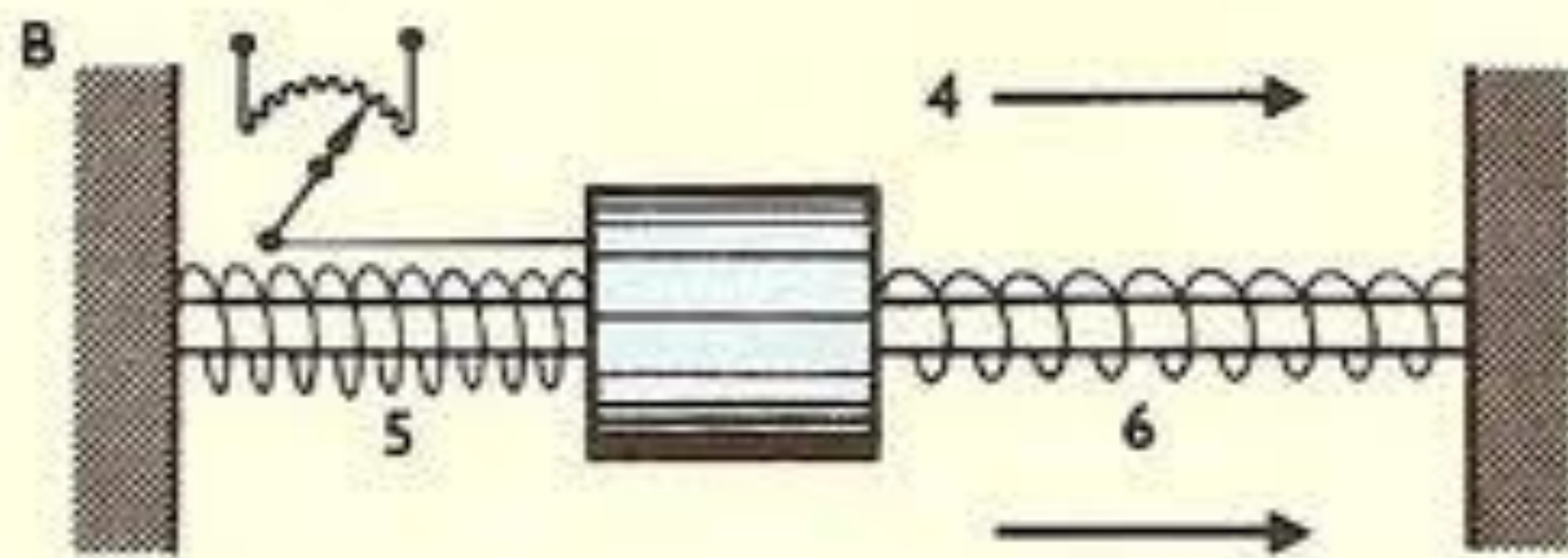
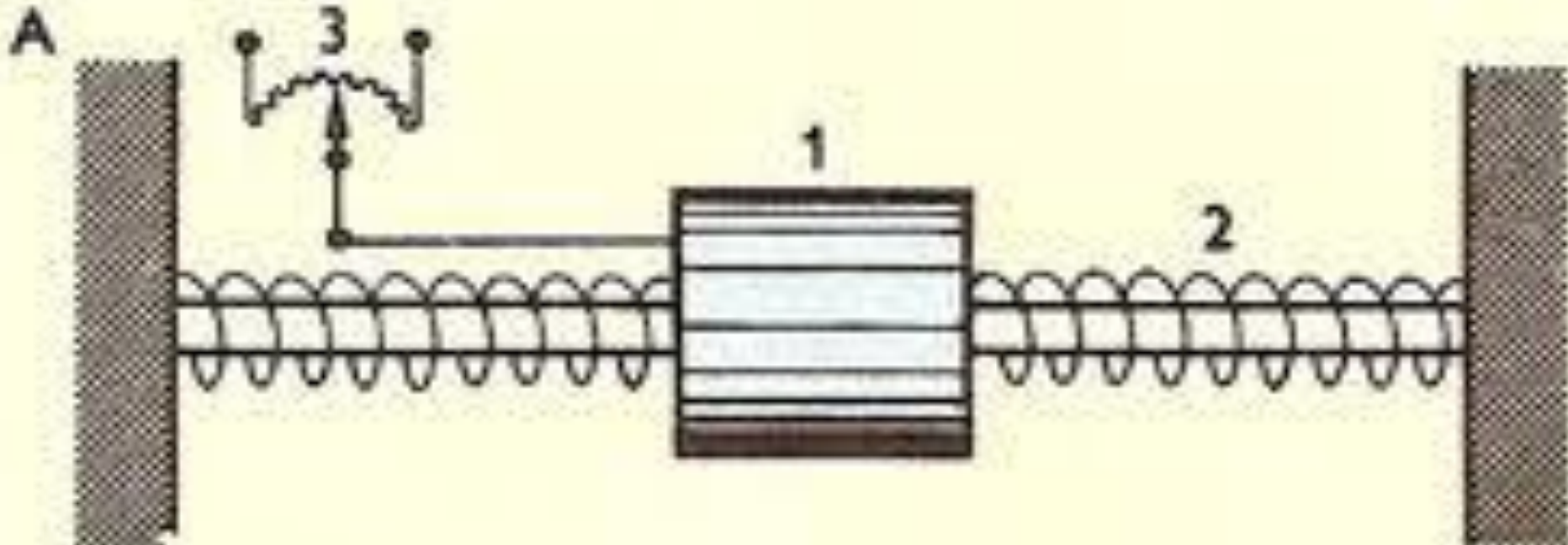


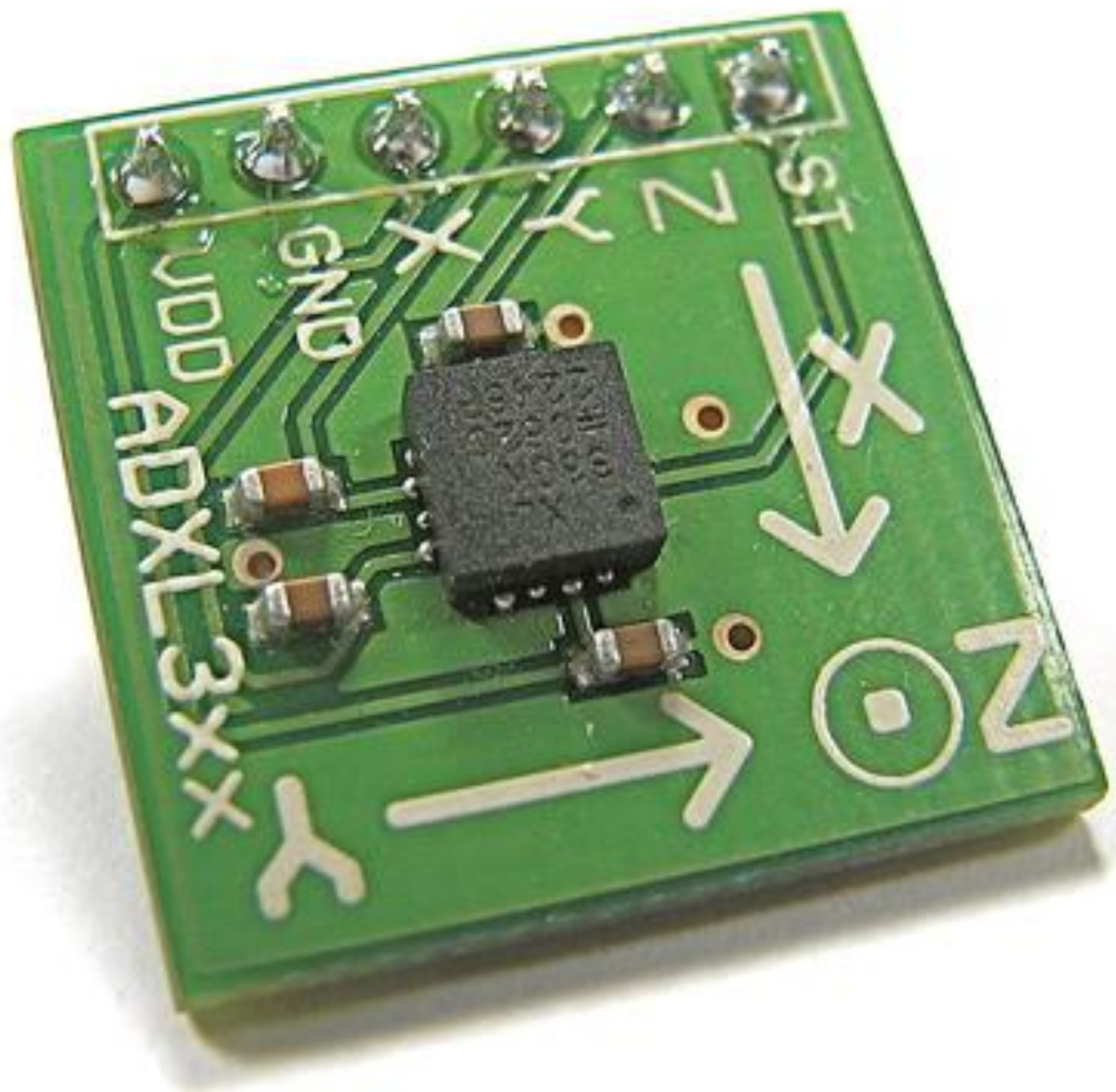
Электростатические гироскопы

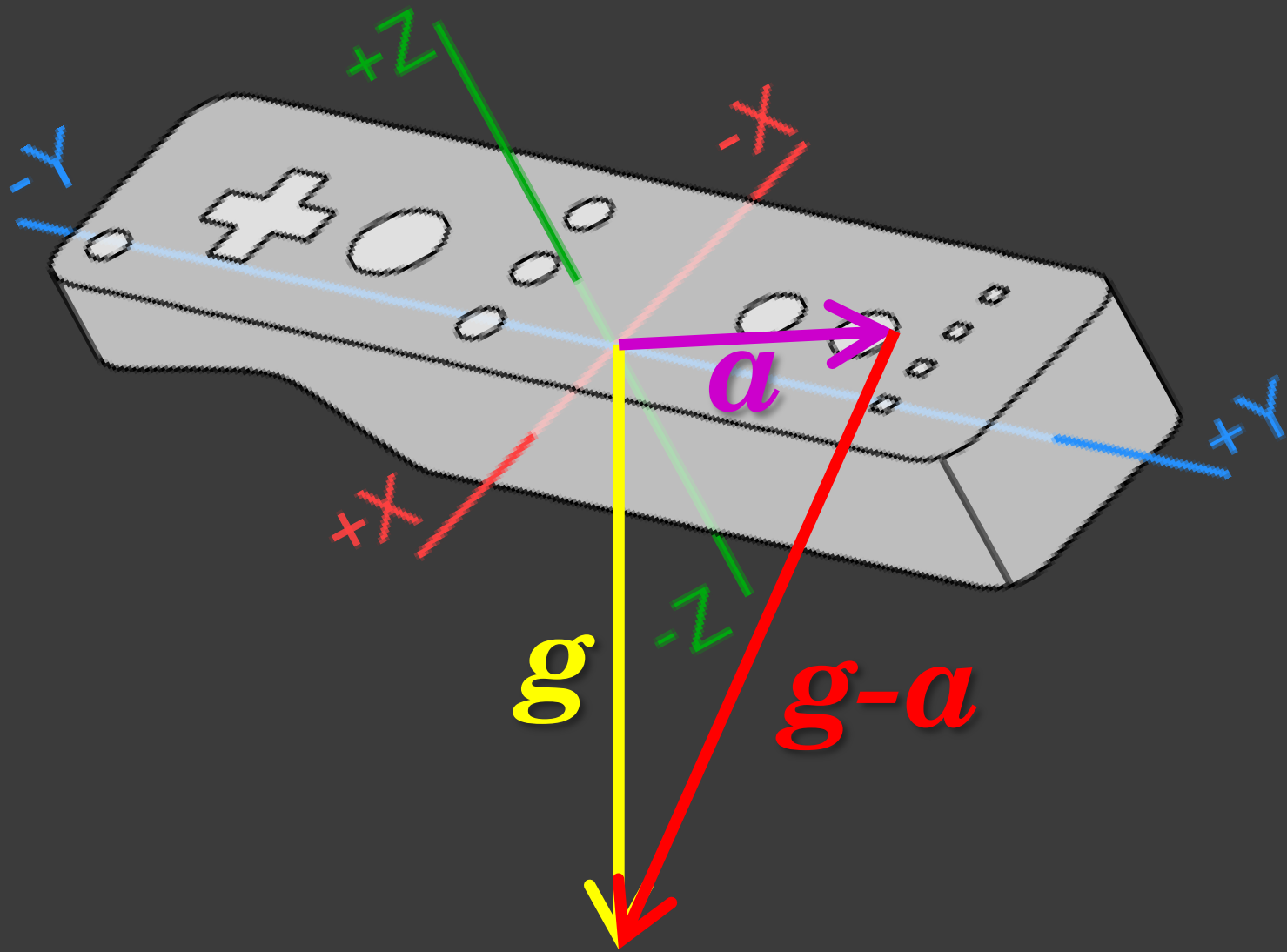
[Link](#)



ACCELEROMETER

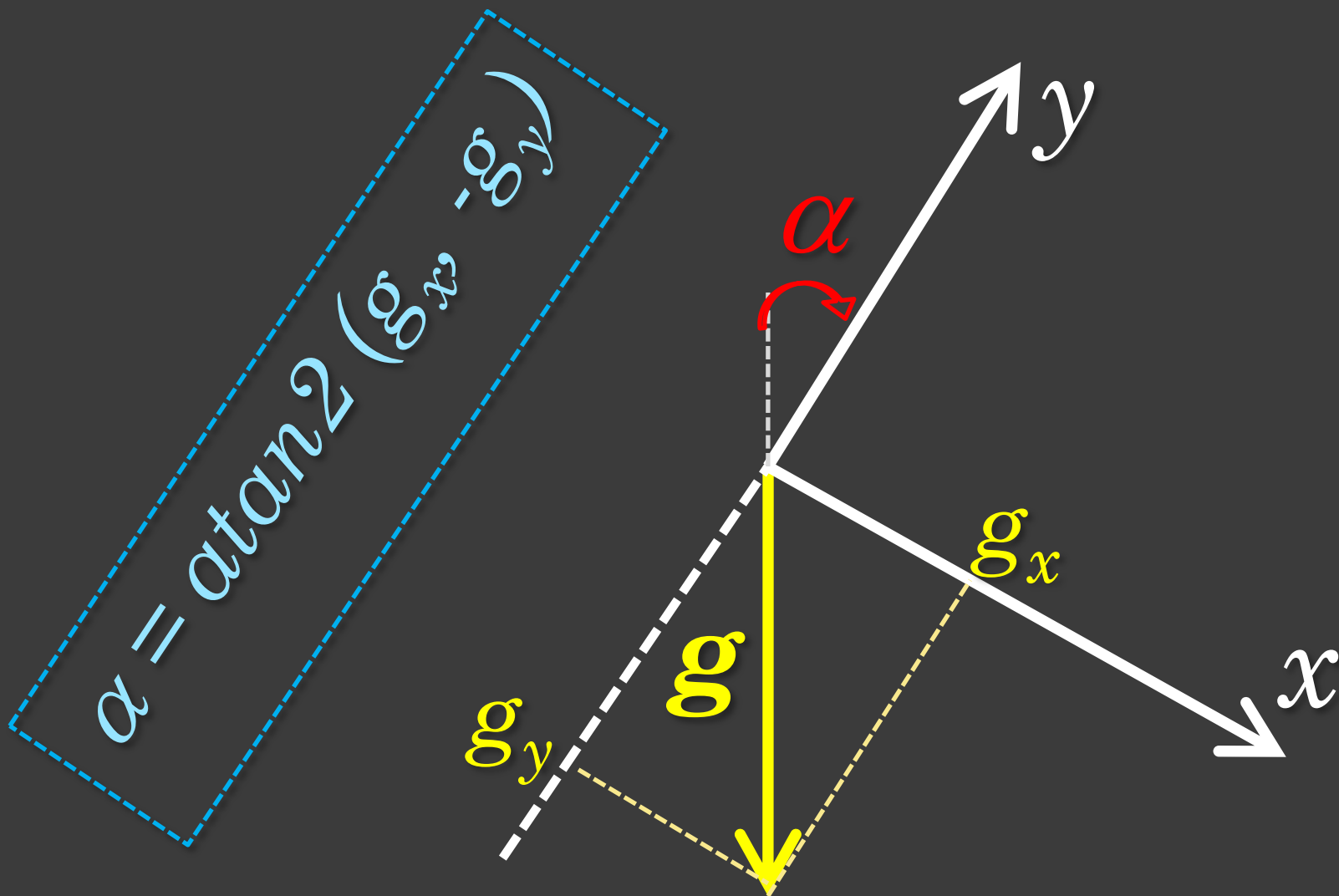


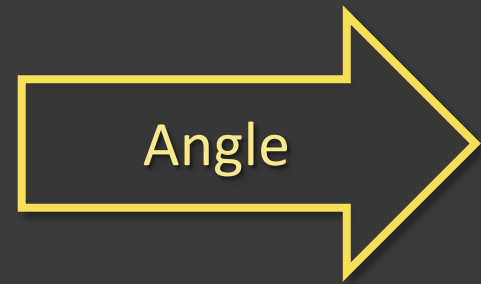
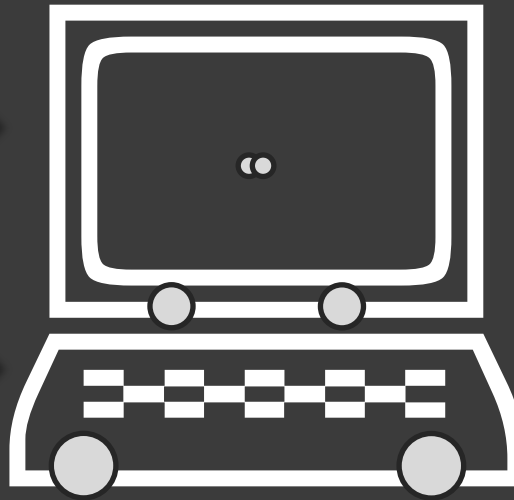
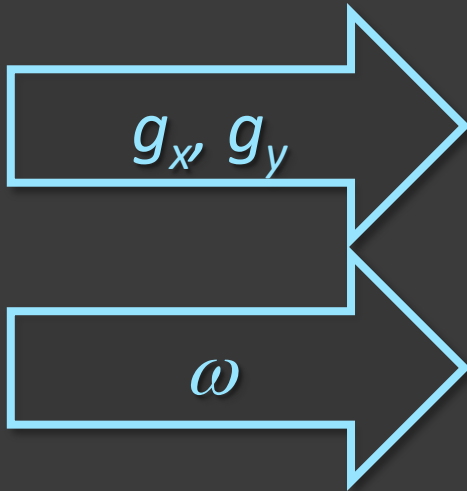




Output is $(g-a)$ in coordinate system of device

Case: 1d, $\mathbf{a} \cong 0$

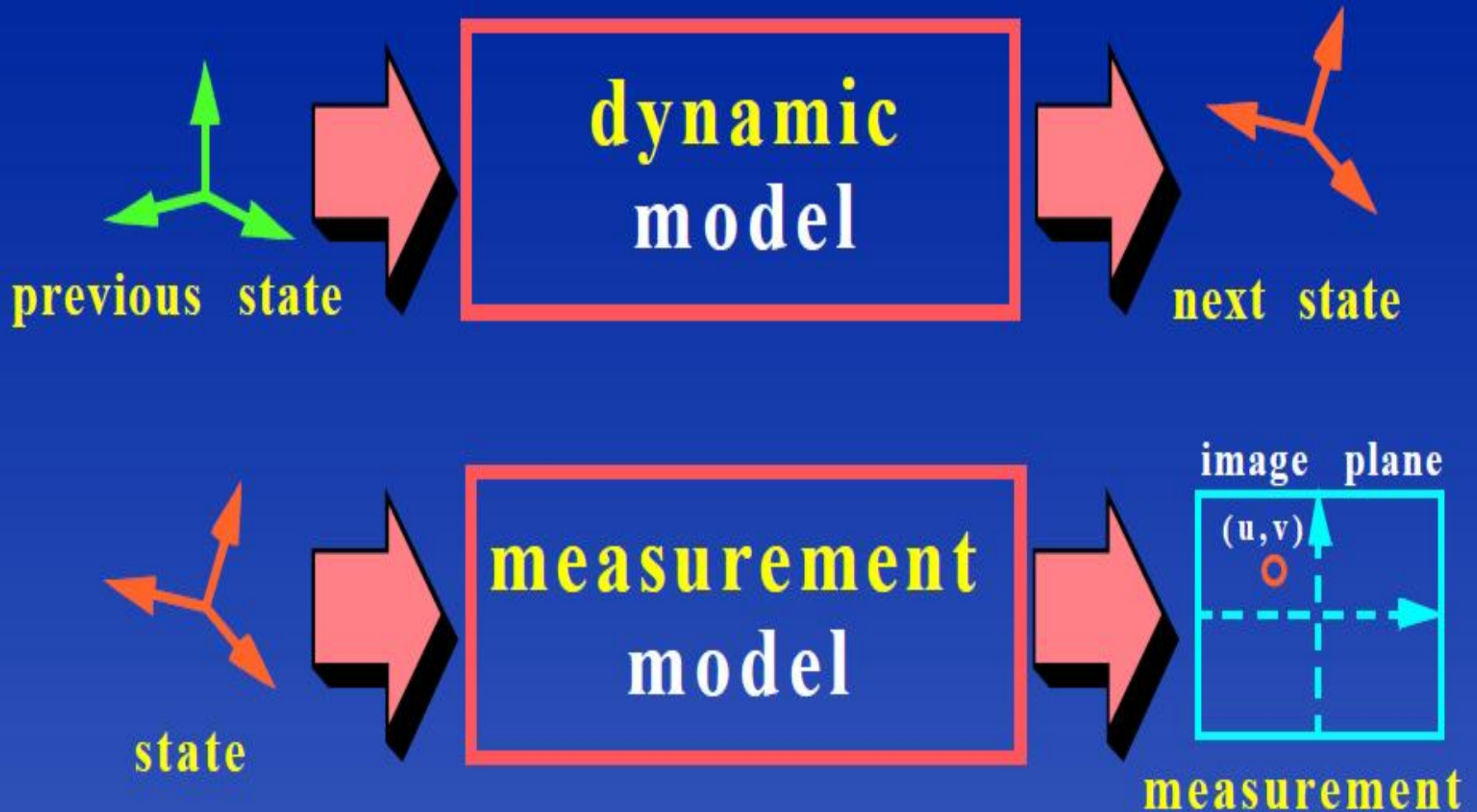


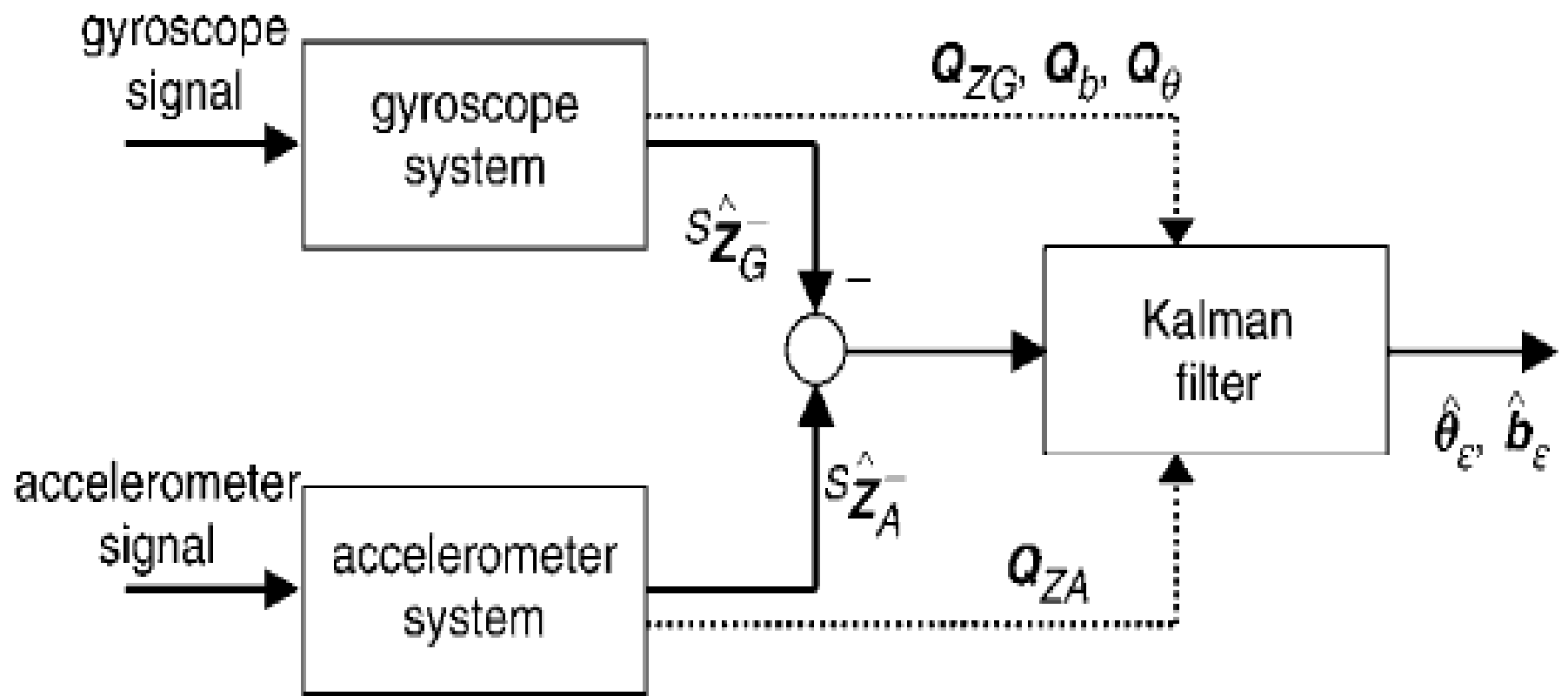


Magic
==
Kalman Filter

Complementary
Filter

KALMAN FILTER IS BASED ON MODELS





[Link](#)

[C++ implementation](#)

kalman filter android



Search

Instant is on ▼

About 41,200 results (0.20 seconds)

[Advanced search](#)

[\[android-developers\] Re: Low accuracy of the accelerometer Sensor](#) ☆

Now for Kalman filtering. I do have a little experience with Kalman ... to the Android NDK (native development kit) 2) Kalman assumes noise ...

www.mail-archive.com/android...com/msg46111.html - [Cached](#)

[Kalman Filter for Android - Stack Overflow](#) ☆

stackoverflow.com/questions/2839090/kalman-filter-for-android

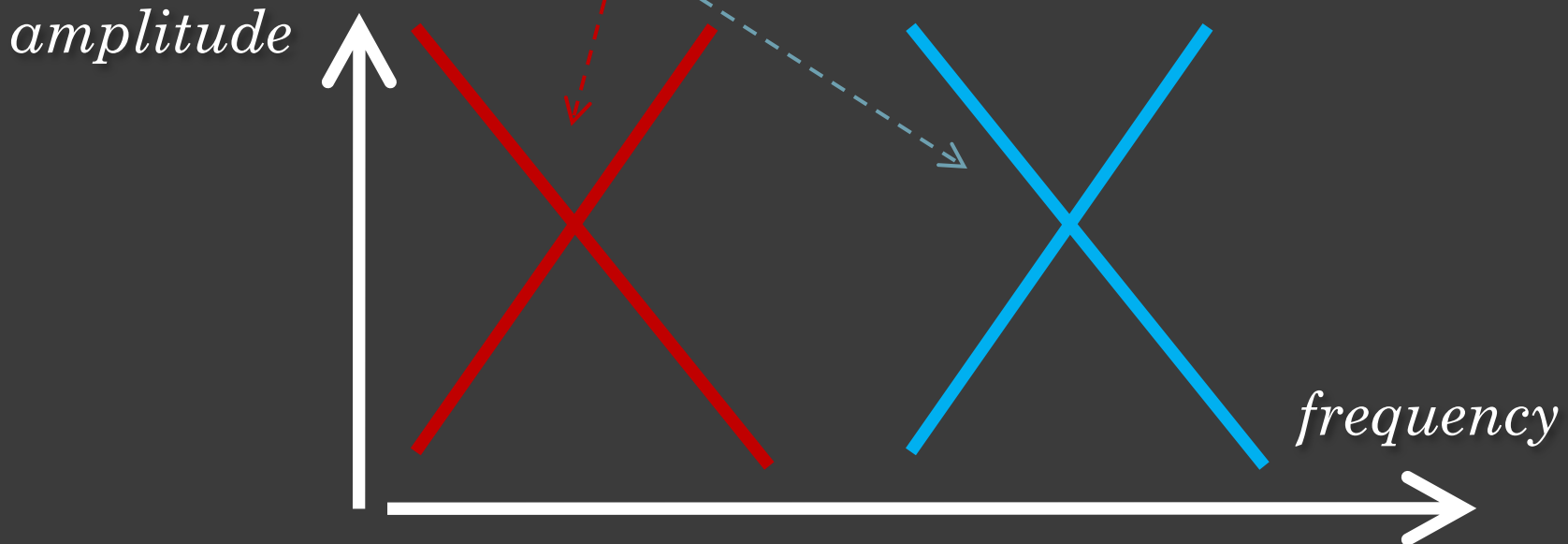
[Filtering accelerometer data noise - Stack Overflow](#) ☆

How do I filter noise of the accelerometer data in Android? ... I have read that Kalman filter might be the best candidate for this, but how do I integrate ...

stackoverflow.com/.../filtering-accelerometer-data-noise - [Cached](#) - [Similar](#)

COMPLEMENTARY FILTER

$$\alpha_{i+1} = (1 - \delta) \cdot (\alpha_i + \omega_i \Delta t) + \delta \cdot \text{atan2}(g_i^x, -g_i^y)$$



HOW TO CHOOSE VALUE OF COEFF.?

$$\tau = \frac{1 - \delta}{\delta} \Delta t$$

e. g. $\delta = 0.02, \Delta t = 0.01sec$

$$\Rightarrow \tau = \frac{0.98}{0.02} 0.01sec = 0.49sec$$

FIXATION COMPLÉMENTAIRE

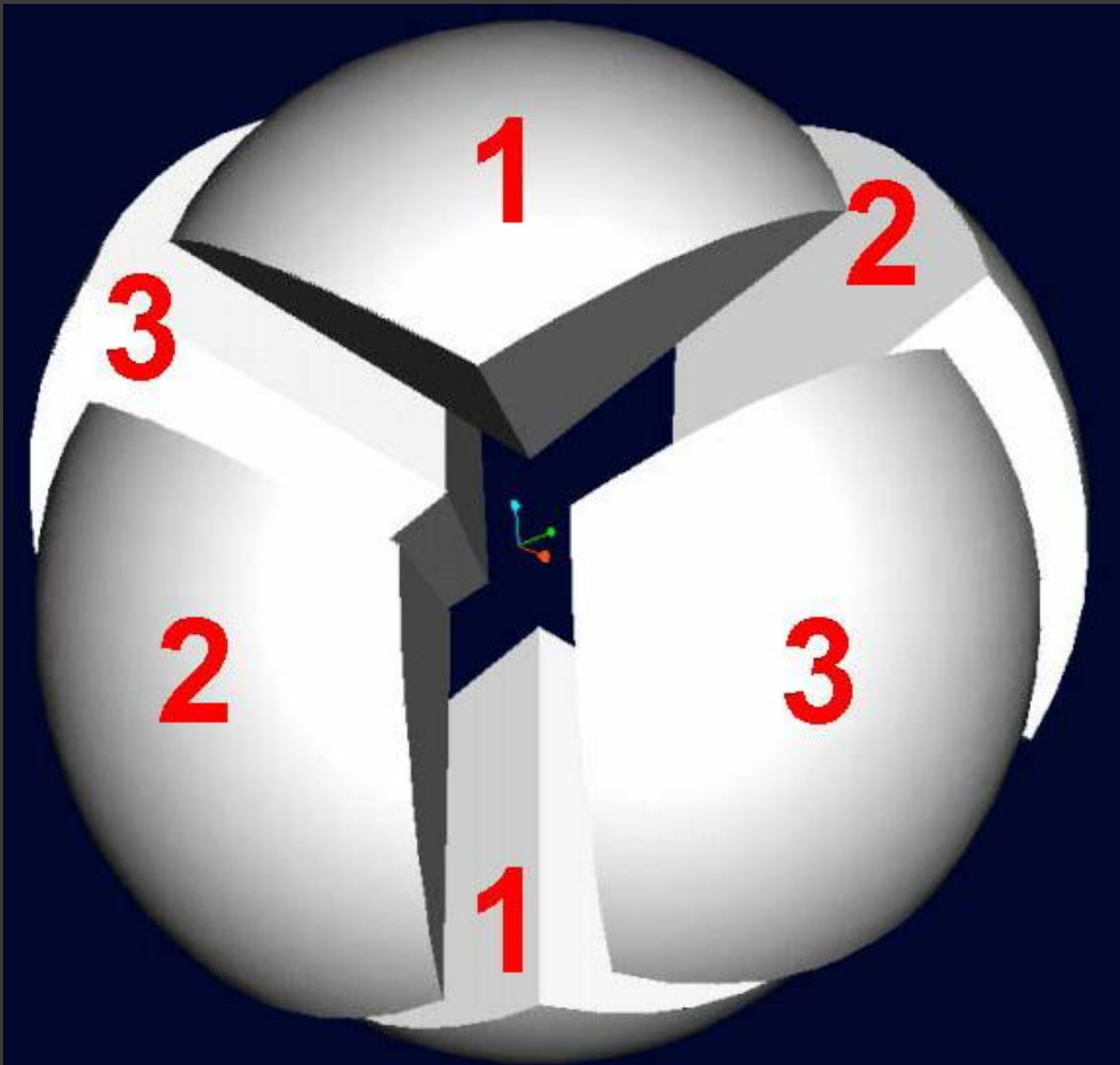
COMPLÉMENTAIRE

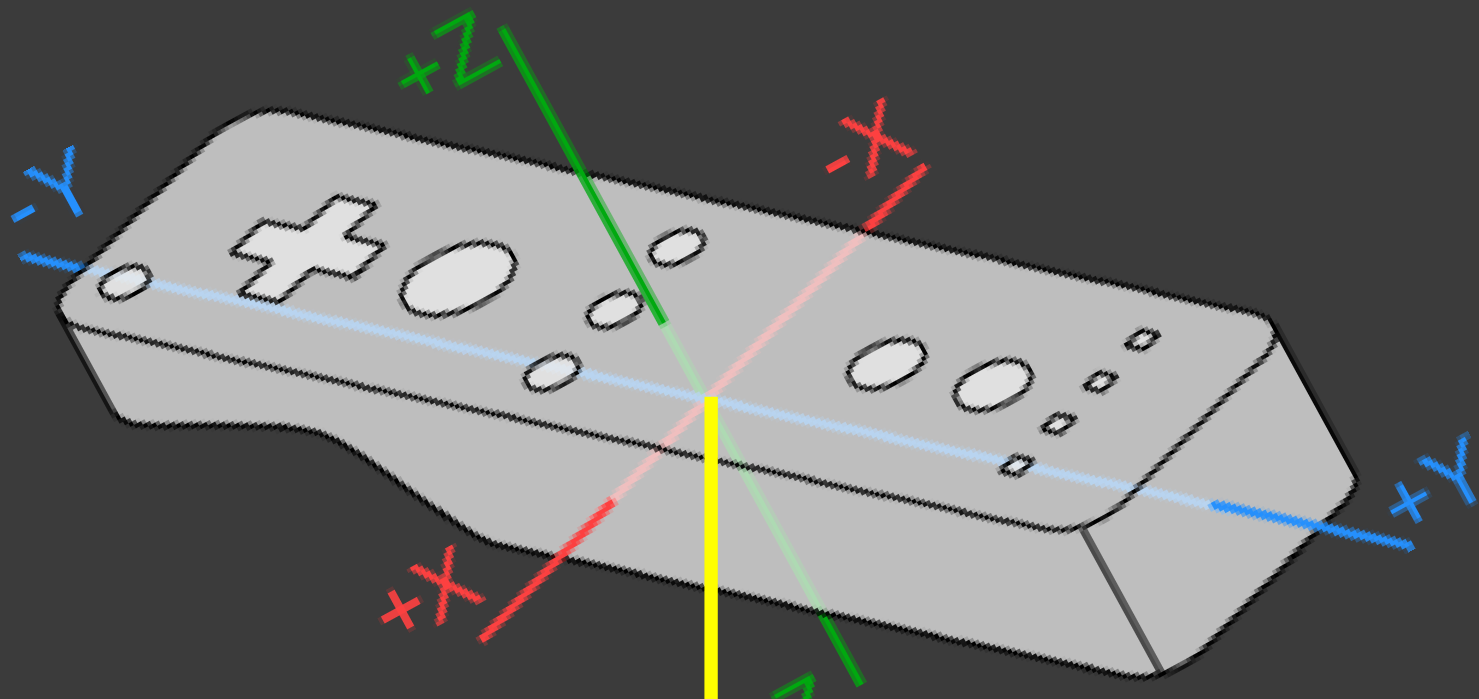


1D \Rightarrow 3D

$$\mathbf{q}_{i+1} = (1 - \delta) \cdot \left(\mathbf{q}_i + \frac{1}{2} \mathbf{q}_i \cdot \begin{pmatrix} \omega_i^x \Delta t \\ \omega_i^y \Delta t \\ \omega_i^z \Delta t \\ 0 \end{pmatrix} \right) + \delta \mathbf{q}_{correct}$$

$$\mathbf{q}_{correct} = \frac{1}{2} \mathbf{q}_i \cdot \begin{pmatrix} error_i^x \Delta t \\ error_i^y \Delta t \\ error_i^z \Delta t \\ 0 \end{pmatrix}$$



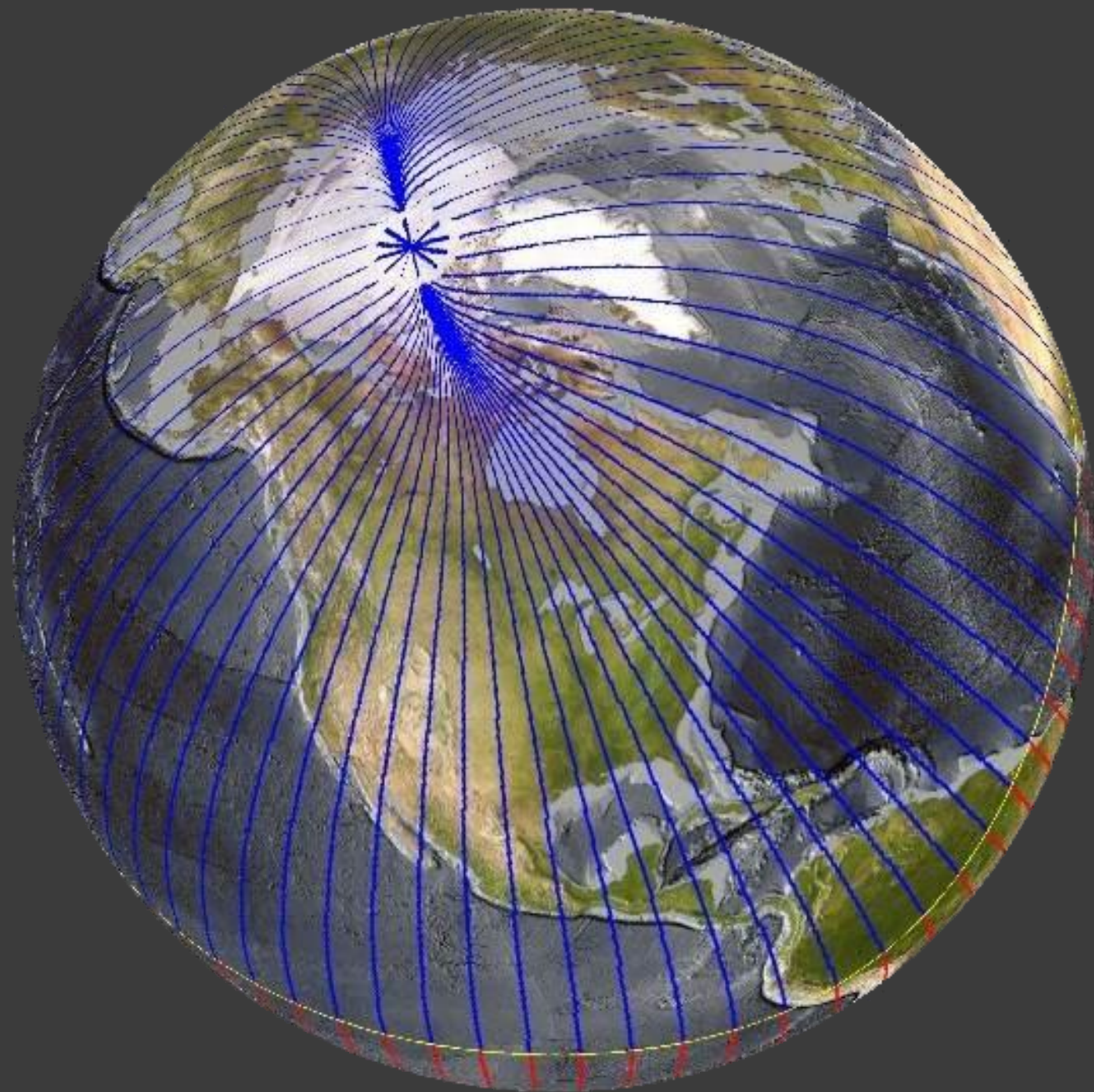


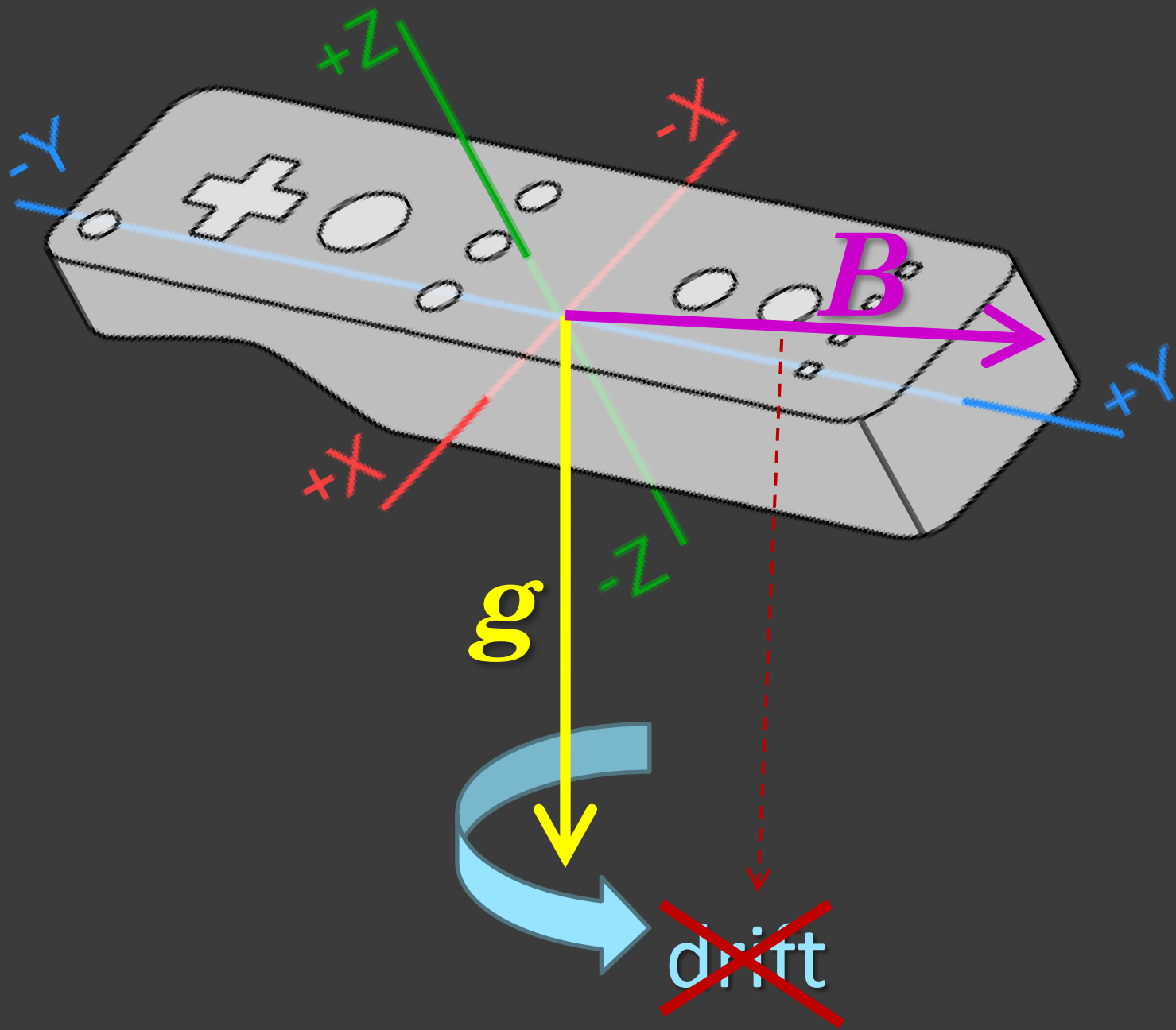
g



drift ☹️

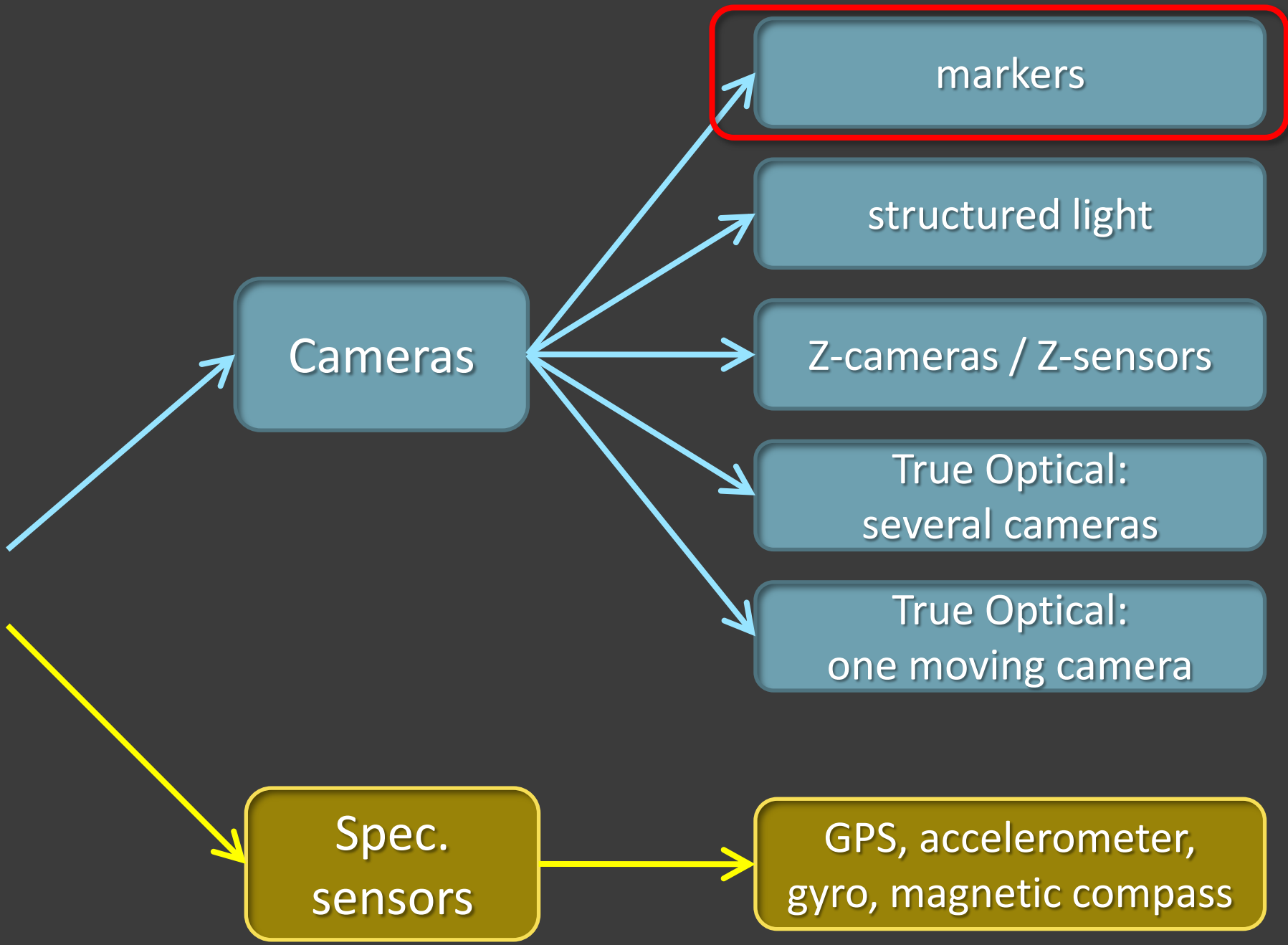
MAGNETIC COMPASS





THUS, MAGNETIC COMPASS

IS VERY IMPORTANT!



markers

structured light

Z-cameras / Z-sensors

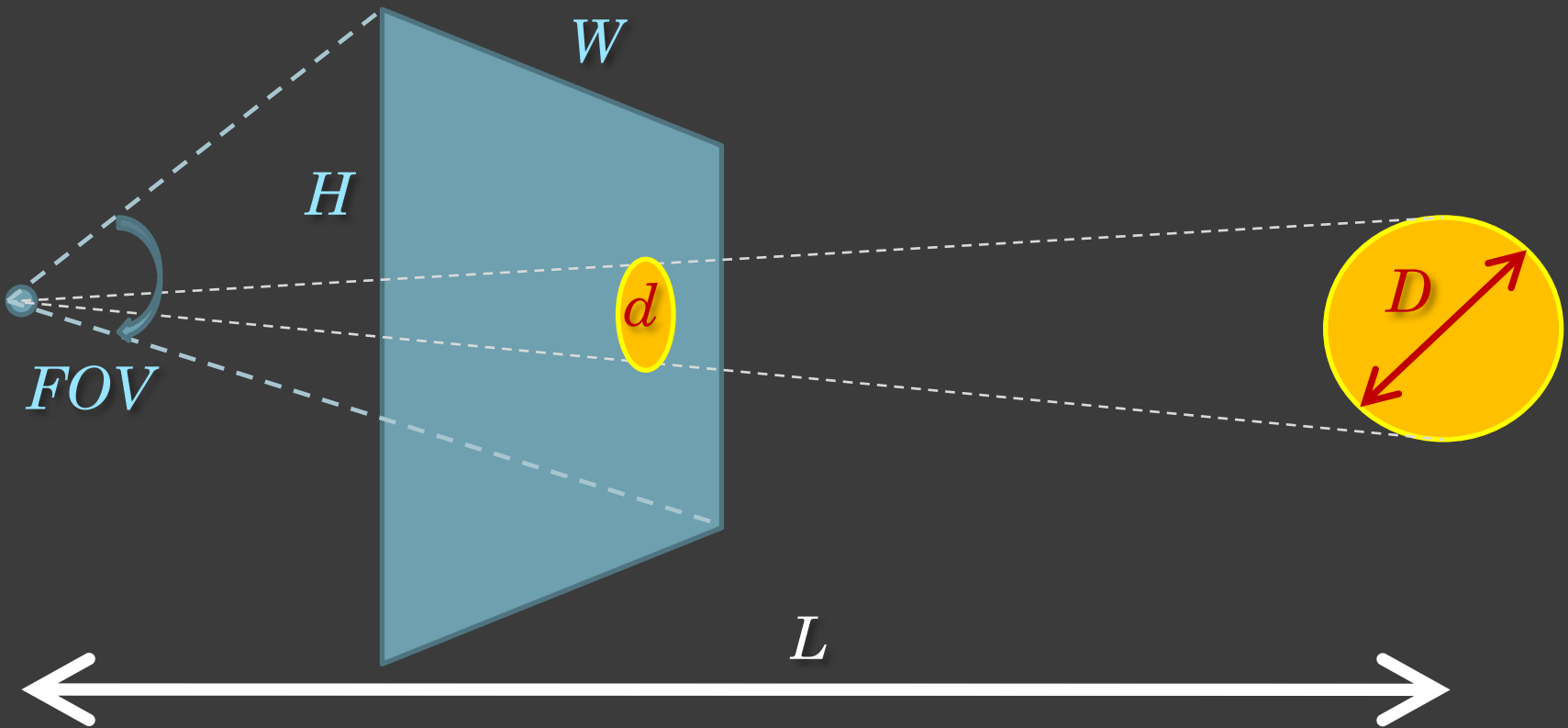
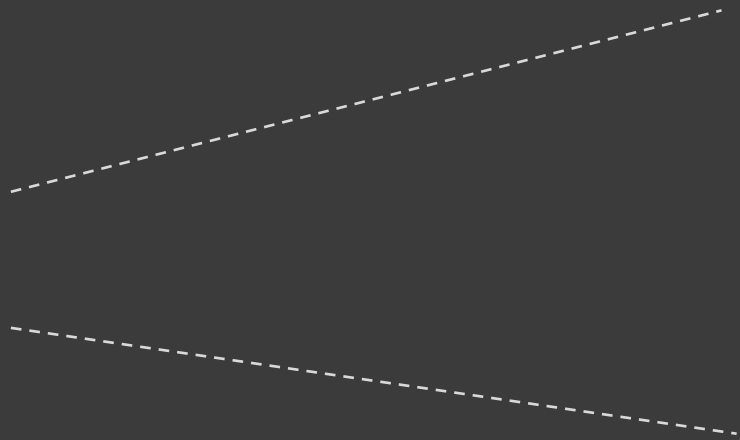
True Optical:
several cameras

True Optical:
one moving camera

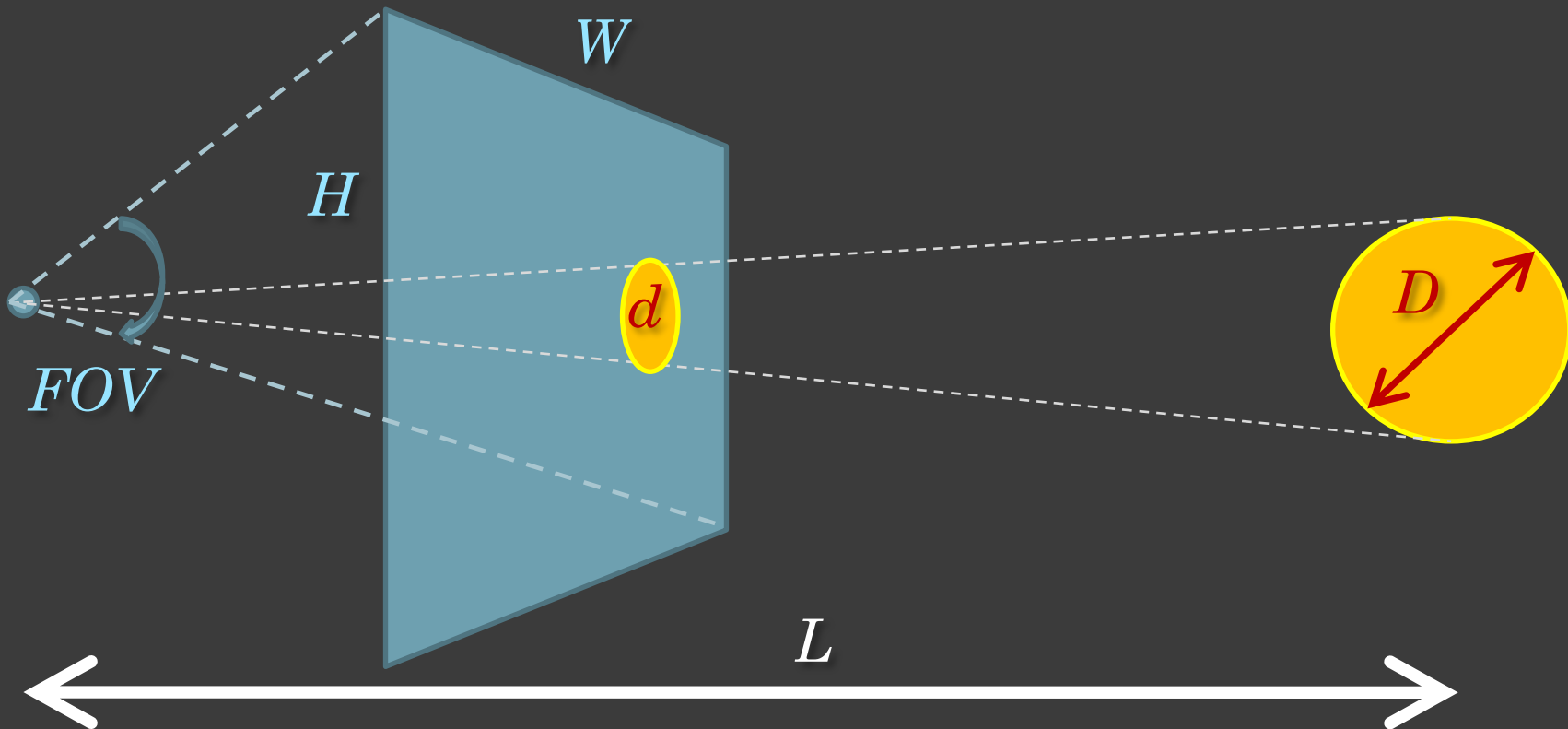
Cameras

Spec.
sensors

GPS, accelerometer,
gyro, magnetic compass



$$L = D \frac{\sqrt{H^2 + W^2}}{d \cdot FOV}$$



e.g. $FOV = 75^\circ, W = 640px, H = 480px$

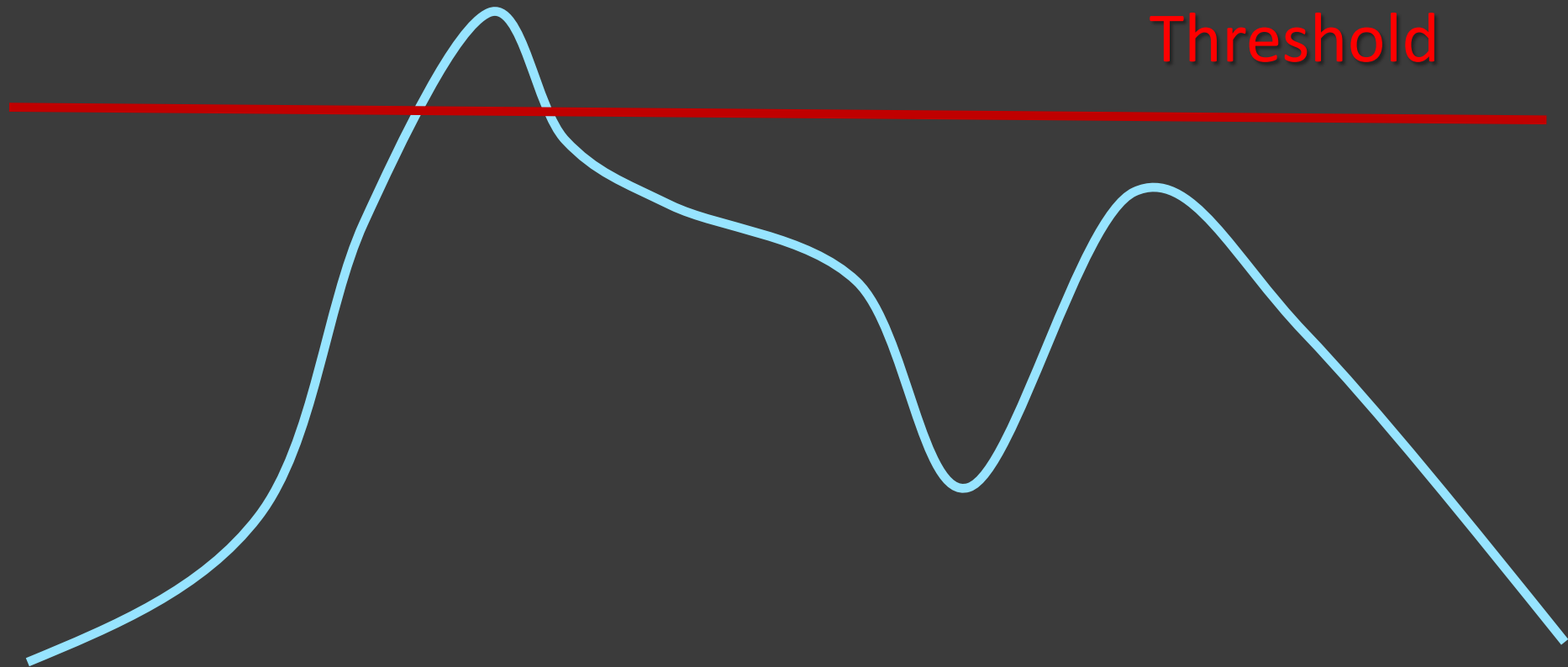
$$D = 5cm, d = 20px$$

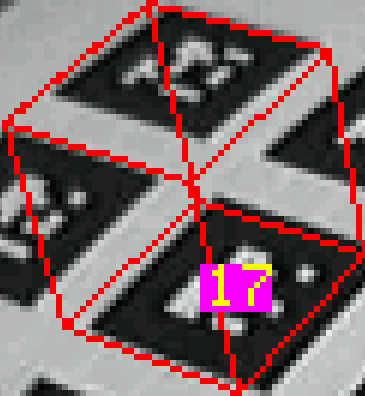
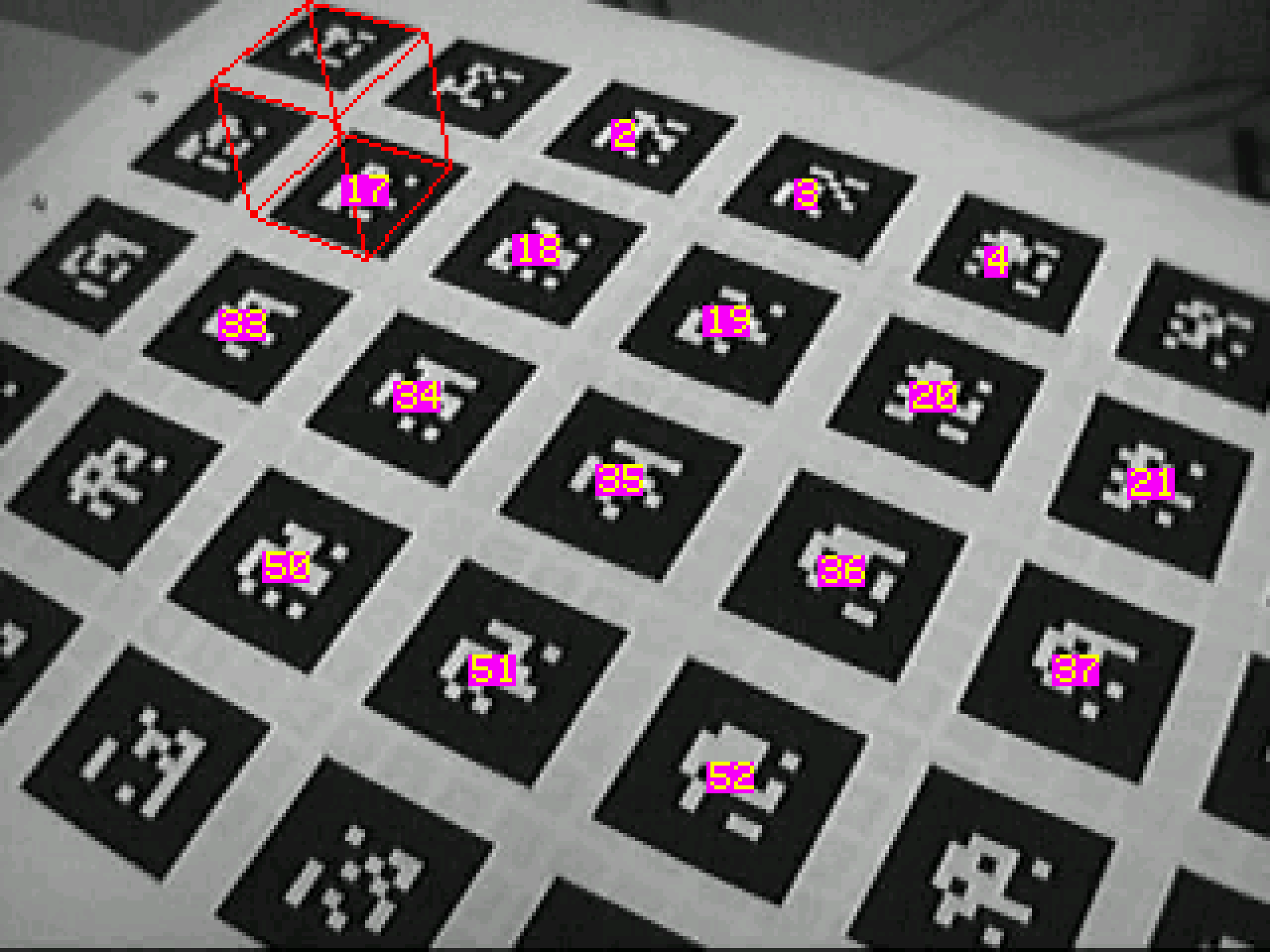
$$L = 5cm \cdot \frac{\sqrt{480^2 + 640^2}}{20 \cdot 75 \cdot \pi / 180} \approx 153cm$$





HOW TO DETECT MARKER(S) ON IMAGE





17

2

3

4

18

19

33

34

20

21

35

50

36

37

51

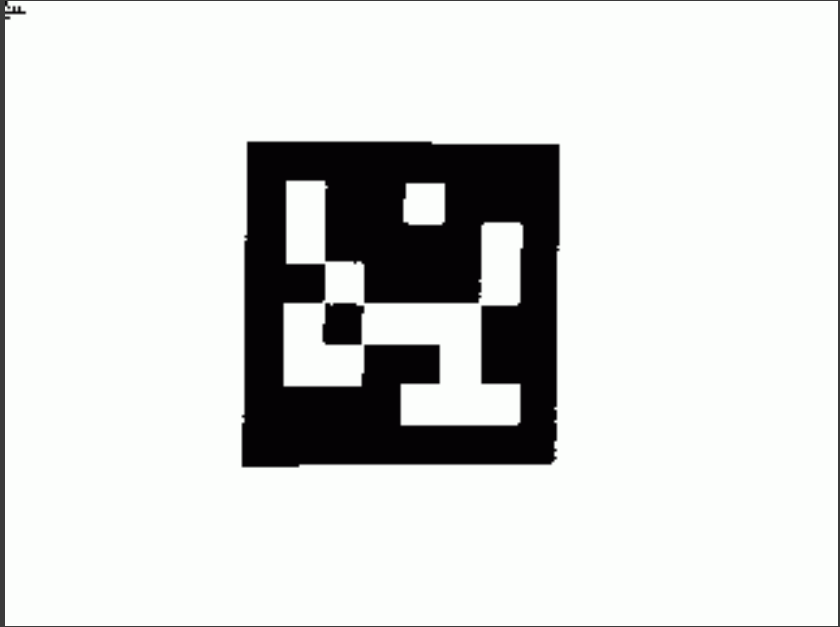
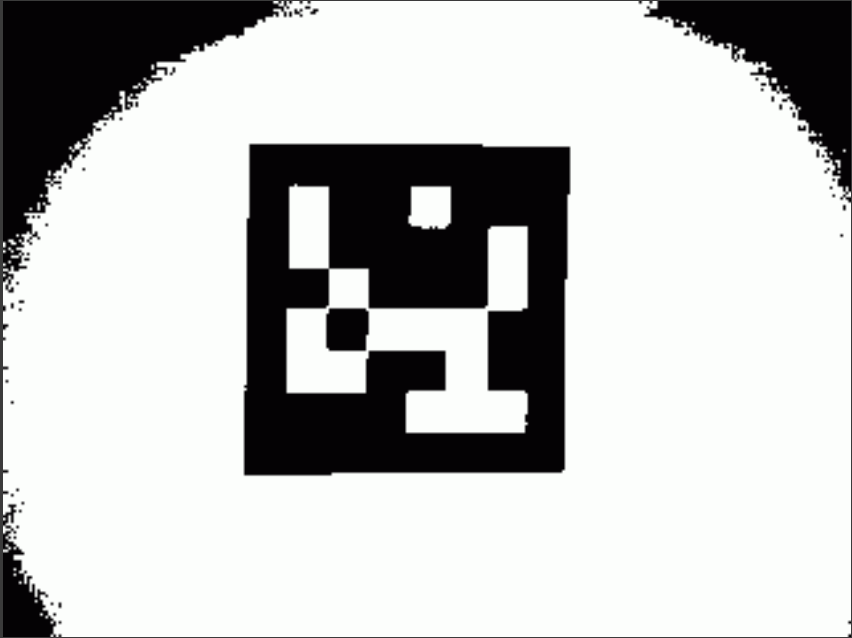
52

38

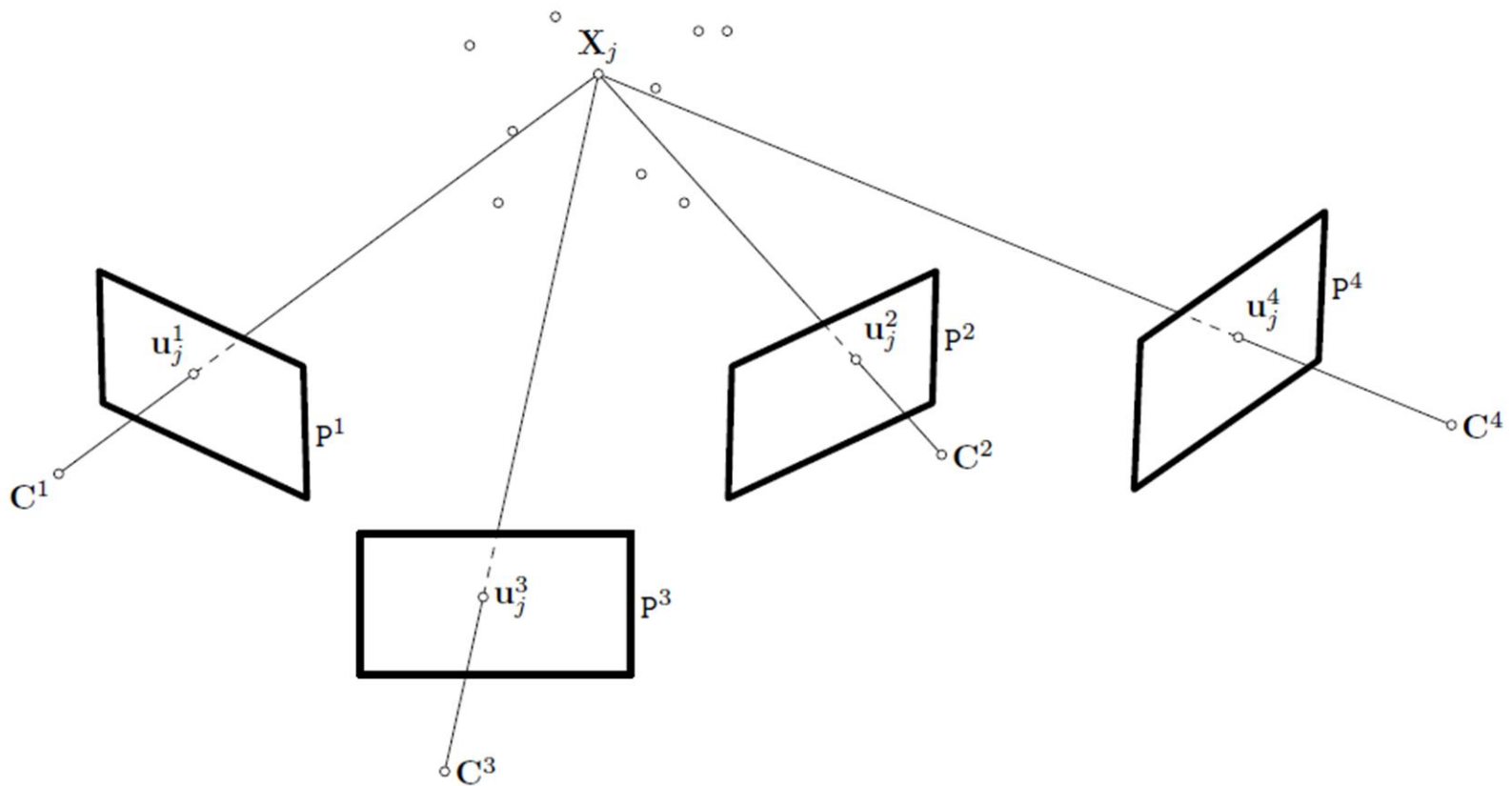
39

40

41



N CAMERAS X M MARKERS



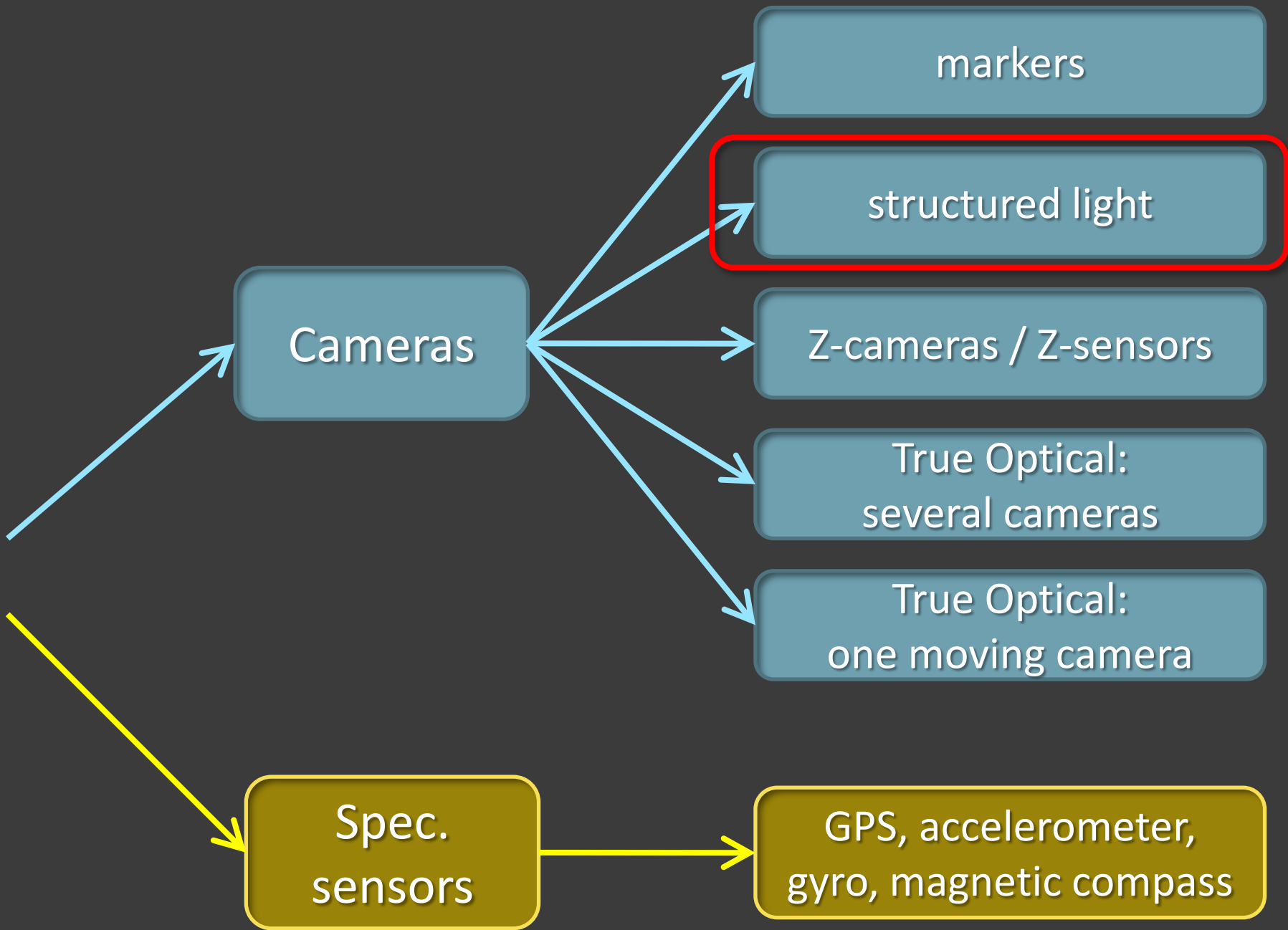
VICON





OPTITRACK

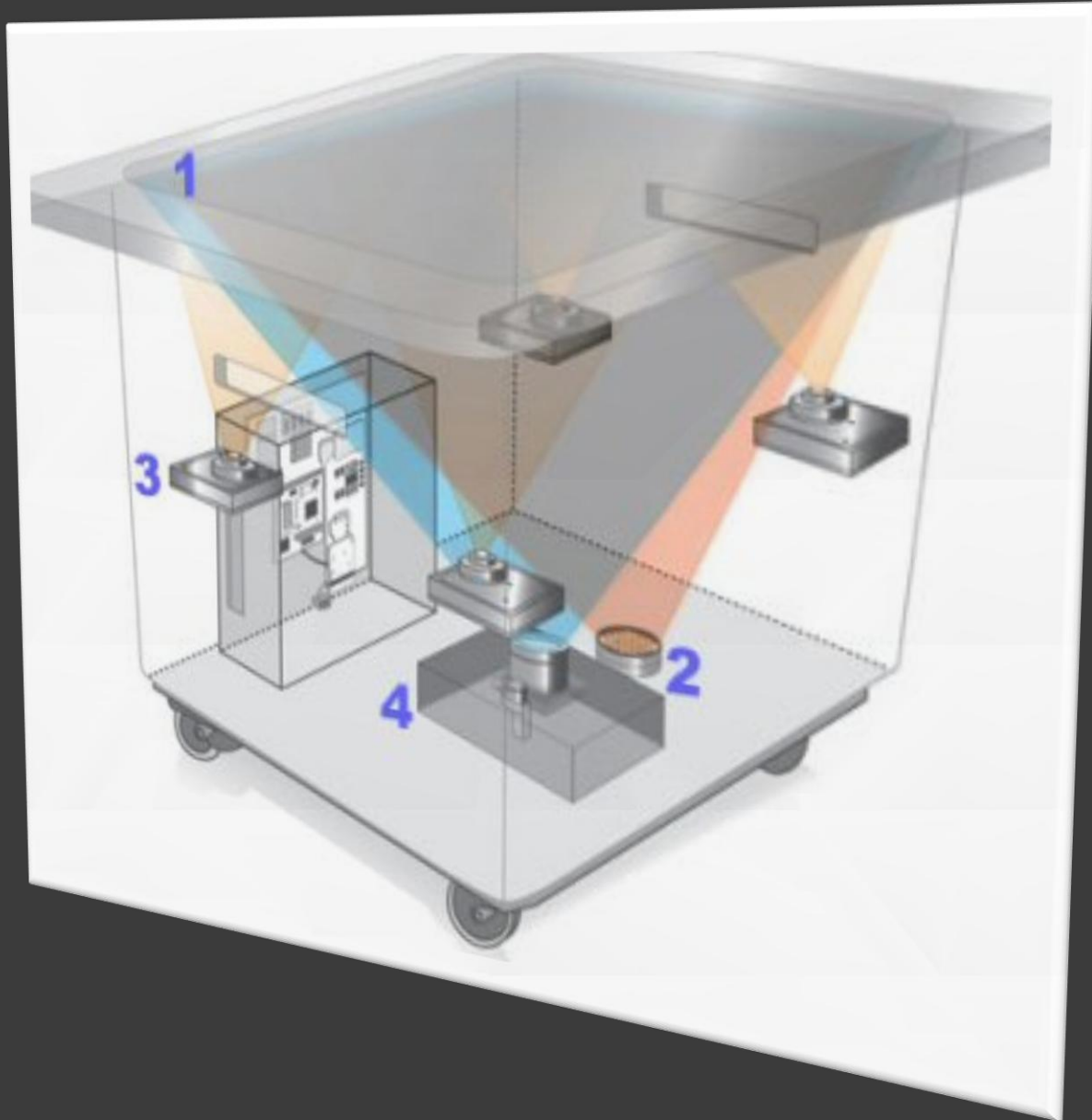






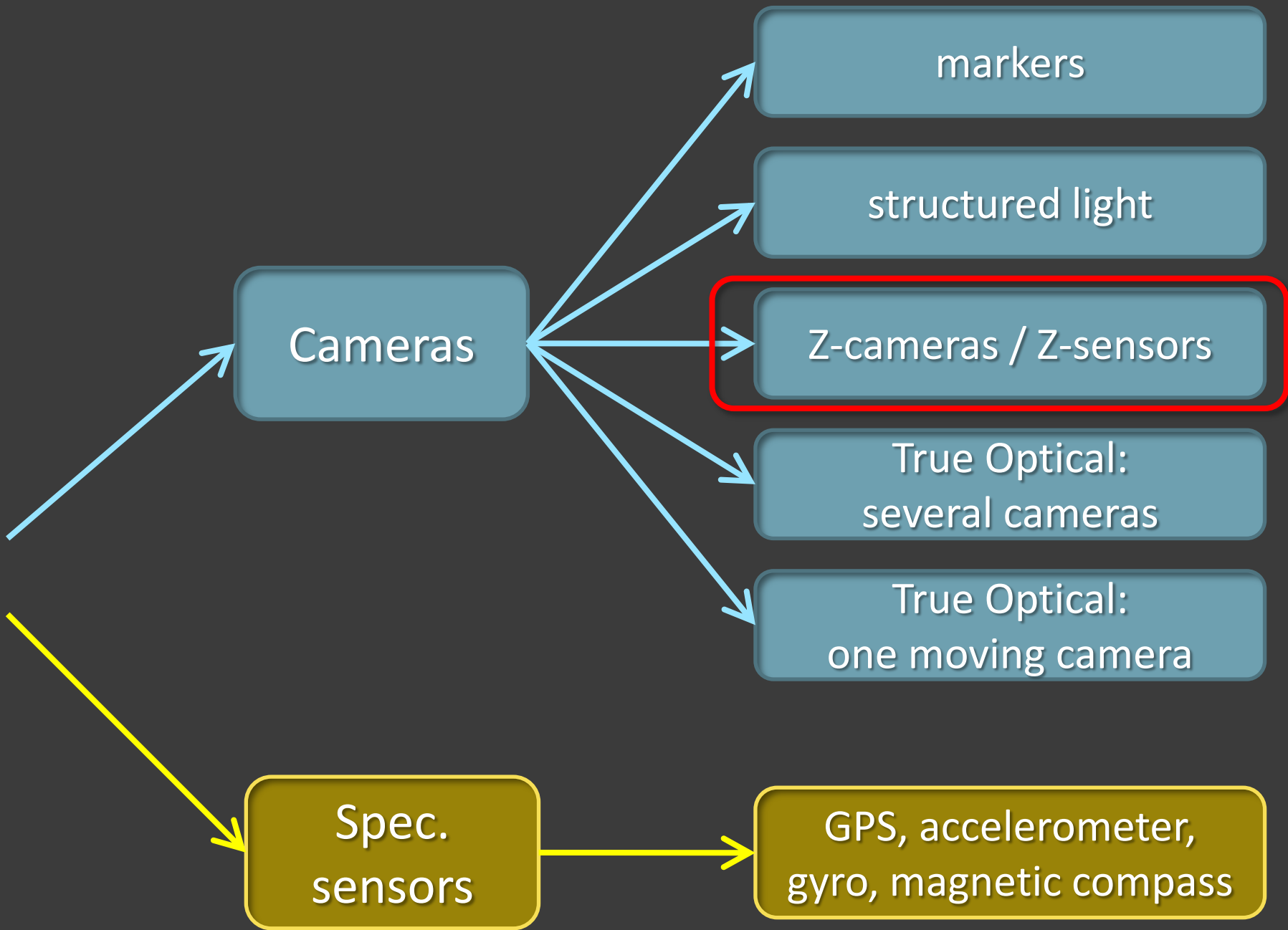


MICROSOFT SURFACE





Cell phone





KINECT™
for  XBOX 360.

for  XBOX 360™
KINECT™

ROOTS OF NATAL == 3DV ZCAM

FILED UNDER *Gaming, Peripherals*

Microsoft's Project Natal roots revealed: 3DV Systems ZCam

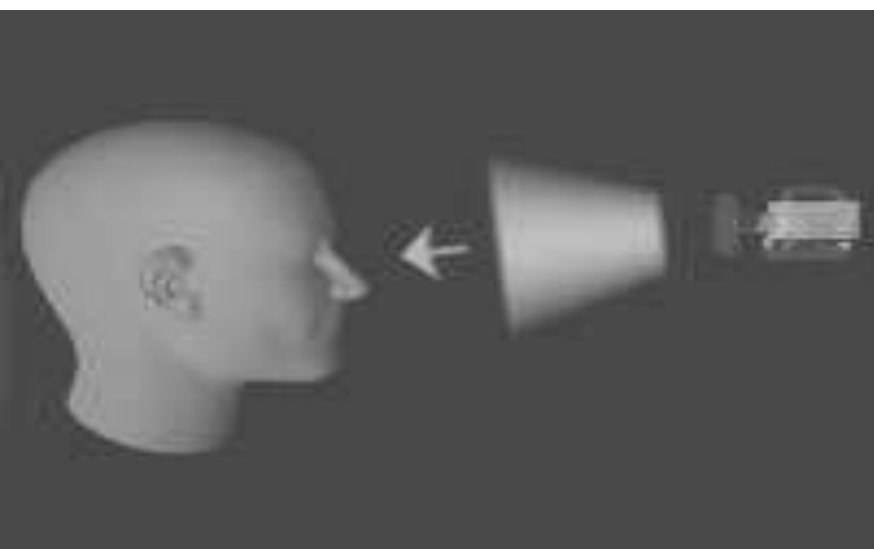
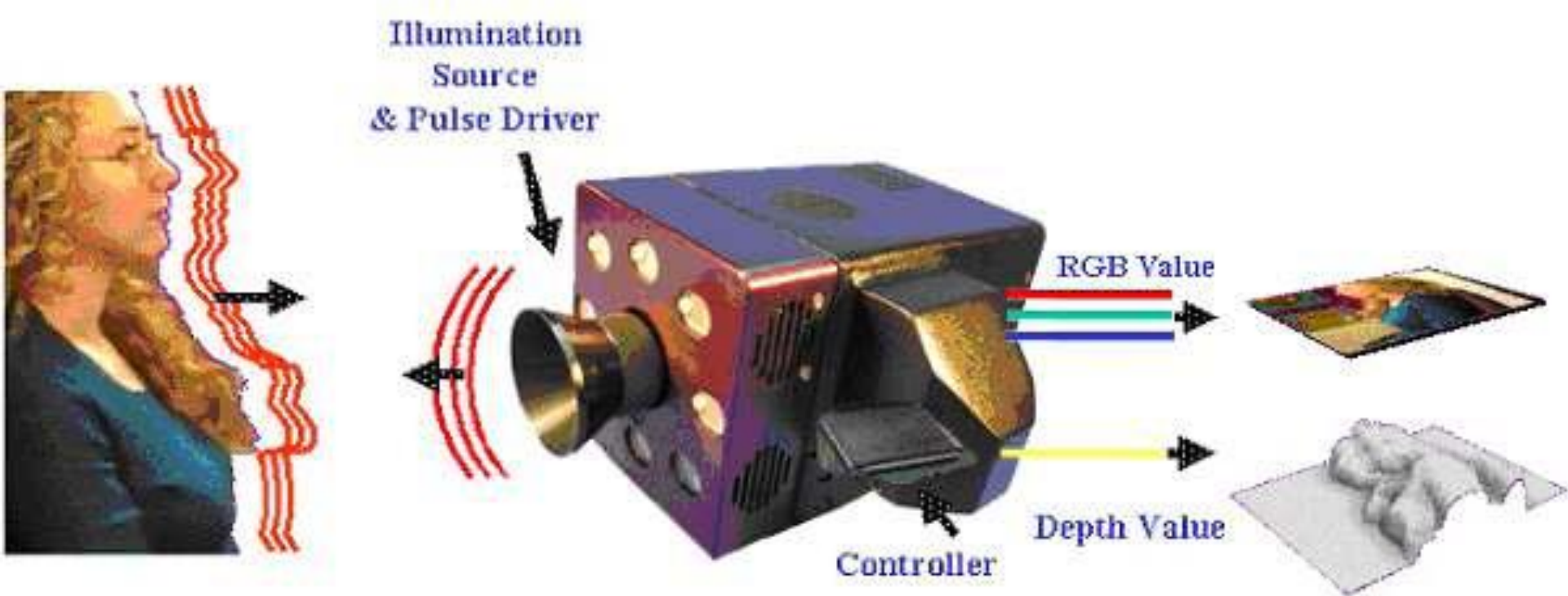
By Darren Murph  posted Jun 3rd 2009 4:21PM



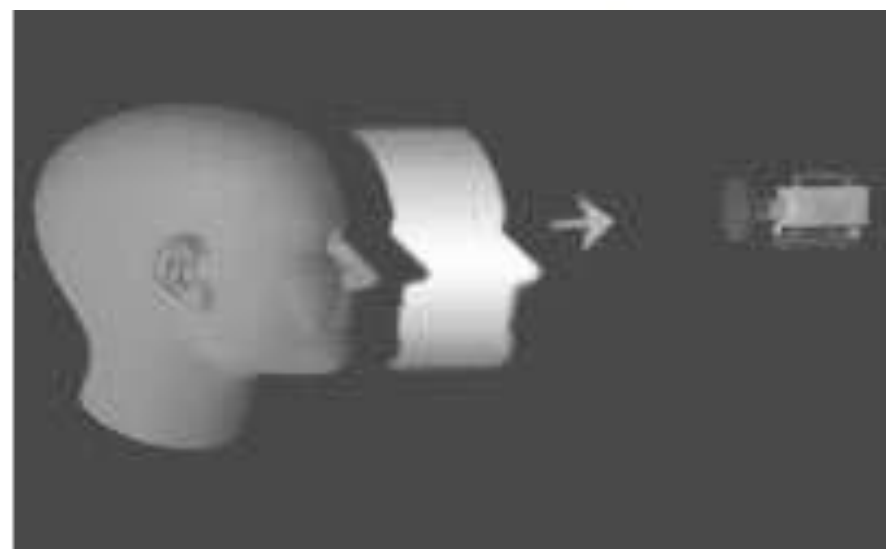
YOU
are
the
Interface

engadget 





Stage 1 - Pulsed light thrown at the Object



Stage 2 - Reflected Light sent back towards the Camera

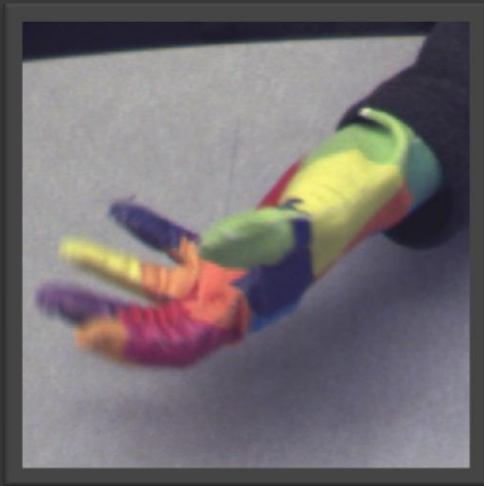




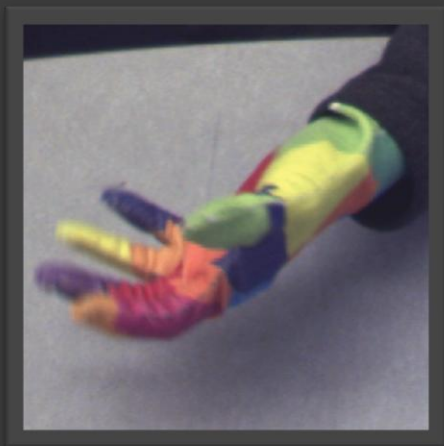
KINECT™
for  XBOX 360.

for  XBOX 360™
KINECT™

ABOUT USING OF DATABASES



[Link](#)



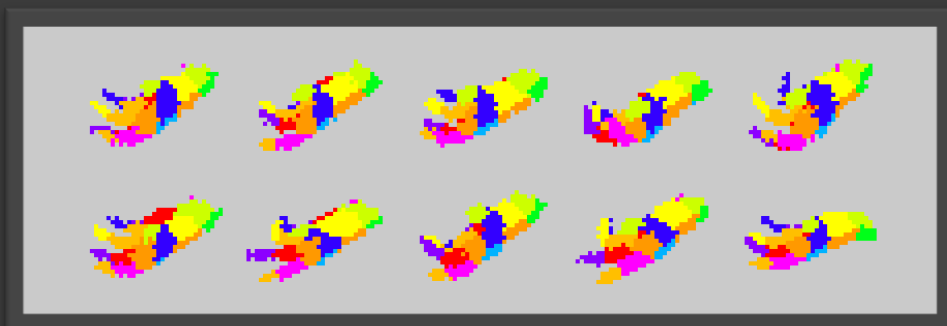
Camera input



Tiny image

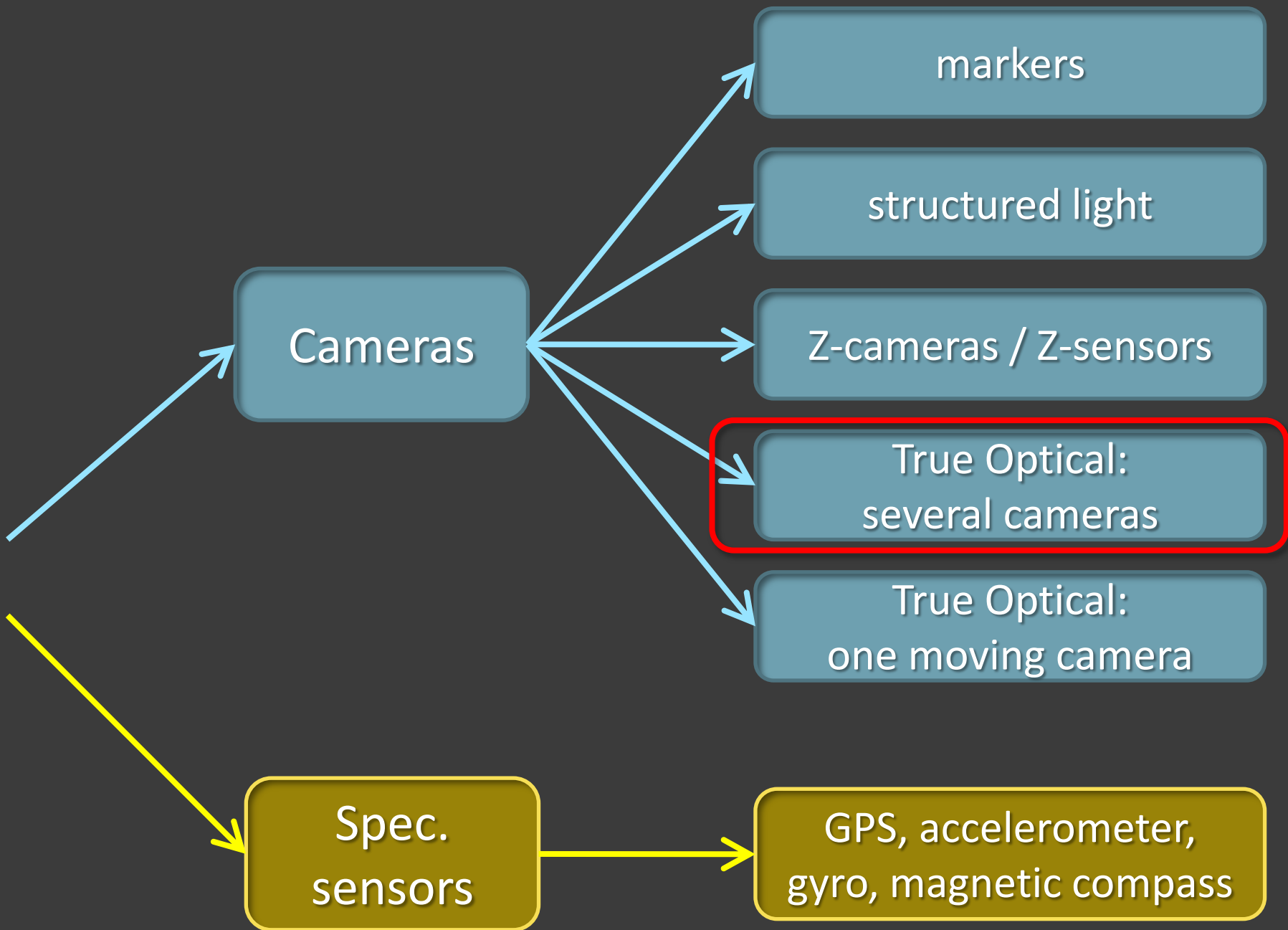


Blended pose of
nearest neighbors



Database nearest neighbors





Cameras

markers

structured light

Z-cameras / Z-sensors

True Optical:
several cameras

True Optical:
one moving camera

Spec.
sensors

GPS, accelerometer,
gyro, magnetic compass

ORGANIC MOTION

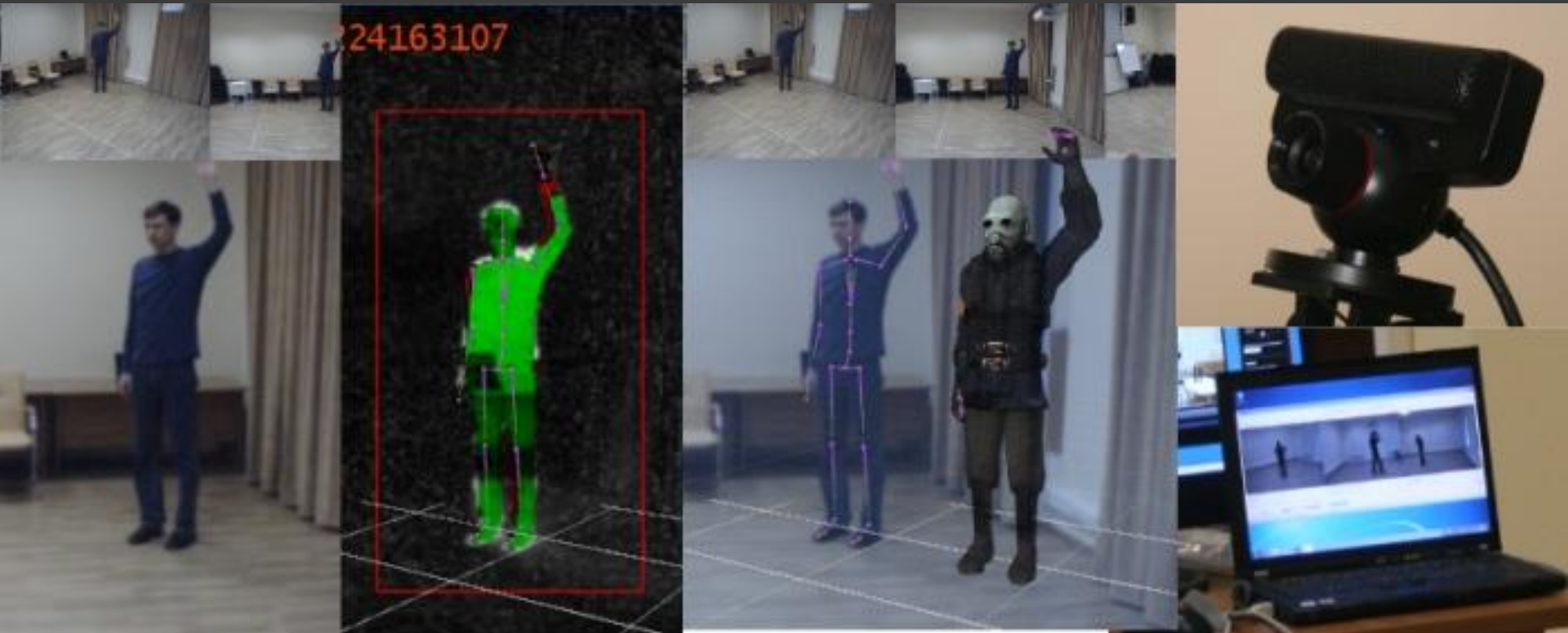






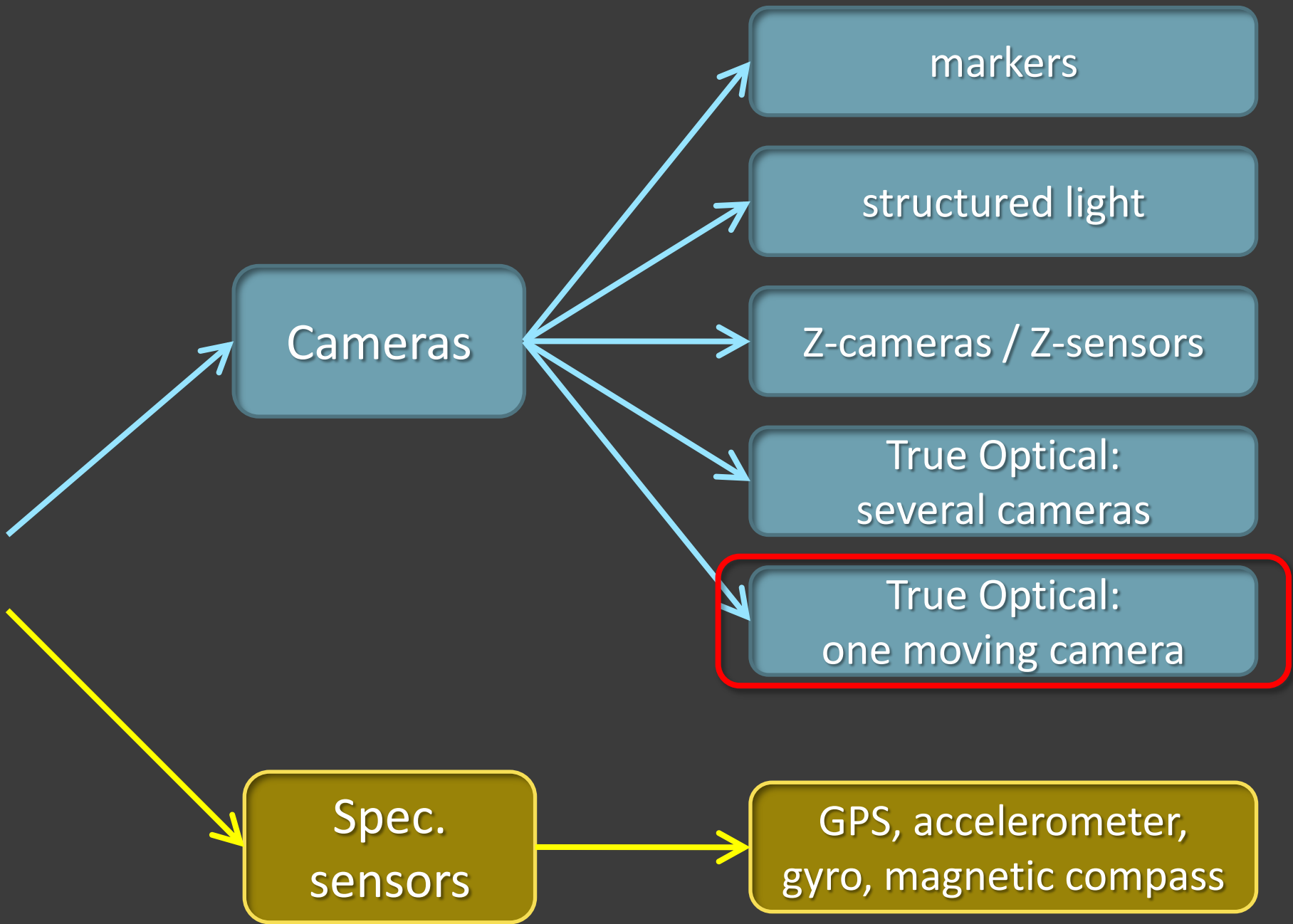
organic

IPIISOFT DESKTOP MOCAP





Markerless motion capture www.ipisoft.com





Moving stuff outside the window doesn't bother the system

SOURCE CODE



Parallel Tracking and Mapping for Small AR Workspaces - Source Code

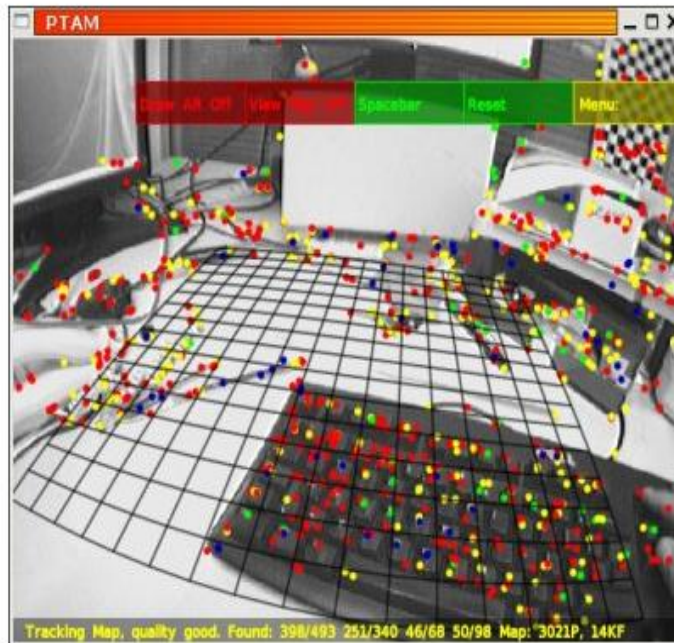
[Home](#)

[Publications](#)

[Vids on youtube](#)

[Source Code](#)

[PTAM Blog](#)

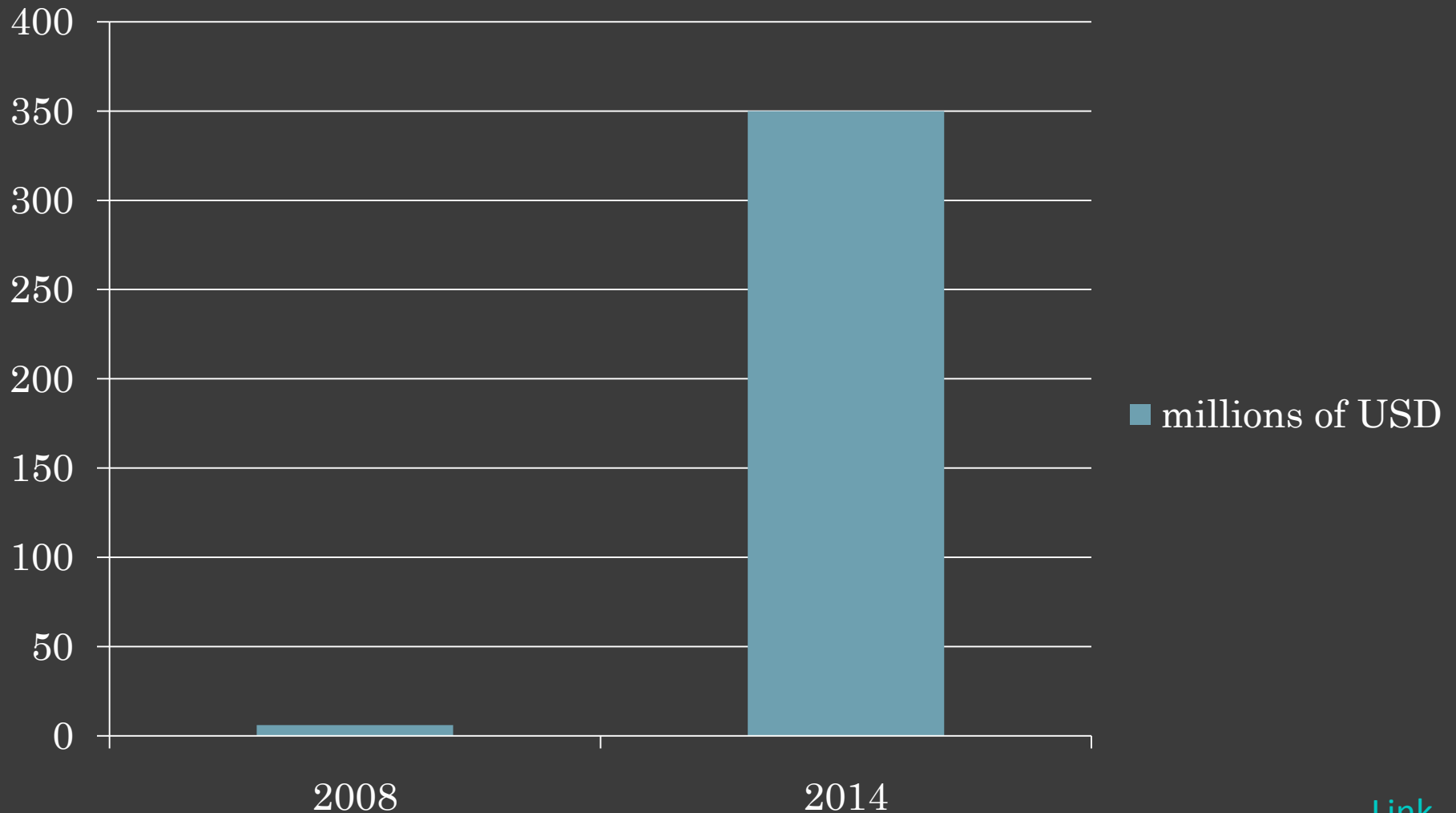


PTAM (Parallel Tracking and Mapping) is a camera tracking system for augmented reality. It requires no markers, pre-made maps, known templates, or inertial sensors. If you're unfamiliar with PTAM [have a look at some videos made with PTAM](#).

Here you may download a reference implementation of PTAM as described in our [ISMAR 2007 paper](#) (with the relocaliser from the ECCV'08 paper, and a Faugeras-Lustman initialiser instead of 5PP). This implementation was developed on Linux but should also compile on OSX and Win32 (With Visual Studio); please see the included [README](#) file for requirements and compilation instructions. Have a look at a [video of typical operation](#).

FUTURE

AUGMENTED REALITY REVENUE



1. ROBUSTNESS

robustness *сущ.*

общ. здоровье; сила; здравомыслие; трудность; эксплуатационная надёжность; прочность

автом. надёжность

безоп. способность системы восстанавливать работоспособность при возникновении ошибочных ситуаций

воен. жёсткость; защищённость

выч. устойчивость (к нарушениям исходных предпосылок); "выносливость"; живучесть; устойчивость к нарушениям исходных предпосылок

комп. ошибкоустойчивость

контр.кач. прочность (конструкции)

Макаров робастность (оценки в статистике); устойчивость (к нежелательным, но возможным воздействиям)

матем. корректность (метода)

рбт. грубость (напр. системы управления)

редк. грубость

тех. выносливость (к нежелательным, но возможным воздействиям); робастность



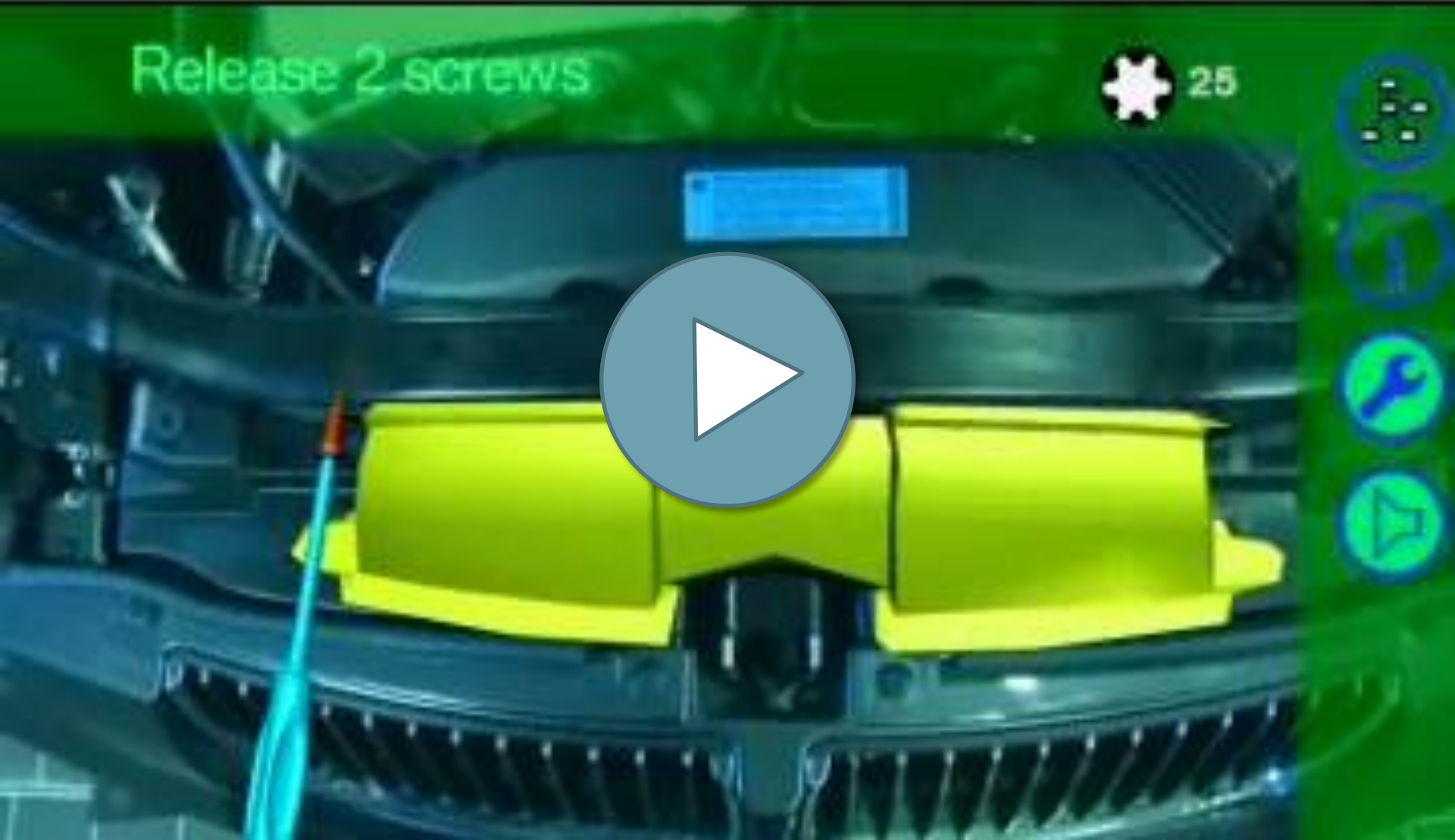
2. QUICK RESPONSE



3. HELPFULNESS



Release 2 screws





SEE YOU IN AR :)
SEE YOU IN AR :)