VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

Virtuální realita

LUDĚK ŽALUD

Pokročilé dálkové ovládání - pojmy

virtuální realita

- pohyb v čistě počítačem generovaném prostředí

rozšířená realita

- do skutečného prostředí jsou přidávána digitální data

teleprezence

- Operátor je přenesen na jiné místo

Virtuální realita

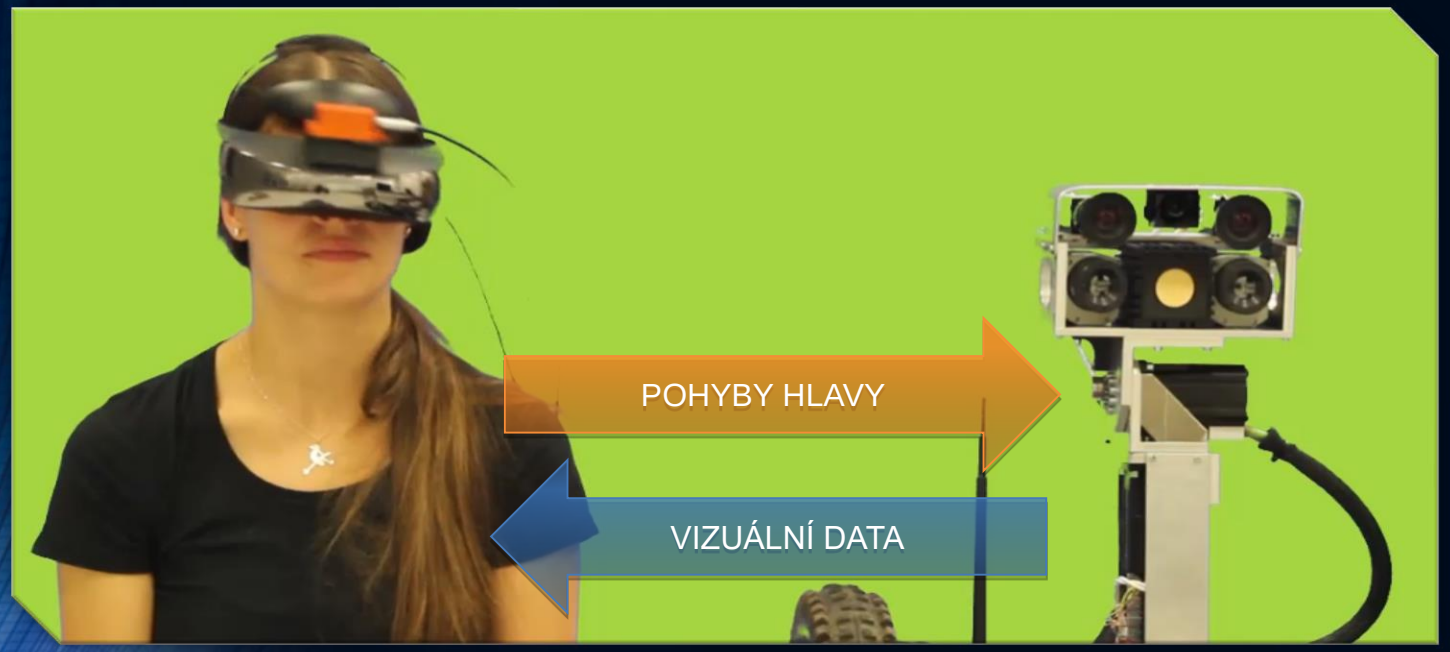
- VR brýle
  - HTC Vive
  - Oculus Rift
  - Velké, těžké

Rozšířená realita

- mobilní telefony
- průhledové brýle
  - MS HoloLens 2
  - malé zorné úhly, kontrast

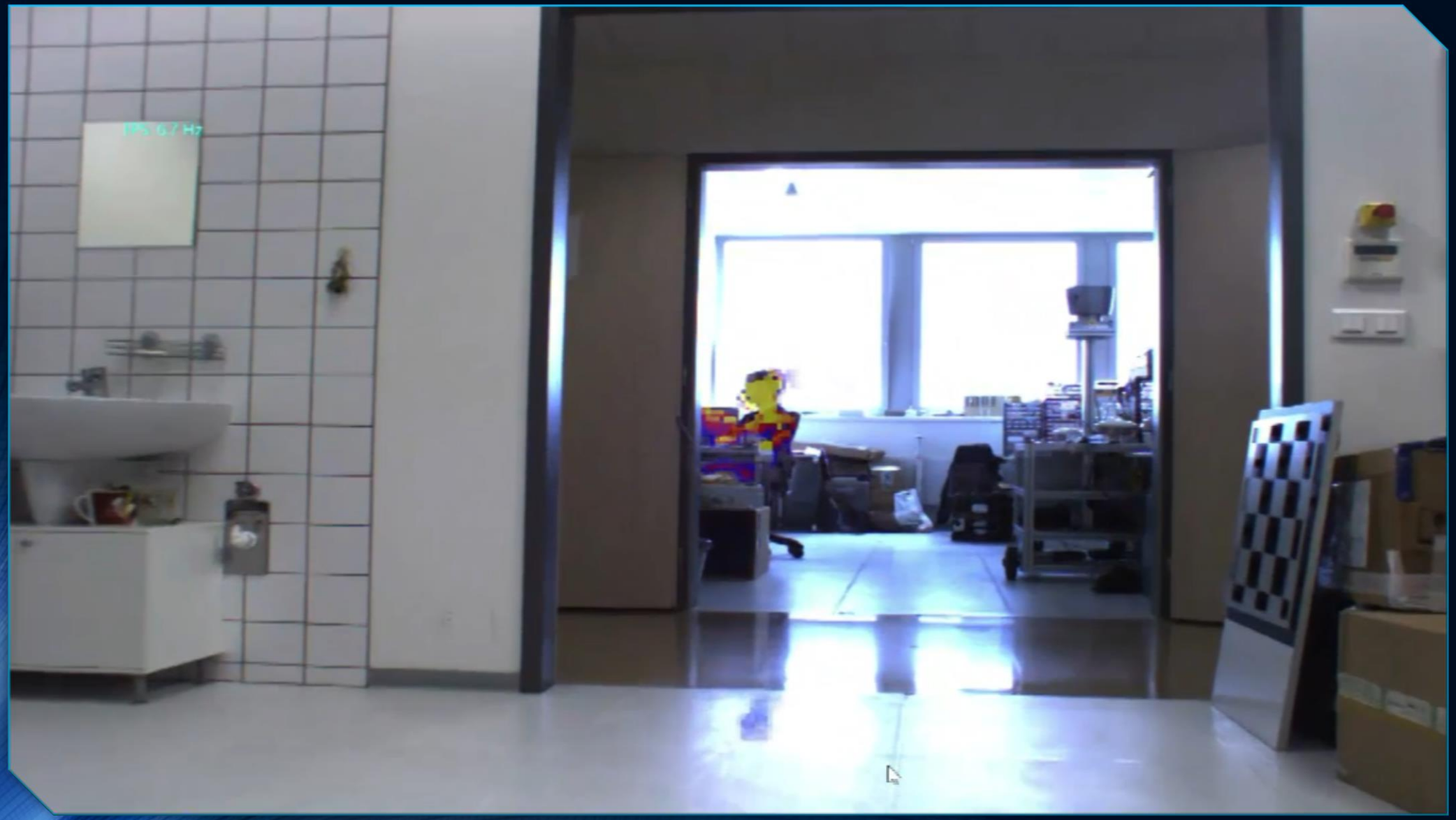
Vizuální teleprezence

OPERÁTOR BY SE MĚL CÍTIT BÝT NA MÍSTĚ ROBOTU

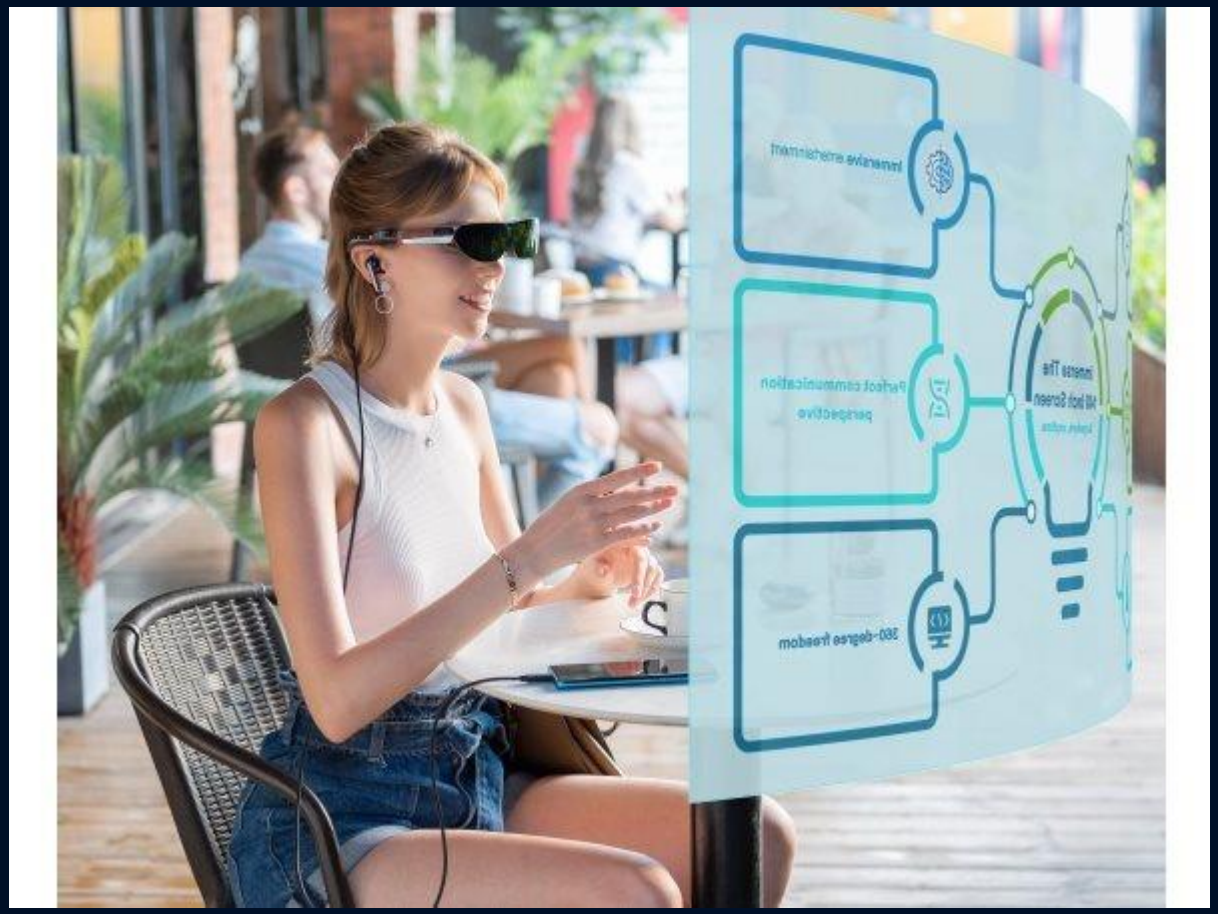


- zvyšuje koncentraci
- dělá ovládání jednodušší a intuitivnější
- funguje lépe na přímém slunci

Multispektrální mapování – VR, AR, teleprezence



K čemu to slouží?



TCL NXTWEAR

- 2x FULL HD, 60Hz
- USB-C, primárně k mobilu
- 100 g


65
126ft
NE
354
MILES TO DESTINATION
73°
68°
65
5

3D displaying technologies

LUDĚK ŽALUD

Introduction

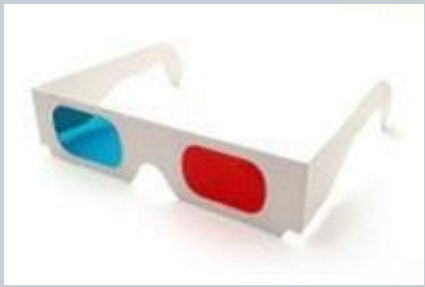
- 3D displaying technologies are not new
  - 1838 – photo
  - 1903 first 3D movie (L'Arrivee du train) – one spectator only – modified stereoscope
  - 2015 – first public short movie with red/green analyph glasses
- 15 years ago – significant development – 3D HMD for scientific applications, design, … development was very slow
- I-Max technology – mass production of "3D movies"
- 2009 real boom after Avatar sci-fi movie
  - rapid development in consumer electronics
  - enough money for hi-tech devices' development

3D x STEREOSCOPY

- Typical commercial technologies (shutter, polarizing) are NOT full 3D!
- No real spatial representation of 3D objects – only mystification of our brain.
- The scene can be seen only from one point, movement around it does not change what we can see!

Color glasses

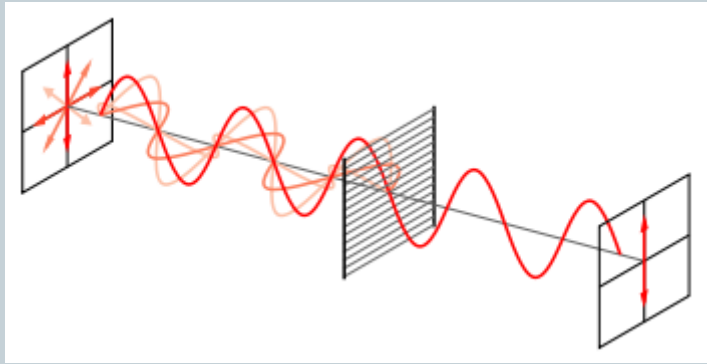
- “color coding” for each eye
- Very cheap glasses – from 1EUR
- No additional expenses – standard monitor
- nVidia cards have better support but are not necessary
- Decolor degradation
- Very tiring for the user
- Not suitable for professional use – only to try the technology



http://www.stereopia.com/english/gallery/anaglyph.html
http://www.nvidia.co.uk/object/GeForce_3D_Vision_3D_Movies_uk.html

Polarization

- So called passive system
- Glasses are necessary, but do not contain any electronics
  - Cheap
  - Lightweight
  - No battery to be charged
- Glasses contain two polarizing filters



Polarization - projectors

- One projector
- Two projectors

Polarization – one projector

- double refresh frequency (100-120Hz)
- rotationg polarizing filter (Z-screen filter) synchronized with the frames

- Fast projector is necessary

Polarization – two projectors

- Two projectors above each
- Static polarizing filters
- Typicaly used in 3D cinemas

- Projectors have to be exactly aligned

- It is possible to use one projector only with optical prism

Polarization - LCD

- Even and odd lines with different polarization
- The resolution is halved

Polarization – advantages, disadvantages

- Glasses necessary, even passive ones
- Special projection screen is necessary
- Polarization is not perfect - crosstalk

- High brightness is achievable
- Very good for more viewers (due to cheap glasses)

Shutter technologies

- LCD display
- Projectors
  - LCD
  - DLP
- Double frequency is necessary

Shutter glasses

- LCD technology in the glasses – battery necessary
- Wired or wireless synchronization is necessary
- Heavier, more expensive glasses
- Number of viewers is not limited – they only need access to the synchronization signal

DLP projectors

- cheap
- high resolution
- e.g. ACER DLP 3D projector H5360

3D glasses comparison

- Glasses always necessary
- Filtration process is not perfect
  - Crosstalk mainly on the edges with high brightness difference
  - Brightness is decreased
- “camera” position is defined
- monitors, TVs, projectors

POLARIZATION

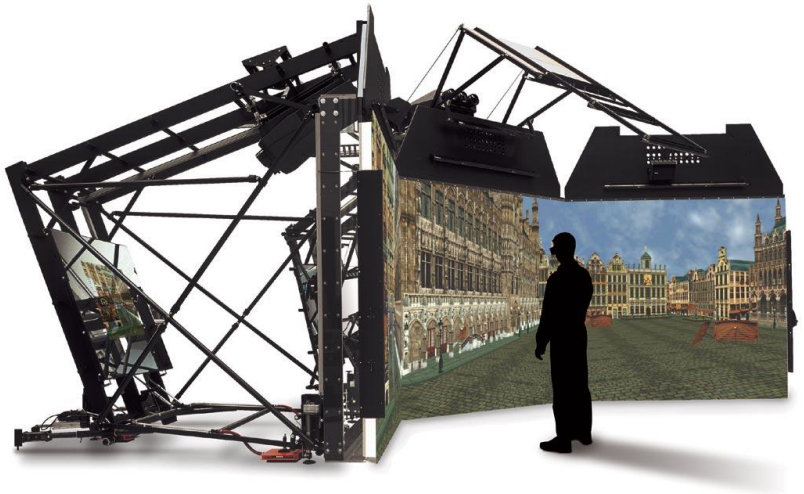
- Glasses without electronics
  - only passive filters
  - lightweight, cheap
  - viever should not incline his head
- Better for more viewers

SHUTTER

- Glasses with electronics
  - heavier
  - more expensive
  - synchronization is necessary
  - have to be charged
  - Some people may have problems with blinkong
- Better for small groups of viewers

Cave Displays/Systems

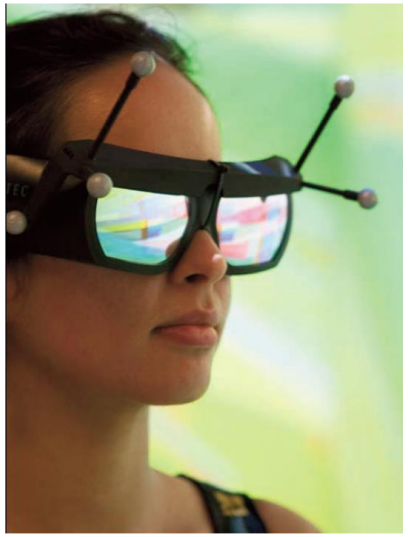
- Barco – leader in cave systems
- 1 - 5 walls (incl. floor)
- rear projection – “short” distance
- stereoscopy with polarizing glasses
- physical objects may be included into immersion – the only (questionable) advantage over HMDs

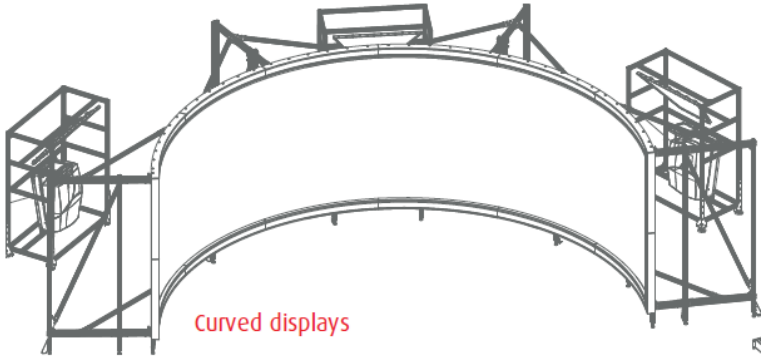


Where to buy?

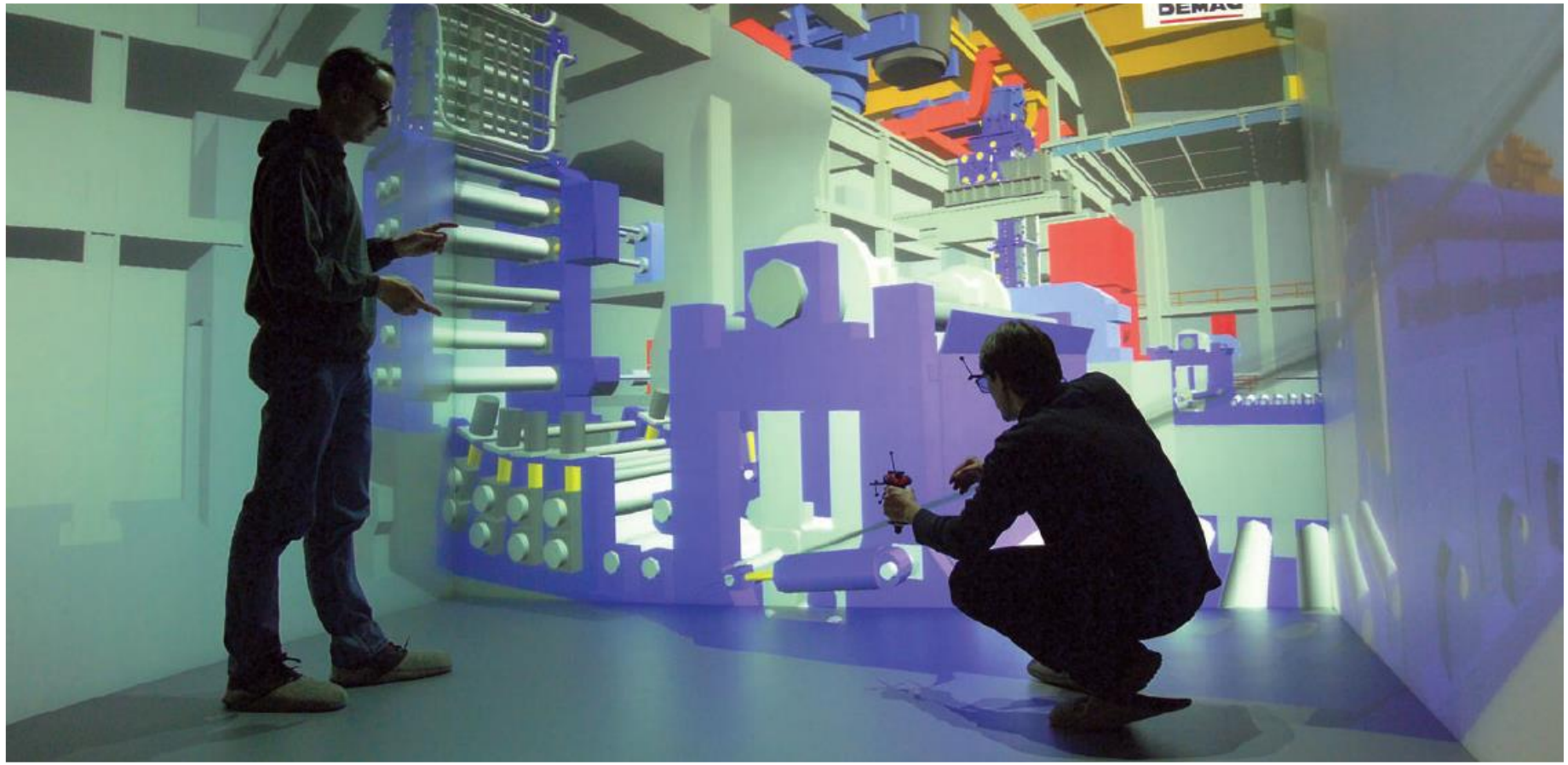
- Nowatron CZ
- A.R.T. Germany

(optical tracking)





Cave Displays/Systems



LCD glasses/HMD's

- Small LCD with electronics in the glasses
- High price – rises nonlinearly with resolution and FOV
- Cable to the HMD is necessary
- Usually warms up during longer operation
- Image moves with the operator's head
- Stereovision without any problems

LCD glasses – Z800 3d Visor

- 800x600 OLED
- 40° diagonal FOV
- 3D – page flipping
- contrast 200:1
- Head-tracking
- USB powered
- Different color skins
- Ruggedized version available
- Cca 1300 USD

LCD HMD – nVisor SX60

- 1280x1024 LCOS (reflective)
- 60° diagonal FOV (44° x35°)
- contrast 200:1
- two DVI inputs
- Mass about 1kg
- Cca 20 000USD

nVisor ST60

- nVisor ST60
- the same resolution and FOV as nVisor SX60
- see-through capability

Oculus Rift

- 2 DK for developers
- Final version 06/2016
- Price 599 USD
- Hi-tech graphics card necessary – min. nVidia GTX 970

- Parameters:
  - Resolution 2160x1200
  - Refresh rate 90Hz
  - 6DOF tracking

HTC Vive

- Release date 5 april 2016 worldwide, June 2016 Czech Republic
- 899 EUR (Czech Republic), two handheld controllers in price

Resolution	2160x1200 (1080x1200 per eye)[1]
Refresh Rate	90 Hz[1]
Field of view (Nominal)	About 110 degrees[2]

HTC Vive PRO

Resolution	2800x1600
Refresh Rate	90 Hz[1]
Field of view (Nominal)	About 110 degrees[2]

- eye-tracking version exists

HTC Vive Focus 3 – Business Edition

Resolution	2448 x 2448 (one eye)
Refresh Rate	90 Hz
Field of view (Nominal)	About 120 degrees
Connection	USB-C, WiFi

- Battery operated
- No need for external trackers
- Hand controllers included

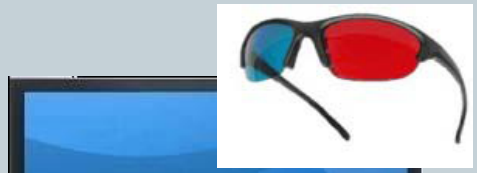
- About 37000 CZK (02/2022)

Autostereoscopy

- LCD monitor with so called prizm mask
- Passive – only two directions, the user's eyes have to be placed in so called sweet-spot
- Active – automatic user detection – e.g. camera
- Version with up to 9 directions – for more users, it is possible to see the object from more points of view
- Already in use on game consoles, notebooks, mobile phones
- No glasses necessary
- Expensive (small displays), the quality is lower than technologies with glasses

nVidia 3D Vision

- DirectX
- 3D Stereo Driver



nVidia 3D Vision

1
- DirectX

2
- nVidia driver

3
- hardware

Literature

- http://www.gali-3d.com
- http://blogy.moviezone.cz/KARLOS/filmove-policko-technickym-pohledem/2009/12/02/jit-na-avatar-a-nezabloudit-v-technice/
- www.nvidia.com
- www.developer.nvidia.com
- **Stereoscopic Cinema and the Origins of 3-D Film, 1838-1952**

TELEPRESENCE

LUDEK ZALUD

LECTURE OUTLINE

- Telepresence – what is it?
- Visual perception
- Displaying technologies, 3D displays, HMD's
- Head movement measurement
- Video – optics, field of view, compression

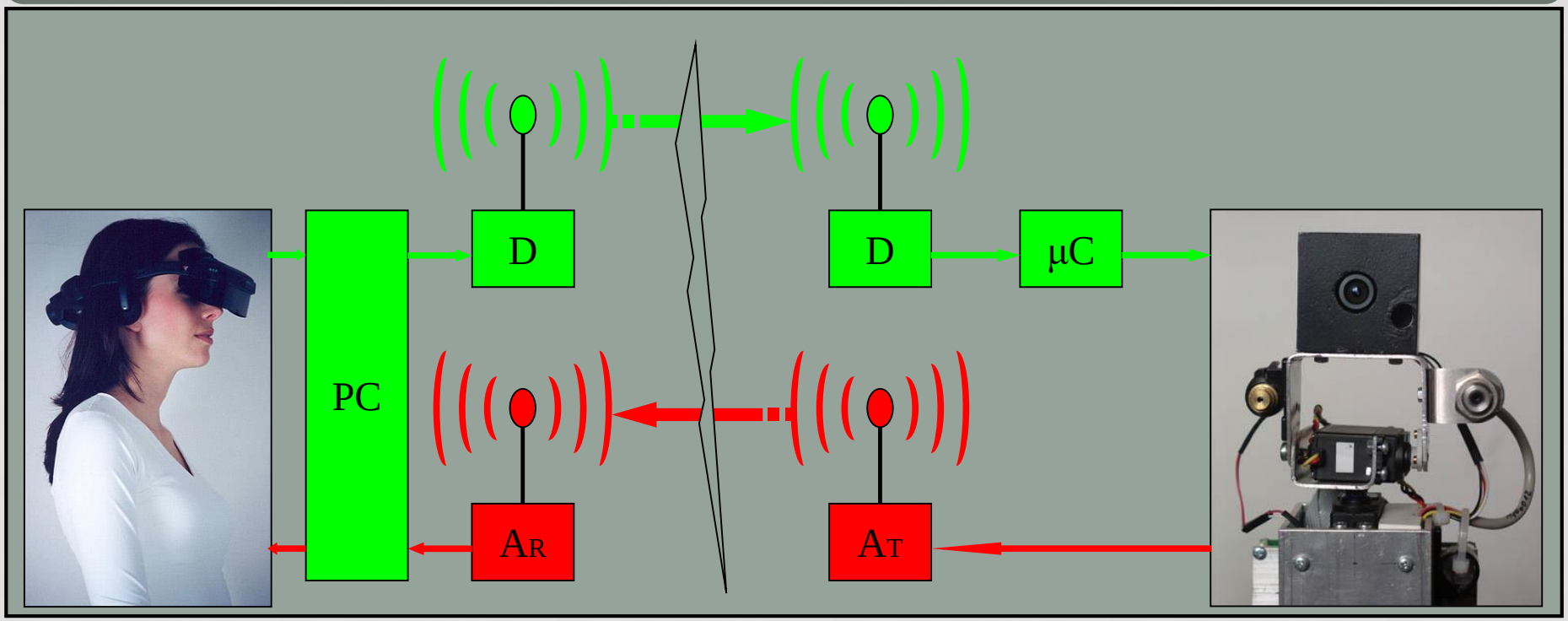
- User interfaces – input devices, UI design
- Teleoperated robots at BUT
- Augmented reality user interface

TELEPRESENCE

WHAT IS IT?

WHAT IS IT TELEPRESENCE?

Operator should feel to be in the robot's place



- increases concentration
- makes control easier and more intuitive
- better on direct sunshine

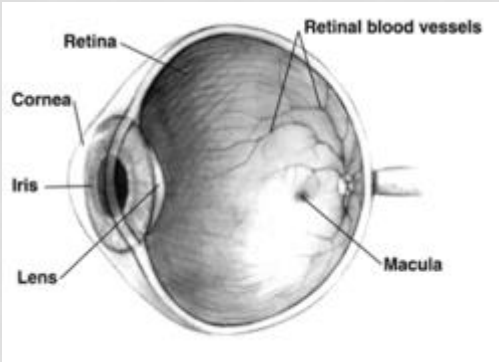
AUGMENTED REALITY

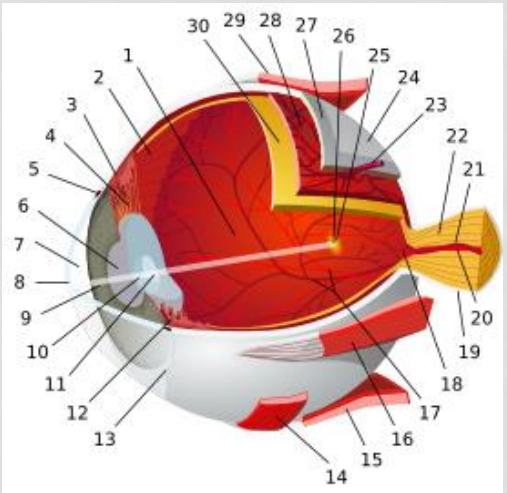
- Enhanced reality – the real image plus some other data

HUMAN VISUAL PERCEPTION

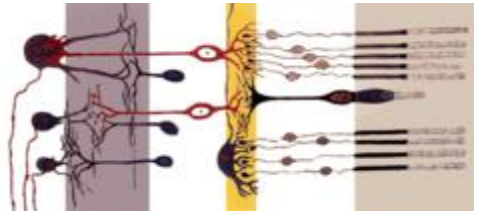
HUMAN EYE

- Rodopsin – chemical reaction to light

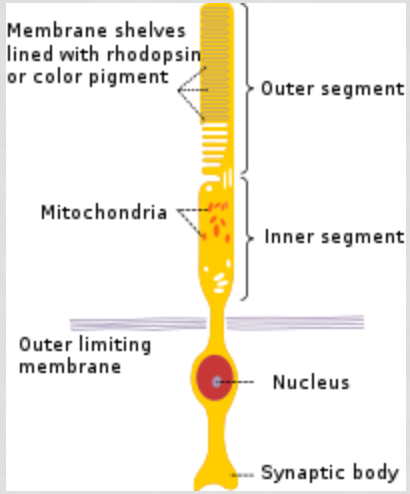


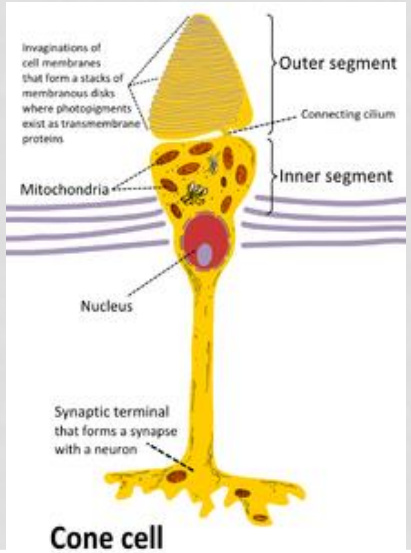


RETINA



- 22mm diameter, 72% of a sphere
- Photoreceptor cells - Modified neurons
- Rod cells
  - 100-150 milions/eye (20x more than cone cells)
  - B&W vision
  - high light sensitivity
  - Image is not sharp
- Cone cells
  - 6-7 milions/eye
  - Color perception
  - Low light sensitivity – daytime only
  - Photopsin (iodopsin) sensitive mostly to red, green, or blue respectively





RETINA

- Fovea - At its center is the fovea, a pit that is responsible for our sharp central vision but is actually less sensitive to light because of its lack of rods
- Around the fovea extends the central retina for about 6 mm and then the peripheral retina.
- The blind spot (optic disc - optic-nerve fibers leave the eye) – oval, 3mm2

VISION - PHYSIOLOGY

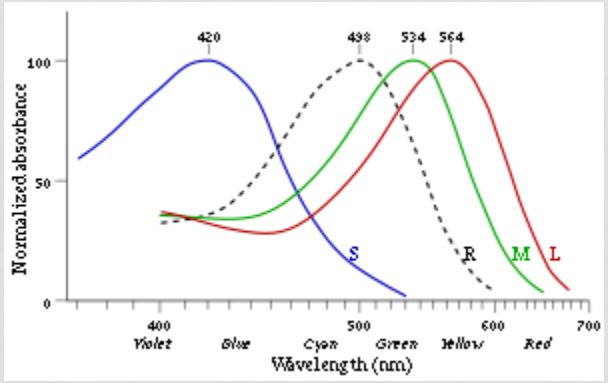
- cones - high-resolution color vision during daylight illumination (called photopic vision), rods - saturated at daylight levels - don't contribute to pattern vision
- rods do respond to dim light and mediate lower-resolution, monochromatic vision under very low levels of illumination (called scotopic vision) -
- the illumination in most office settings falls between these two levels and is called mesopic vision. At these light levels, both the rods and cones are actively contributing pattern information to that exiting the eye – it is unclear how
- Humans have three different types of cones (trichromatic vision)

VISION - PHYSIOLOGY

- The retina, unlike a camera, does not simply send a picture to the brain. The retina spatially encodes (compresses) the image to fit the limited capacity of the optic nerve. Compression is necessary because there are 100 times more Photoreceptor cells than ganglion cells
- A rod cell is sensitive enough to respond to a single photon of light,[4] and is about 100 times more sensitive to a single photon than cones.
- Multiple rod cells converge on a single interneuron, collecting and amplifying the signals. Worse image resolution than it would be if the visual system received information from each rod cell individually. The convergence of rod cells also tends to make peripheral vision very sensitive to movement, and is responsible for the phenomenon of an individual seeing something vague occur out of the corner of his or her eye.

VISION – PHYSIOLOGY

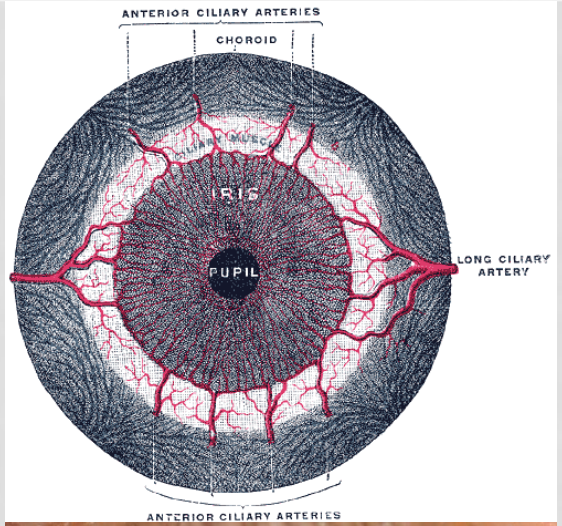
- Rod cells also respond more slowly to light than cones do, so stimuli they receive are added over about 100 milliseconds.
- While this makes rods more sensitive to smaller amounts of light, it also means that their ability to sense temporal changes, such as quickly changing images, is less accurate than that of cones.

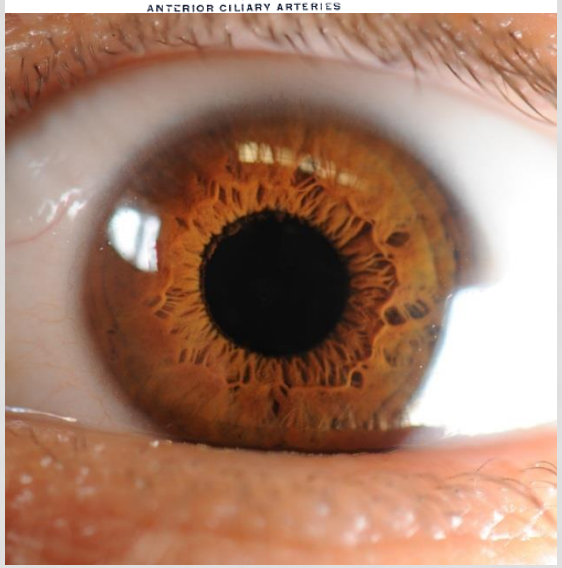


Wavelength responsiveness of rods compared to that of three types of cones. The dashed gray curve is for rods.

IRIS

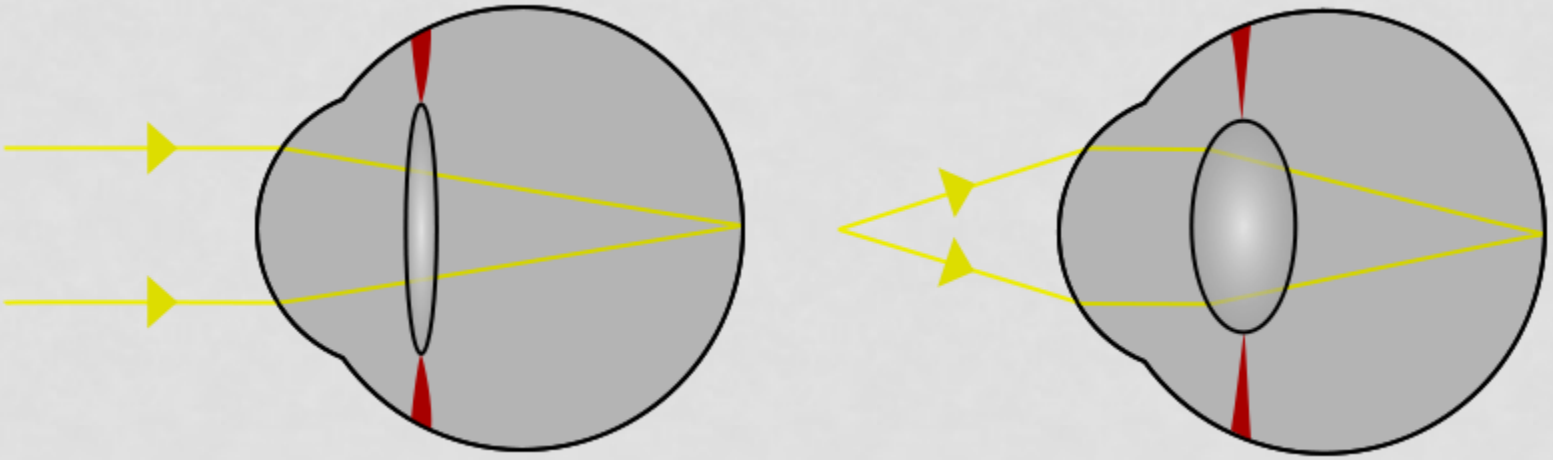
- Our iris works similarly to the one on cameras
- It can change the diameter from 1.5mm to 12mm, which corresponds to f2.6 to 16





LENS

- The lens, by changing shape, functions to change the focal distance of the eye so that it can focus on objects at various distances, thus allowing a sharp real image of the object of interest to be formed on the retina.
- Optically very poor quality!



HUMAN EYE QUALITY

… IS VERY POOR COMPARING WITH MODERN CAMERAS!!!

- Resolution is not high, but the cells are nonlinearly distributed + we can MOVE with eyes and FOCUS

- Much higher dynamic range than cameras!

We can move with the eye and focus to the appropriate object using the most dense part of retina!

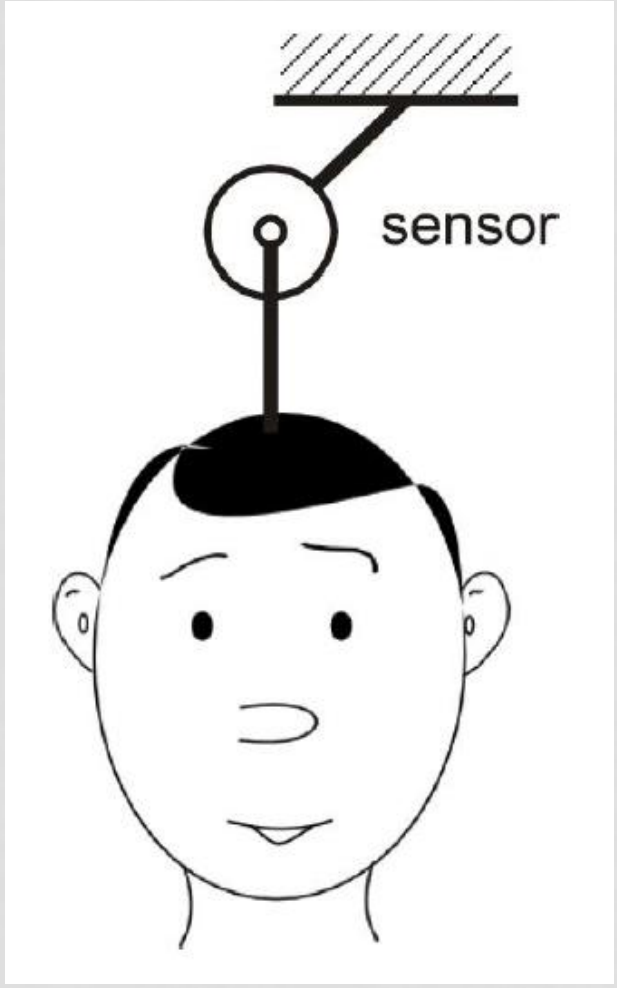
We cannot provide the corresponding (highest) quality the eyes would need.

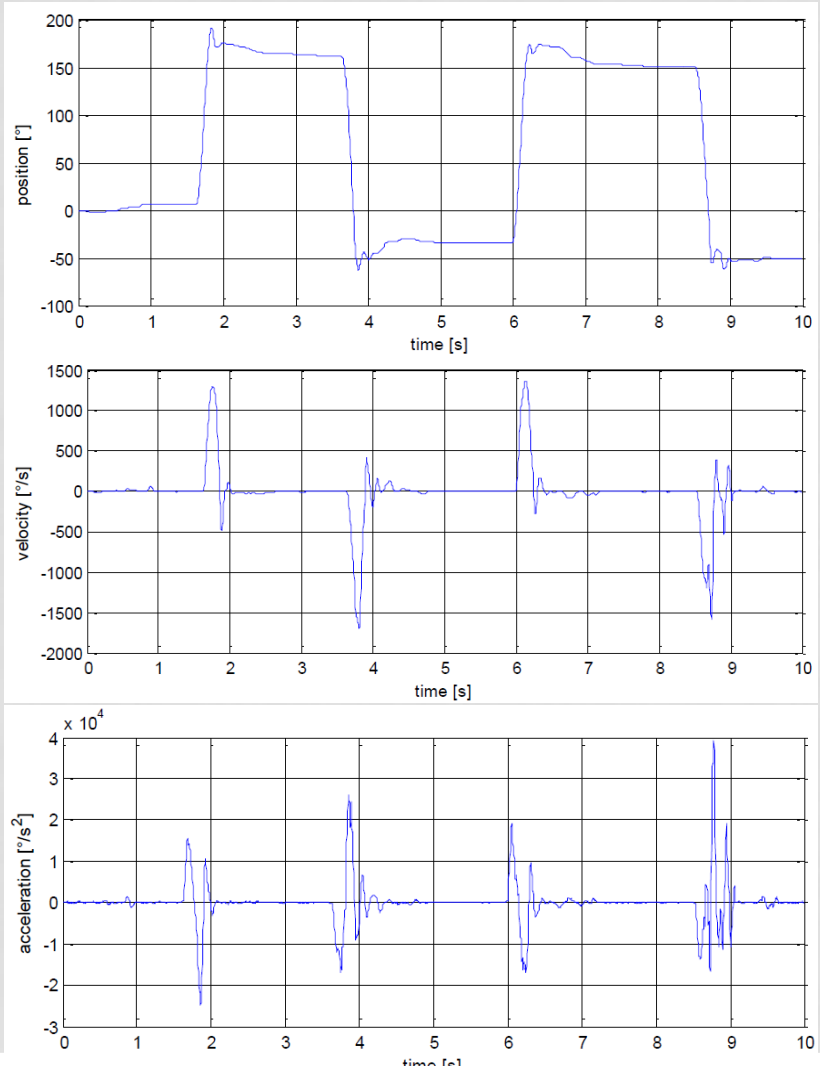
FIELD OF VIEW

- We can perceive up to 180˚ - the wide field of view is very important for our orientation.

HEAD MOVEMENT PARAMETERS

HEAD MOVEMENT PARAMETERS



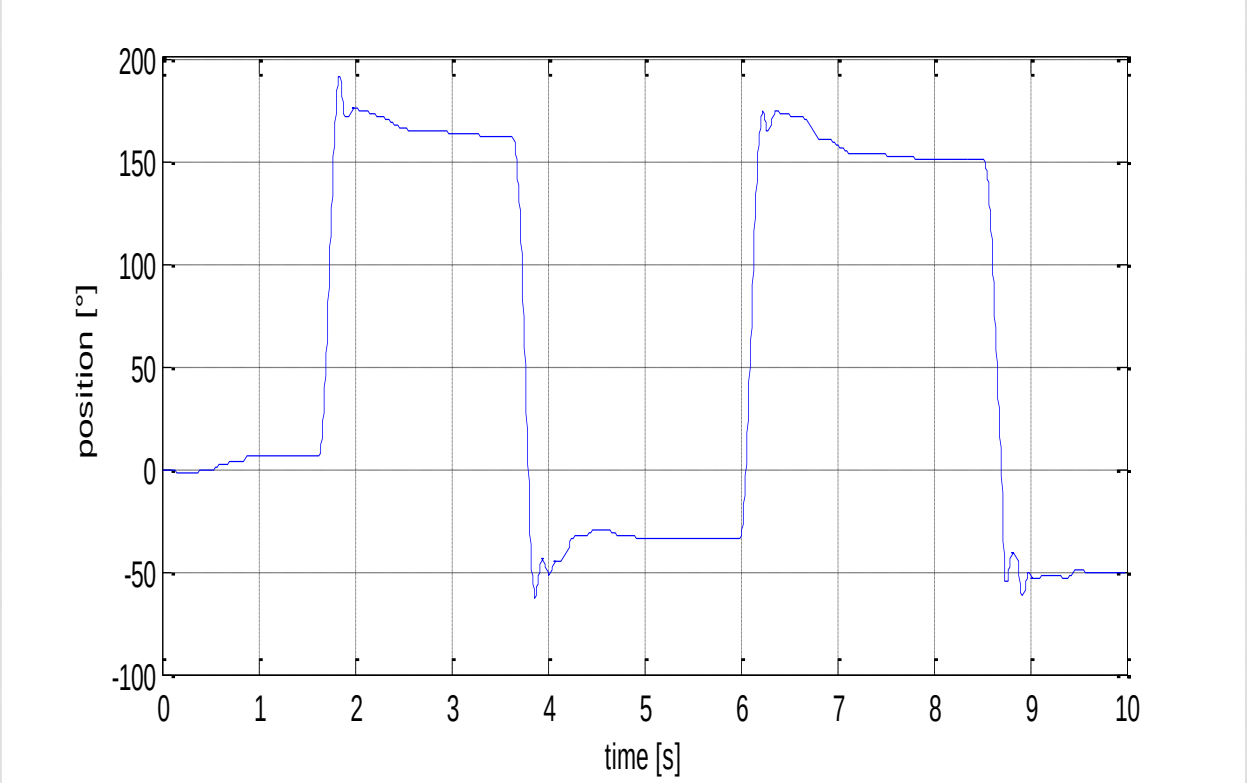


HEAD MOVEMENT MEASUREMENT

- precise incremental encoder with resolution od 8000 pulses per rev

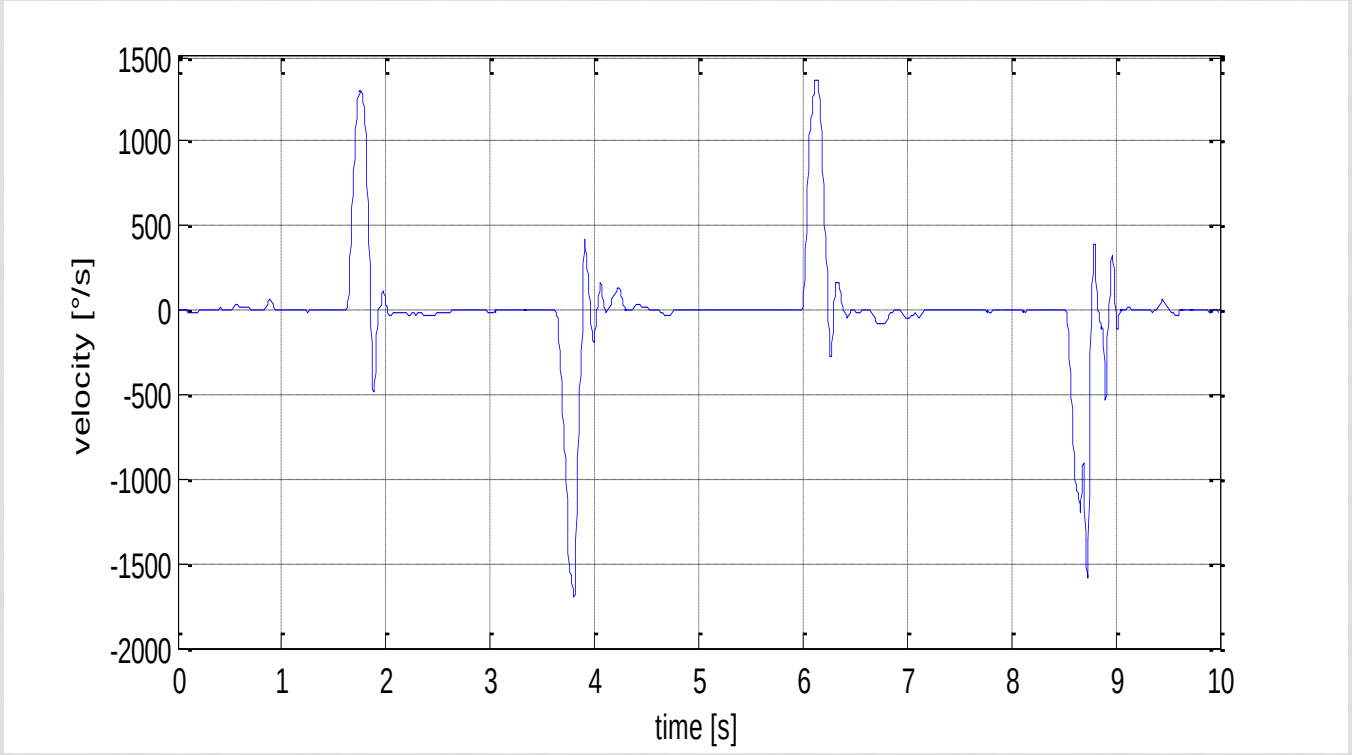
- 3 subjects were tested

MOVING ANGLE



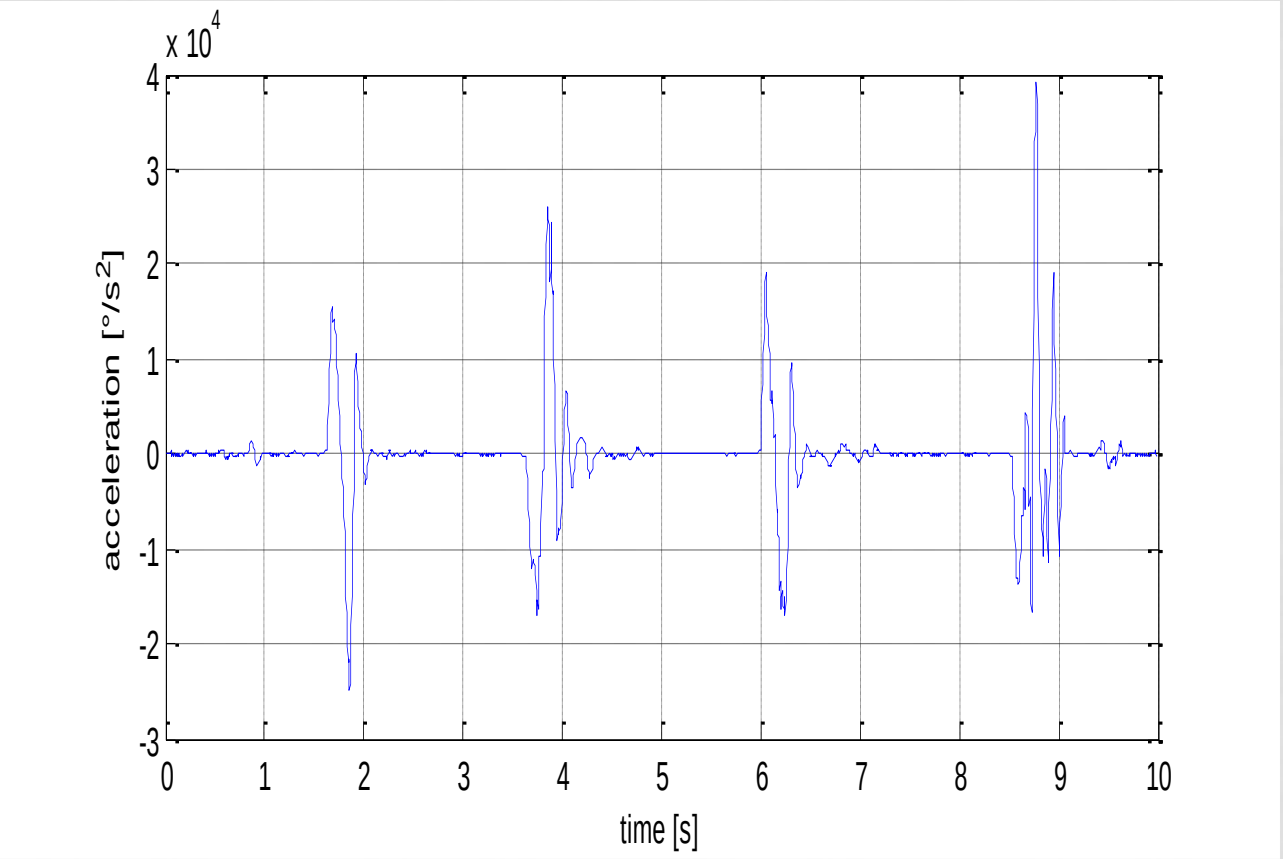
- dynamic - more than 200°
- static - about 180°

MOVEMENT VELOCITY



- more than 1500°/s

ACCELERATION



- up to 3.10^4 °/s²

MOVEMENT MEASUREMENT - RESULTS

Maximum head-movement parameters are really hard to achieve!

- measurement – typical MEMS-based IMUs measure up to 300˚/s, high velocity ones up to 720 ˚/s
- mechanical
  - position – no problem, wires
  - velocity & acceleration – very complicated

It has to be considered if the maximum velocity is necessary - 300˚/s is usually sufficient.

SPATIAL DISPLAYING TECHNOLOGIES

VIDEO COMPRESSION

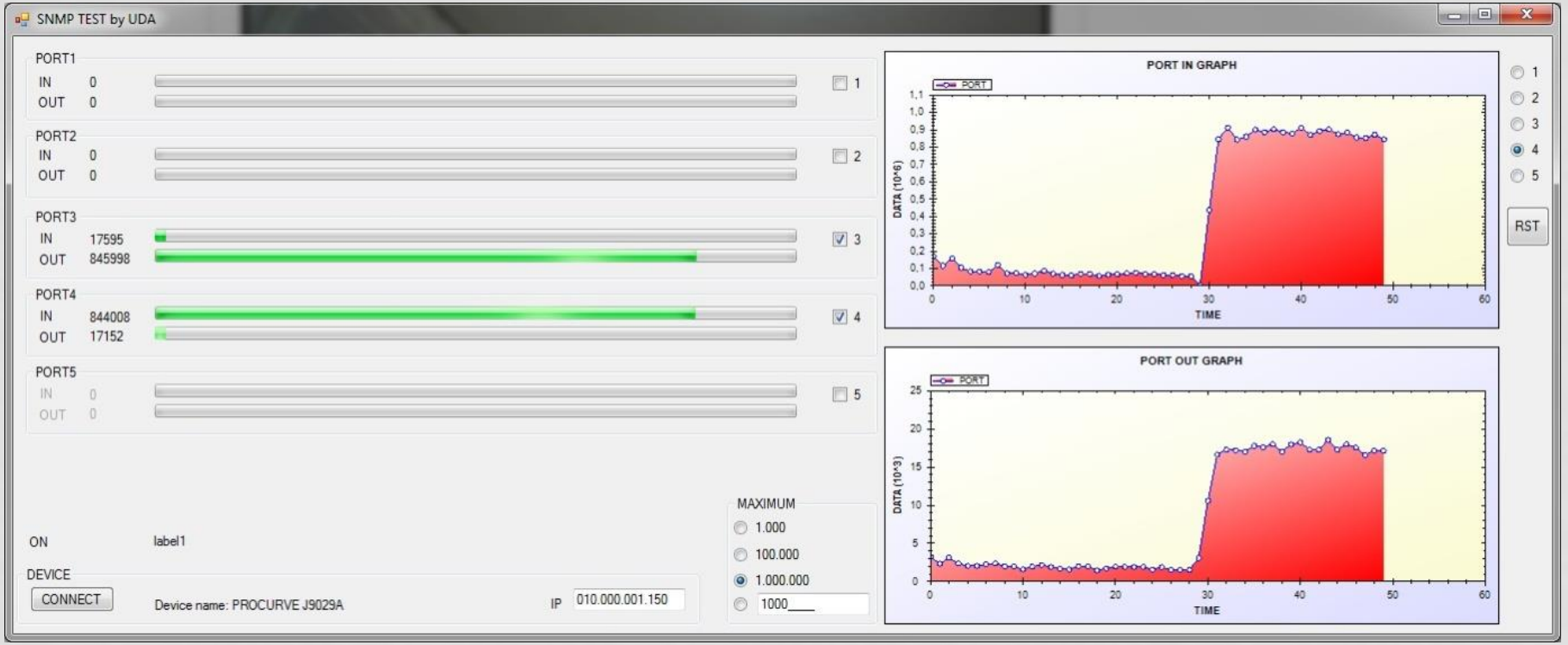
CODEC COMPARISON

We made practical comparison of two most often used video codecs

- MPEG (motion JPEG)
- H.264

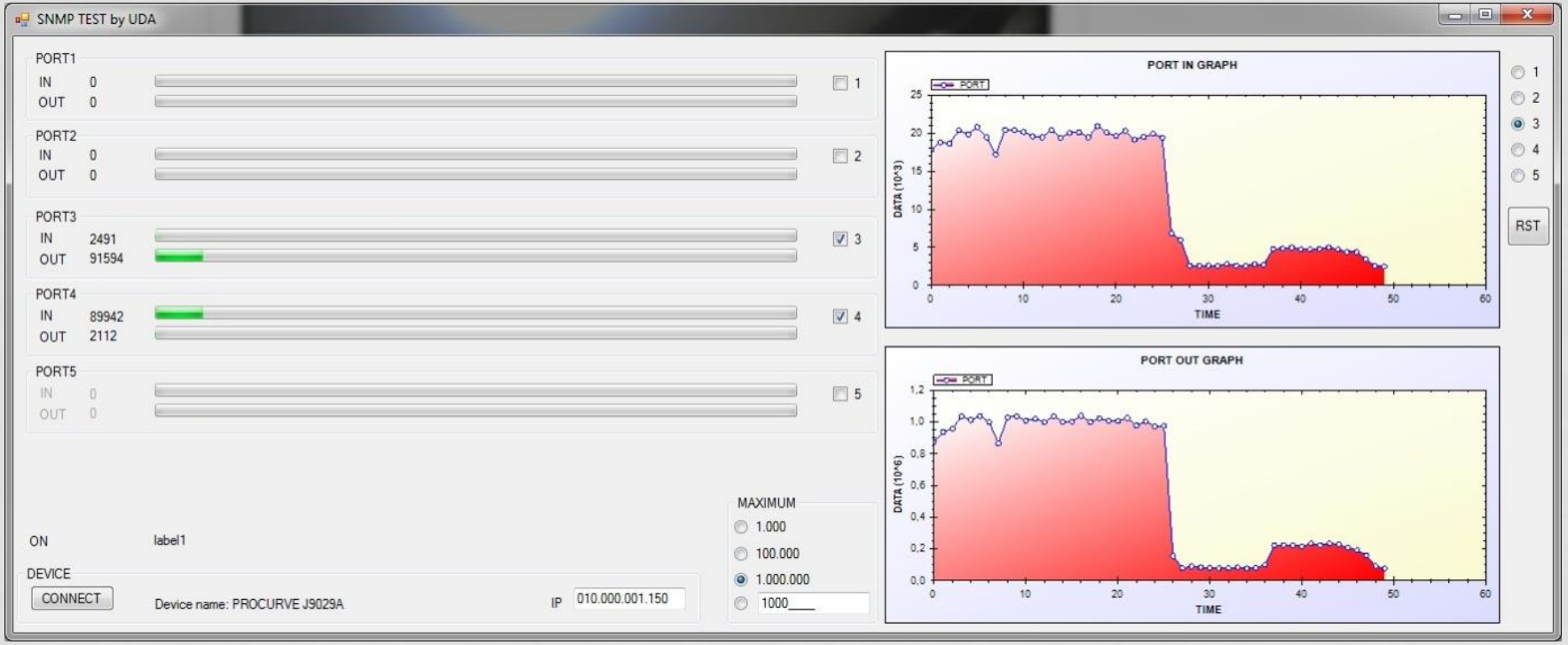
- Axis M7001 frame-grabber with both H.264 and MPEG + high quality analog camera
- data measured by Hewlet Packard ProCurve 1800-8G – high quality gigabit switch
- we measured by our own program SNMP_view based on SNMP protocol

H.264 – MPEG – STATIC SCENE



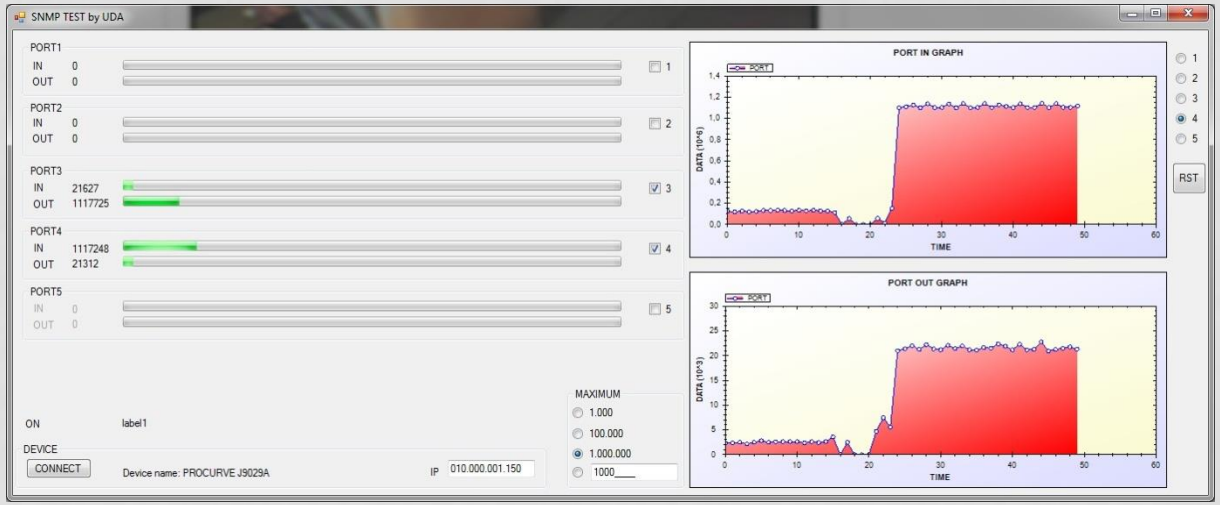
H.264 about 10x better

H.264 VS MPEG – MOVING CAMERA



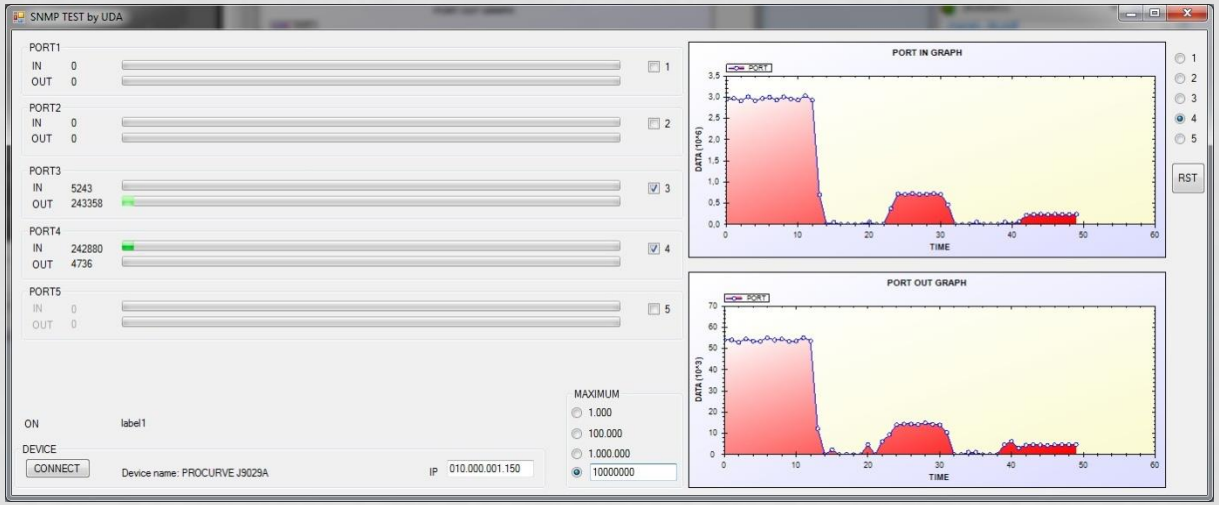
H.264 about 5x better

MJPEG - RESOLUTION



176x120 vs. 720x480, (24-bit color, 25 frames/s)
6x more pixels – 8x more data

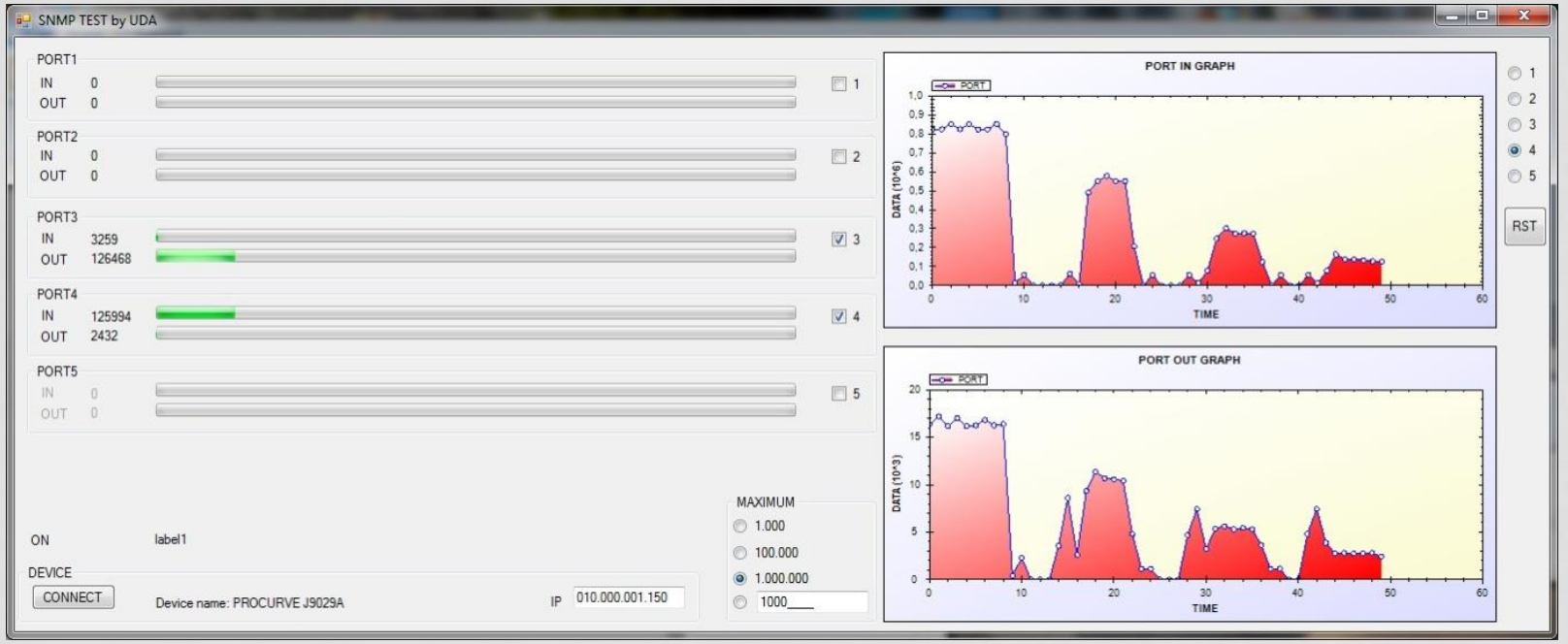
MJPEG COMPRESSION



0% compression (left), 50% (middle), 100% (right)

- visual difference between 0% and 50% is almost invisible, but it is 4x more data
- 100% compression practically unusable

MJPEG - REFRESH RATE



FPS 25 vs. 20 vs. 10 vs. 5

- because of principle (individual JPEG frames the relation is linear

LITERATURE

- MITRE - http://www.youtube.com/watch?v=9WT_kGByTpQ
- iRobot - http://www.techbriefs.com/component/content/article/8084

- http://portal.acm.org – ui related articles