matfyz

Computer Graphics Charles University

Počítačová grafika I
NPGR 003

CGG MFF UK Praha

pepca@cgg.mff.cuni.cz
http://cgg.mff.cuni.cz/~pepca/

Vector graphics

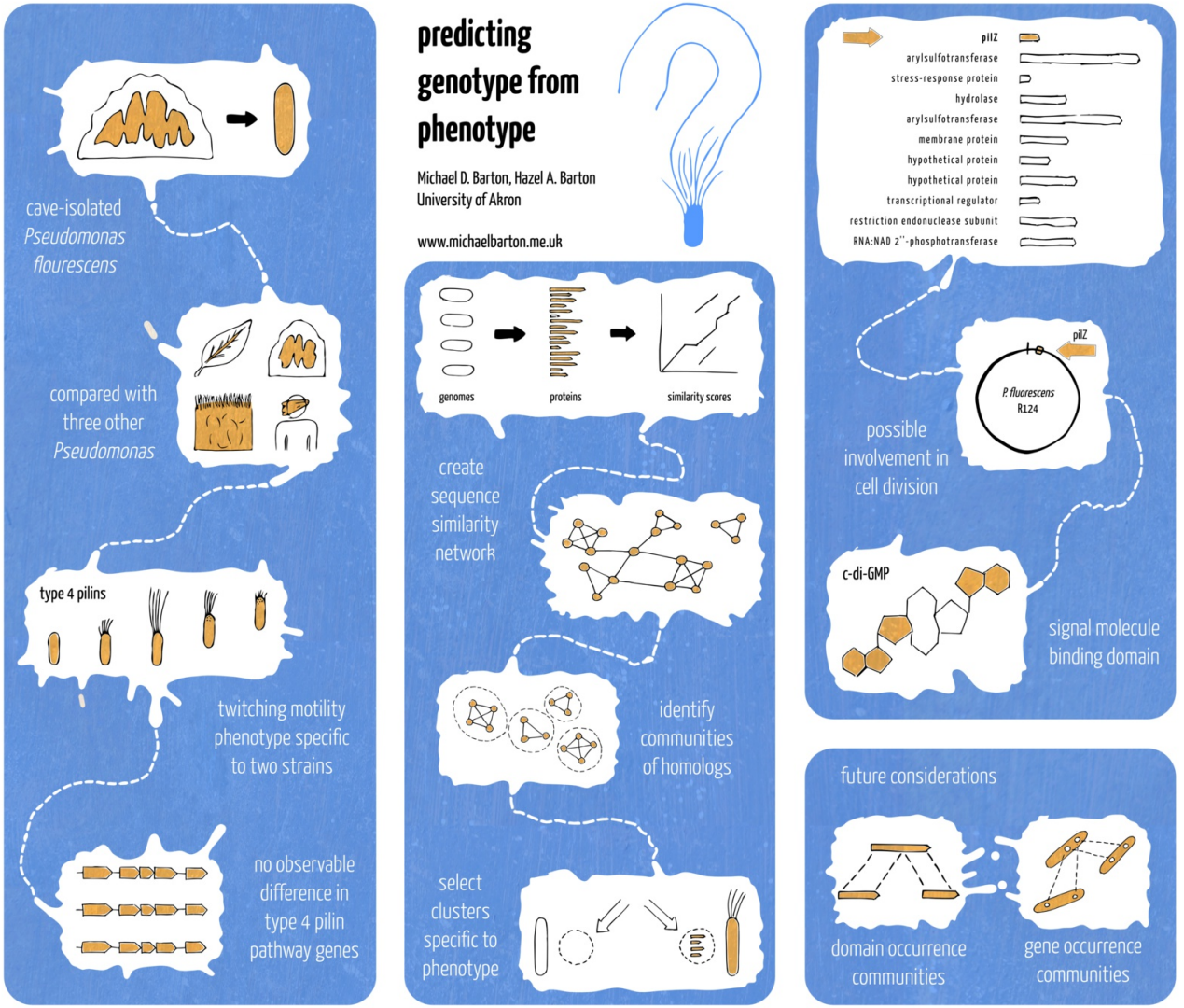
© 2014, Saylerman

Vector graphics

- **interactive editing**
  - splines†, free-form drawing
- **colors***
- **vector image format***
  - SVG, PDF, EPS, DXF, AI
- **transparency***
- **vectorization tool**

*** … in this course**
† … in other courses

Poster, billboard



Poster, billboard

© 1939, Charles Vershuuren

© DaveForYou

Digitized poster

- **digital photography**
- **color balance†**
- **raster image***
  - PNG, TIFF, JPEG
- **image rotation†**

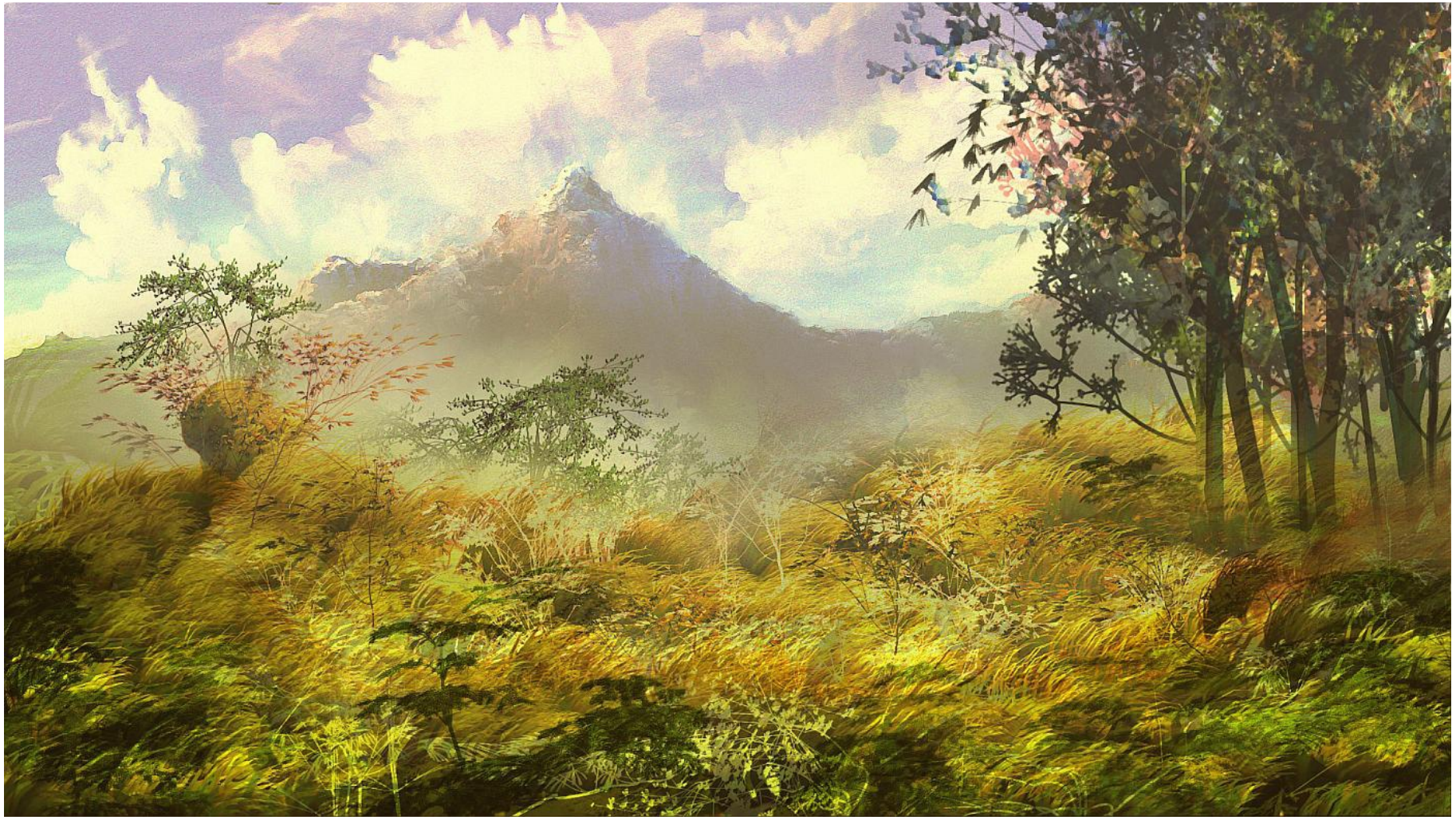
Poster print:

- **color conversion***
  - RGB to CMYK
- **digital halftoning***

Digital painting, 2D effects

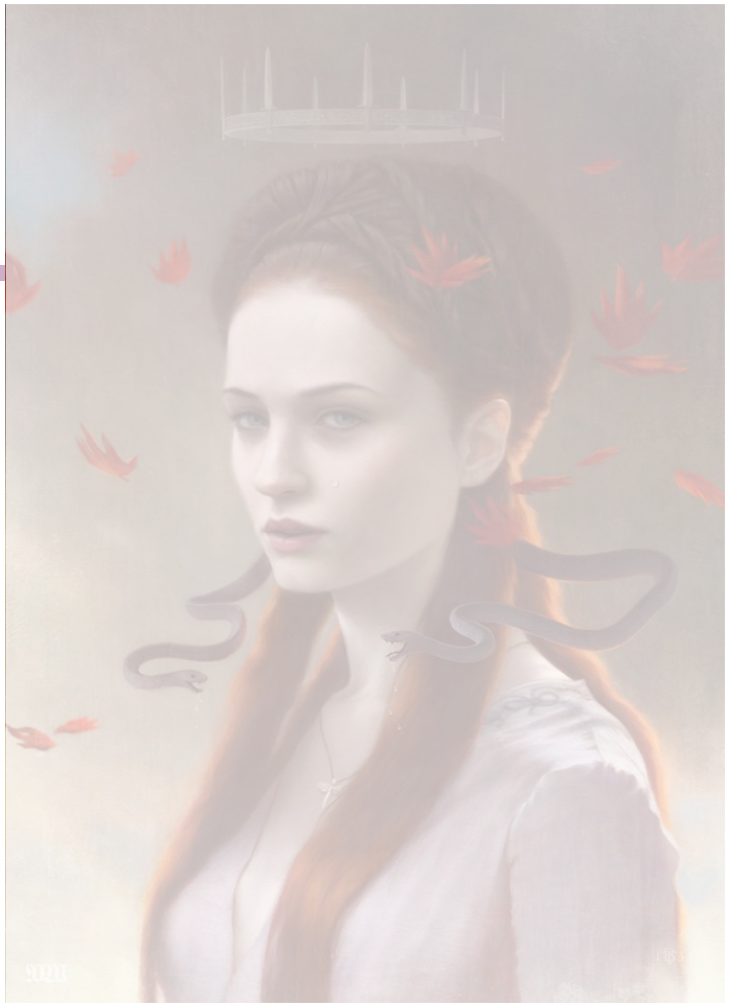
© Corel Painter, Hahin

Digital painting tools



© Dan Ritchie (PD Particles)

Digital painting



- **interactive editing**
  - pens, brushes, special tools
  - „undo“
  - touchpad, touchpen, digitizer
- **colors***
- **transparency***
- **painterly effects***

Digital photography

© 2016, DP Review

Digital photography

- **autofocus**
  - edge-detection†
- **colors***
  - white balance
- **raster image format***
  - JPEG, RAW
- **denoise†**
- **HDR***
  - super-bracketing

Digital effect – Photoshop, GiMP

Digital effect

- **interactive editing**
  - pens, brushes, tools
  - „undo“
- **colors***
- **raster image format***
  - JPEG, PNG, TIFF
- **special effect filters***†
  - image enhancing, edge operators, histogram operation, ..
  - color transforms (rebalance..)

HDR photography

© 2015, Andrea Baldwin

HDR photography

© 2013, Jimmy McIntyre

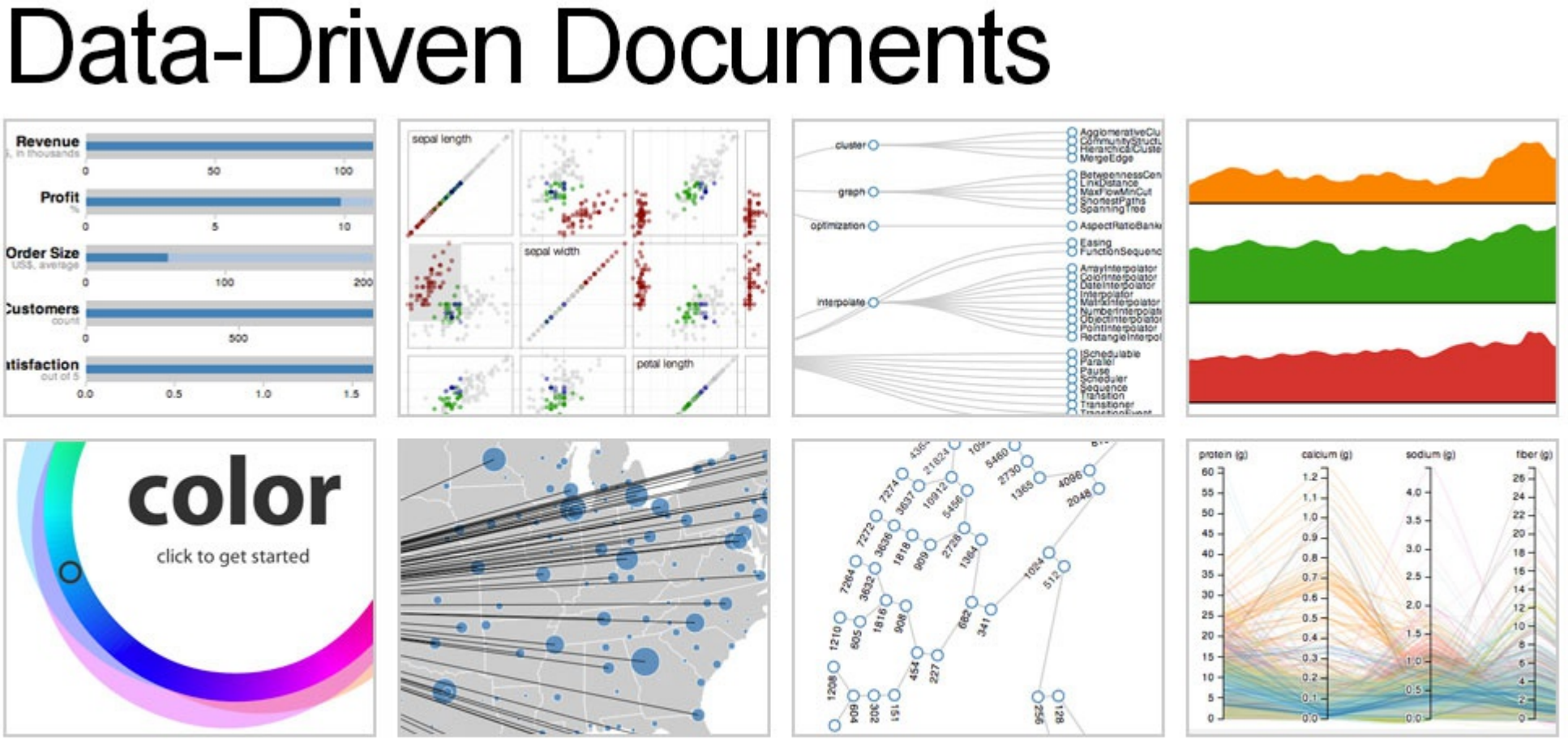
HDR photography

© Conor MacNeill (TheFella)

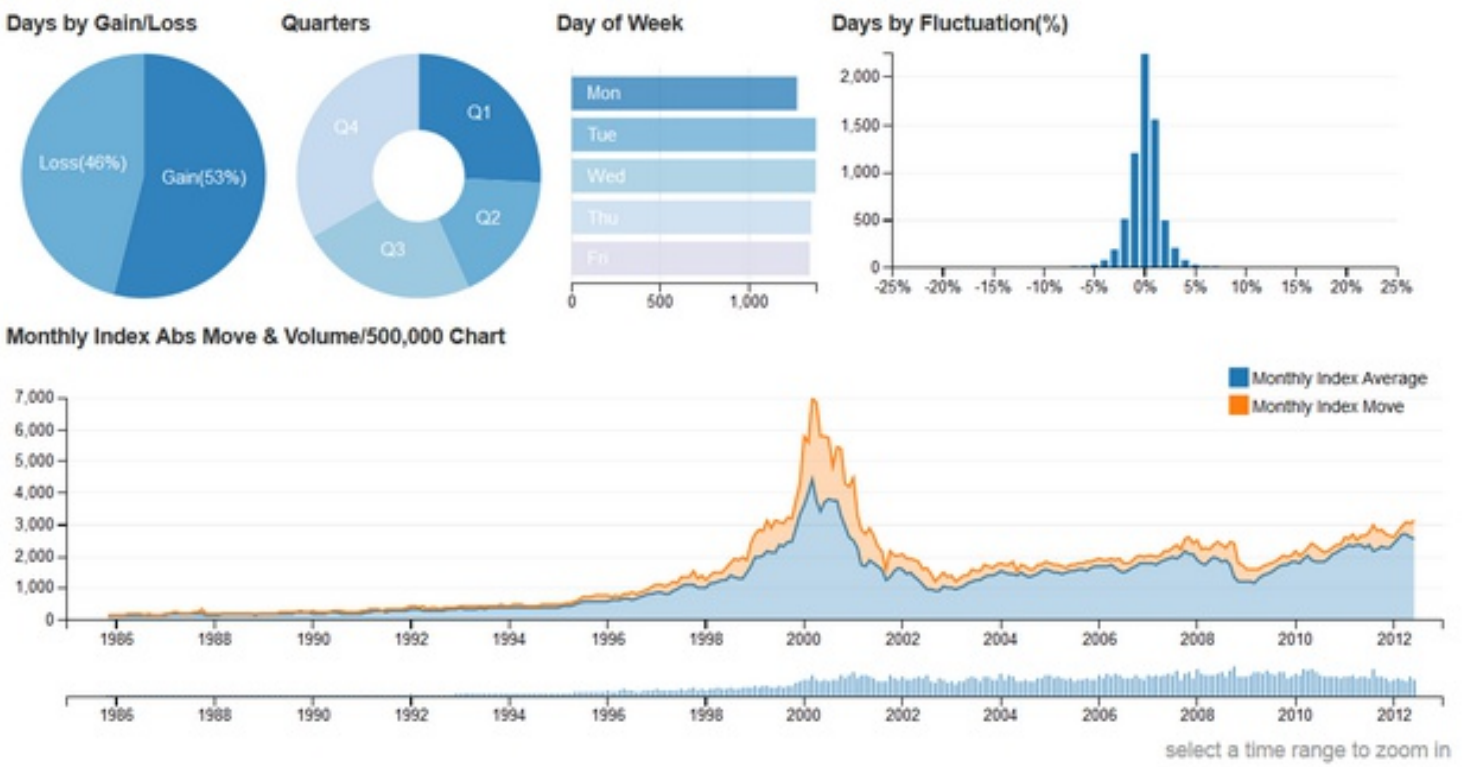
HDR photography

- **HDR acquisition***
  - multiple exposure
  - „super-bracketing“
- **colors***
- **HDR image format***
  - HDR, EXR, PFM
- **tone-mapping***

Web design, data visualization



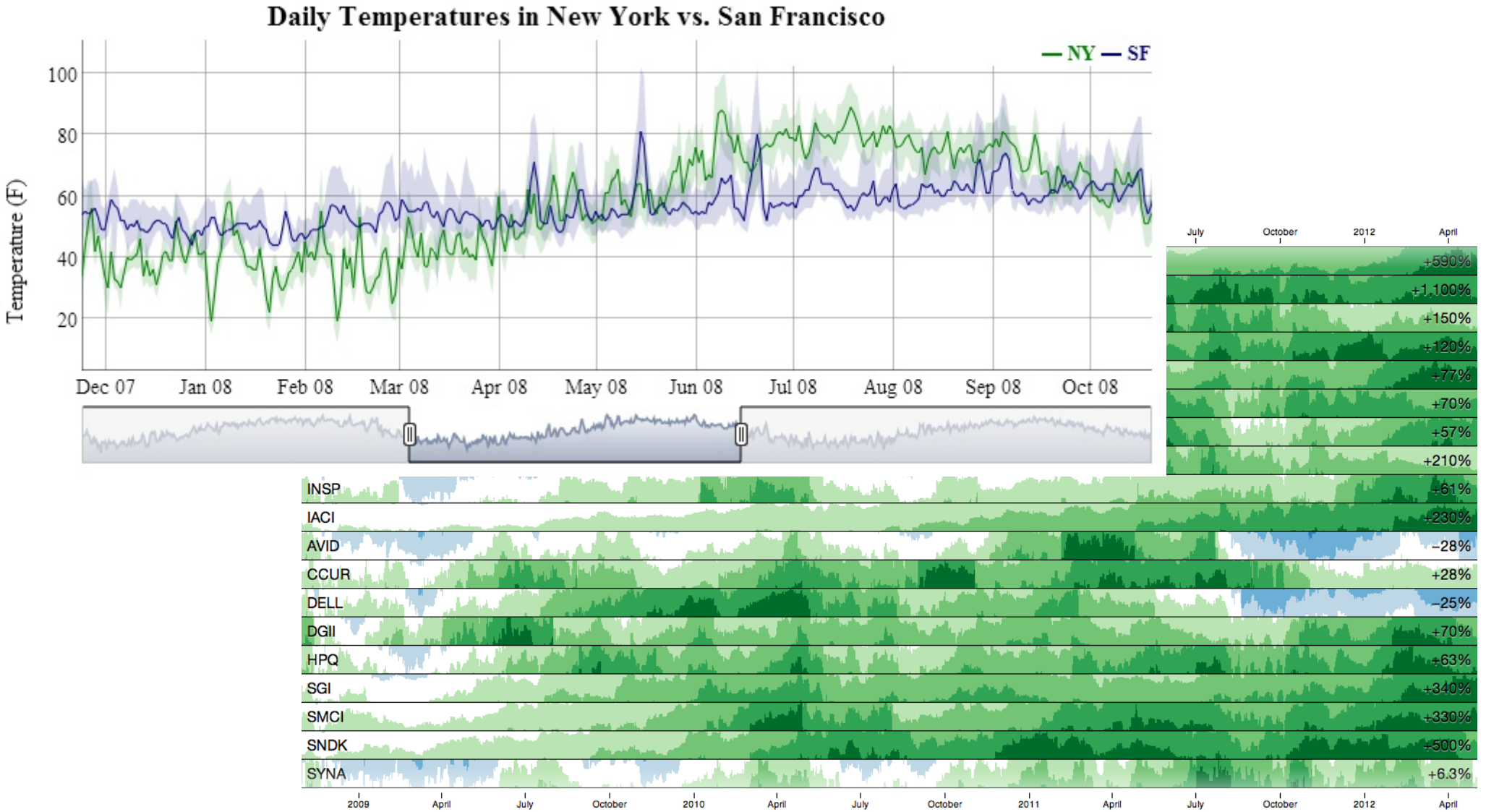
Web design, data visualization



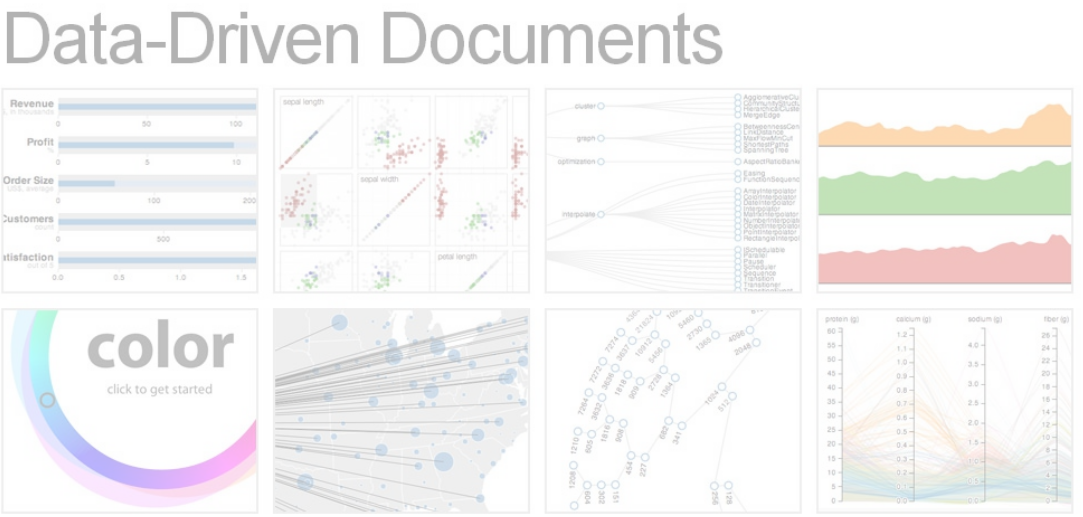
6,724 selected out of 6,724 records | Reset All

Date	Open	Close	Change	Volume
2012/06				
06/18/2012	2570.98	2592.52	21.54	15407330
06/19/2012	2606.43	2620.83	14.40	17714840

Interactive data on web

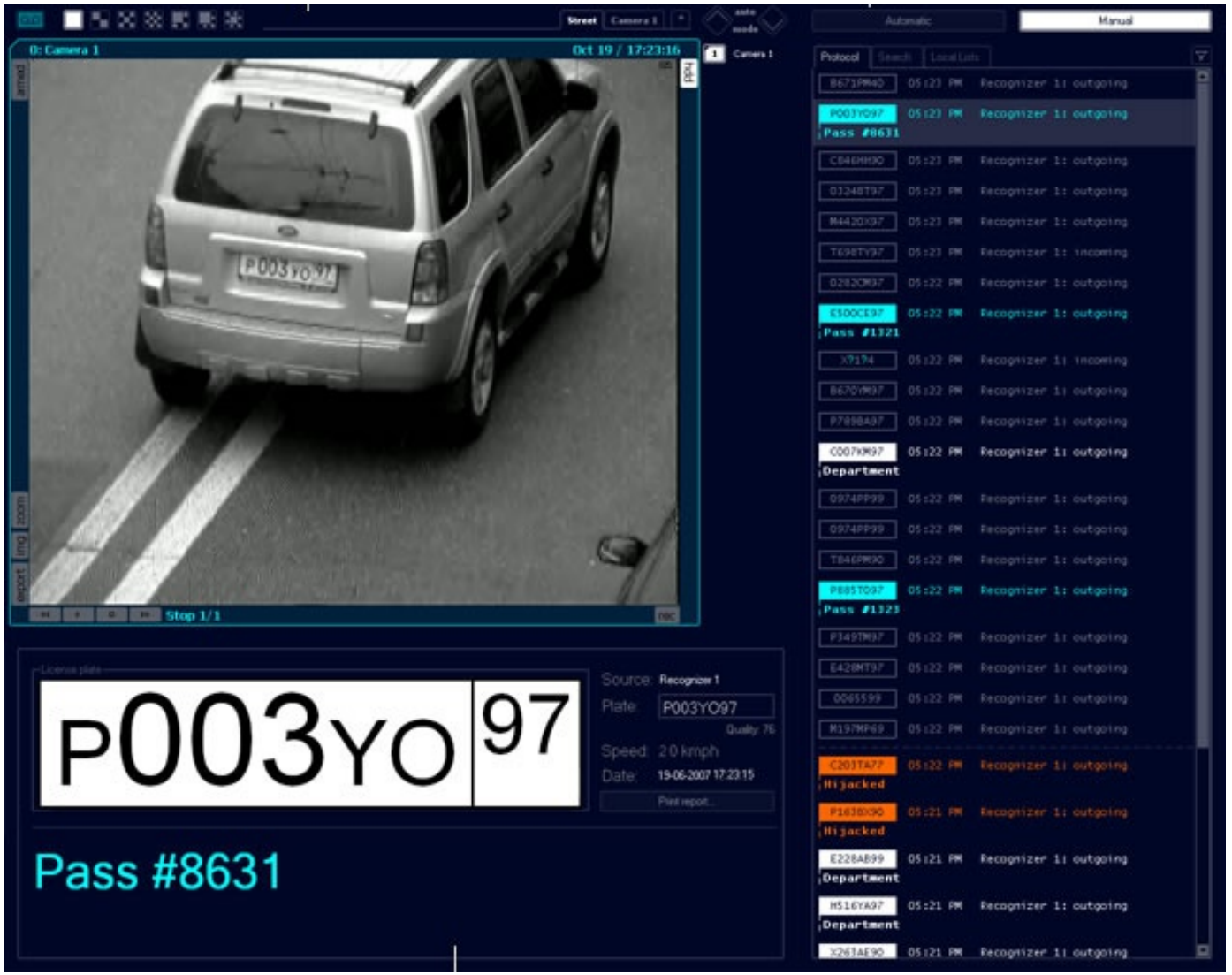


Modern web



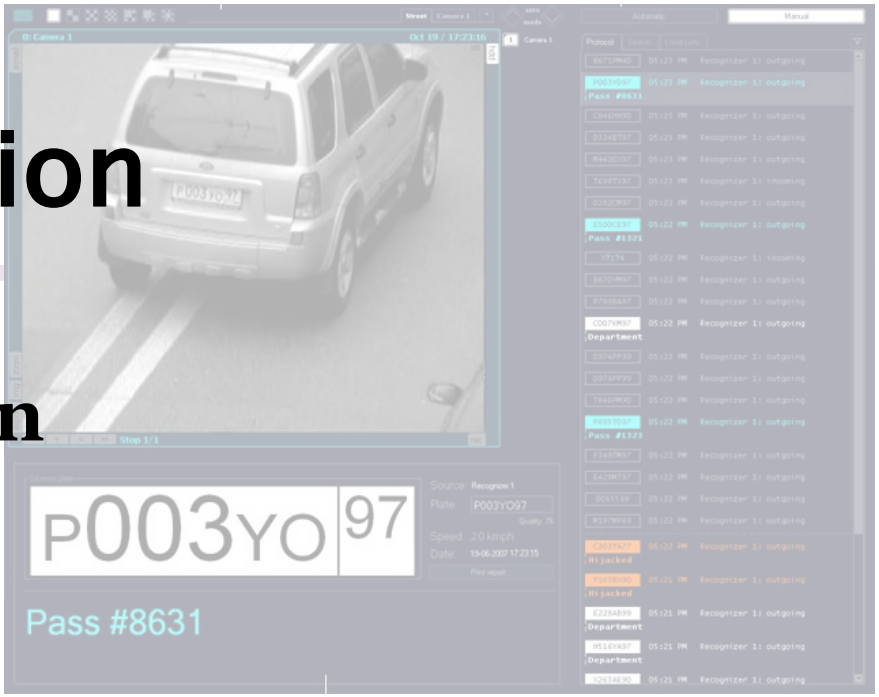
- **HTML5†, CSS3†**
  - JavaScript
  - templates, WordPress
- **interactivity†**
- **Data-Driven Documents†**
  - d3.js library
- **WebGL for 3D†**
  - interactivity
- **video, 360-degree video**

License-plate recognition



© Smart Security Camera, Inc.

License-plate recognition



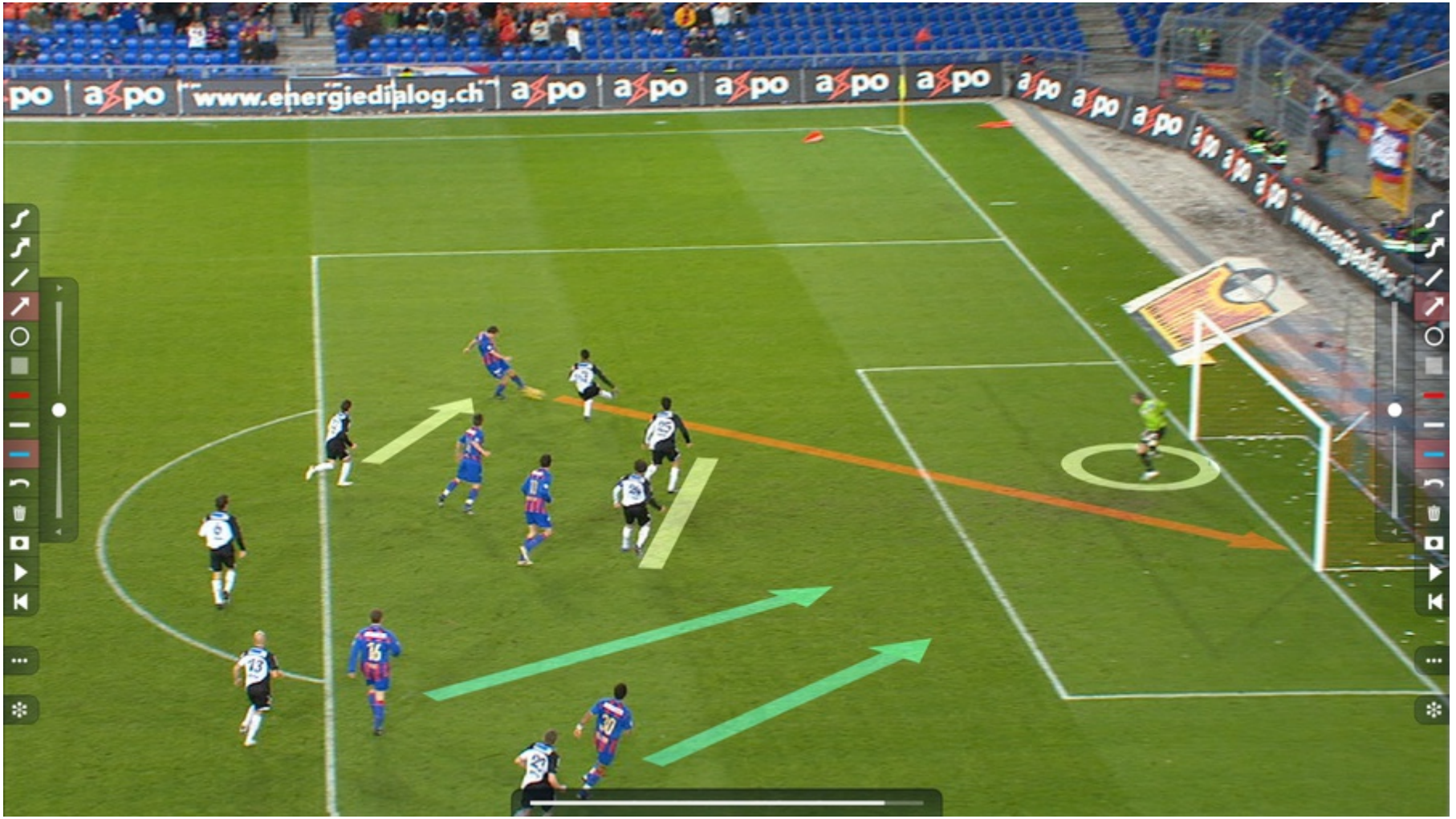
- **real-time image acquisition**
- **plate segmentation†**
- **image warping†**
- **glyph recognition†**
- speed measurement.. ?

Sport live on TV

Sport live on TV

- **vector graphics***
  - real-time!
- **transparency***
- **real-time video signal composition**
  - real-time video compression†

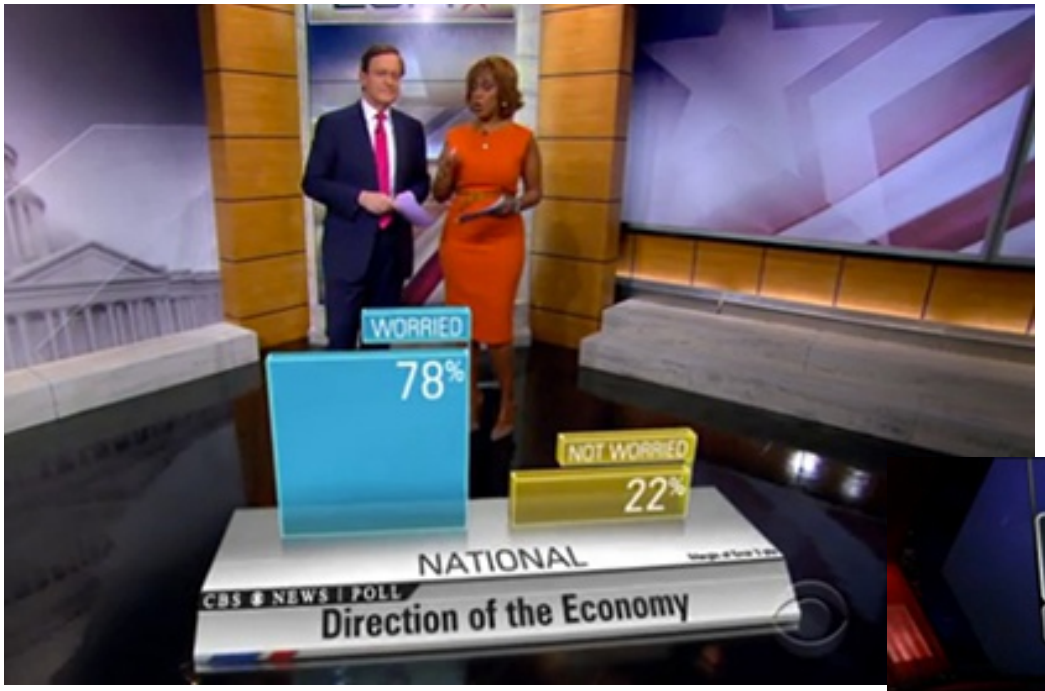
„Next-generation“ sport TV

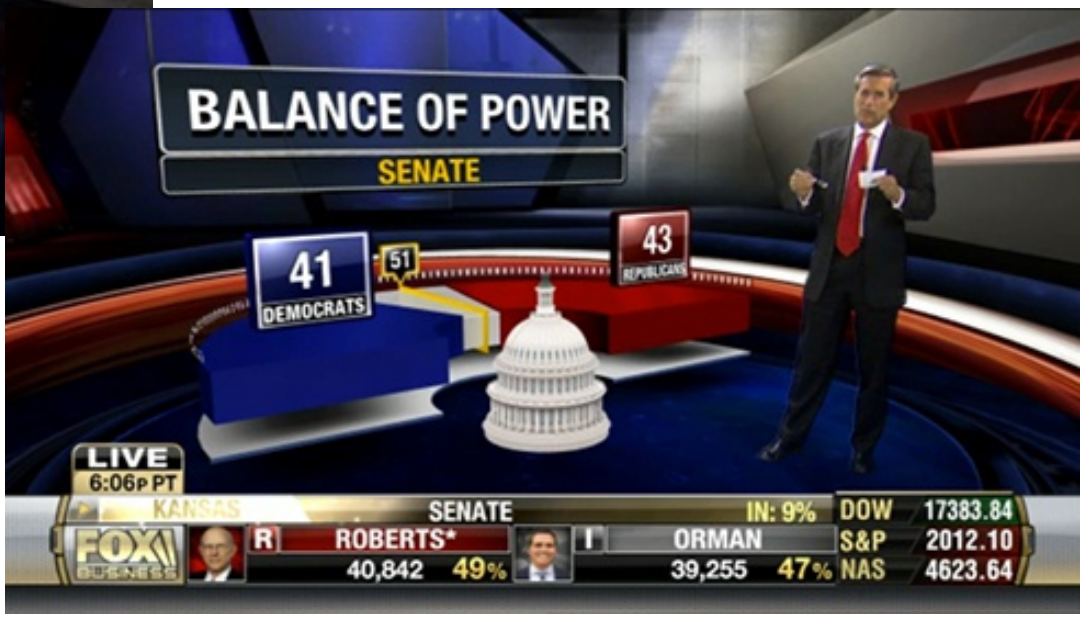


„Next-generation“ sport TV

- **3D computer vision†**
  - camera calibration
  - object recognition, segmentation
- **3D „extra“ model***
- **real-time interaction ?**
  - reporter in a studio..
- **real-time video composition**
  - layers, transparency*
  - video compression†

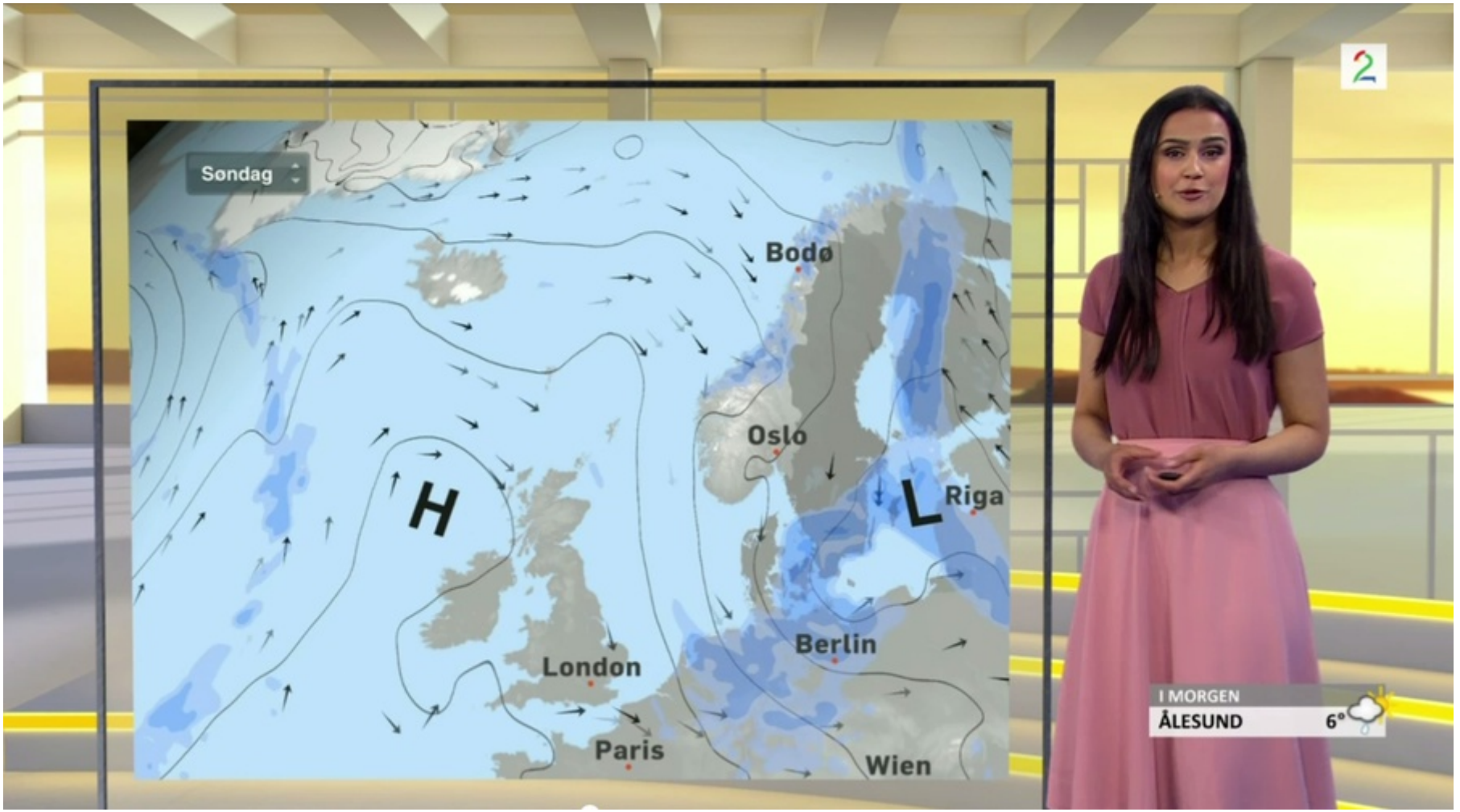
Virtual TV studio





© CBS, FOX TV

Virtual TV studio

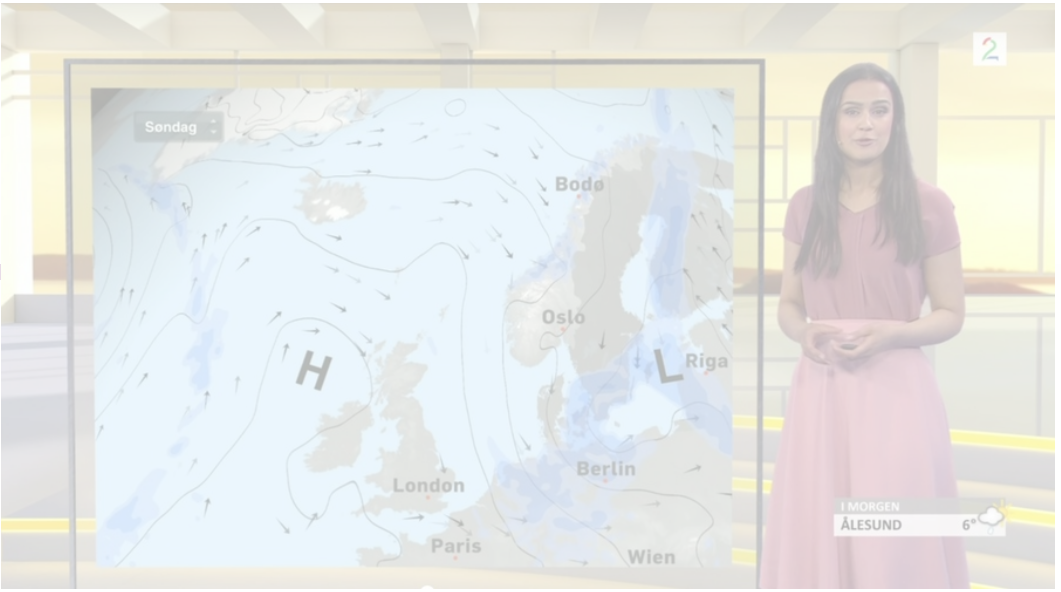


© TV 2

Green screen („virtual studio“)

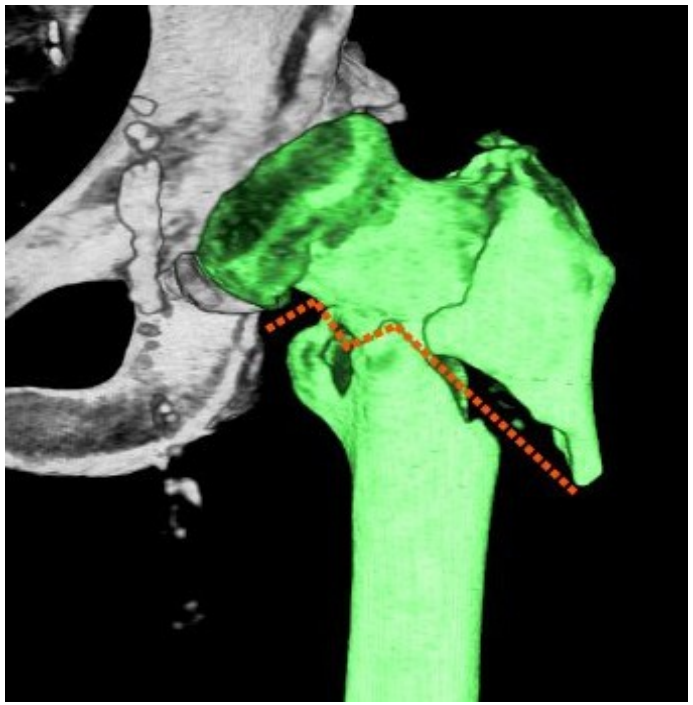
© 2009, vr3 virtual production oHG

Virtual TV studio



- **„green-screen“**
  - keying in hardware
- **3D virtual model***
  - can be dynamic (animations, additional video channels..)
- **real-time video composition**
  - layers, transparency*
- **video compression†**
  - all in real-time

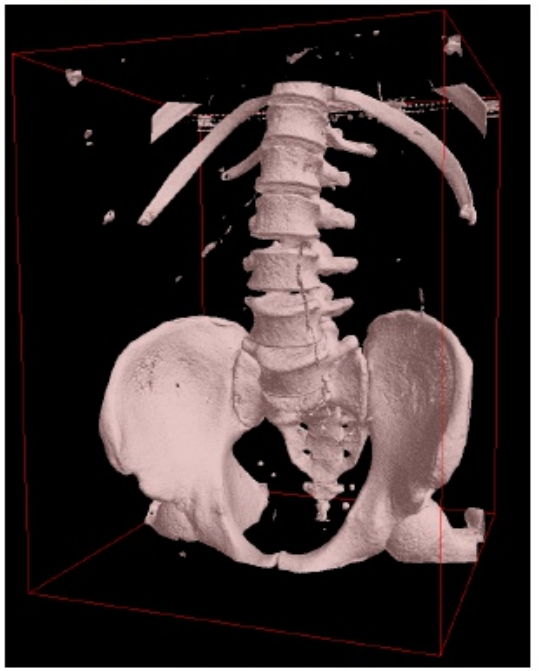
Medical data



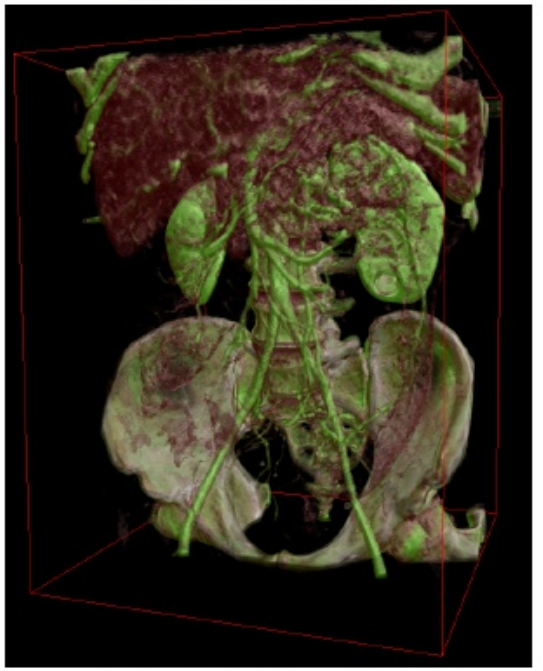
© 2016, Jan Horáček,
Jan Kolomazník

(a) Maximum intensity projection

(b) Density integration

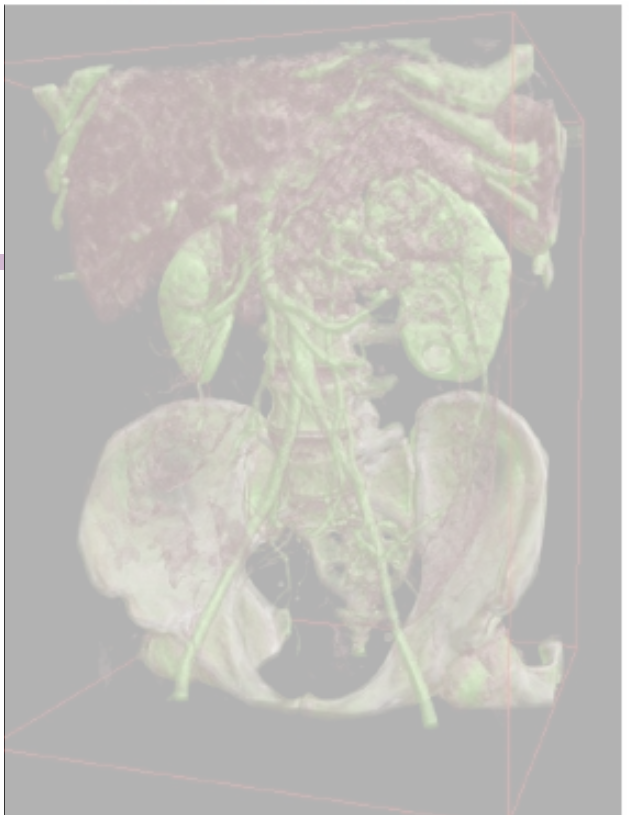


(c) Isosurfaces



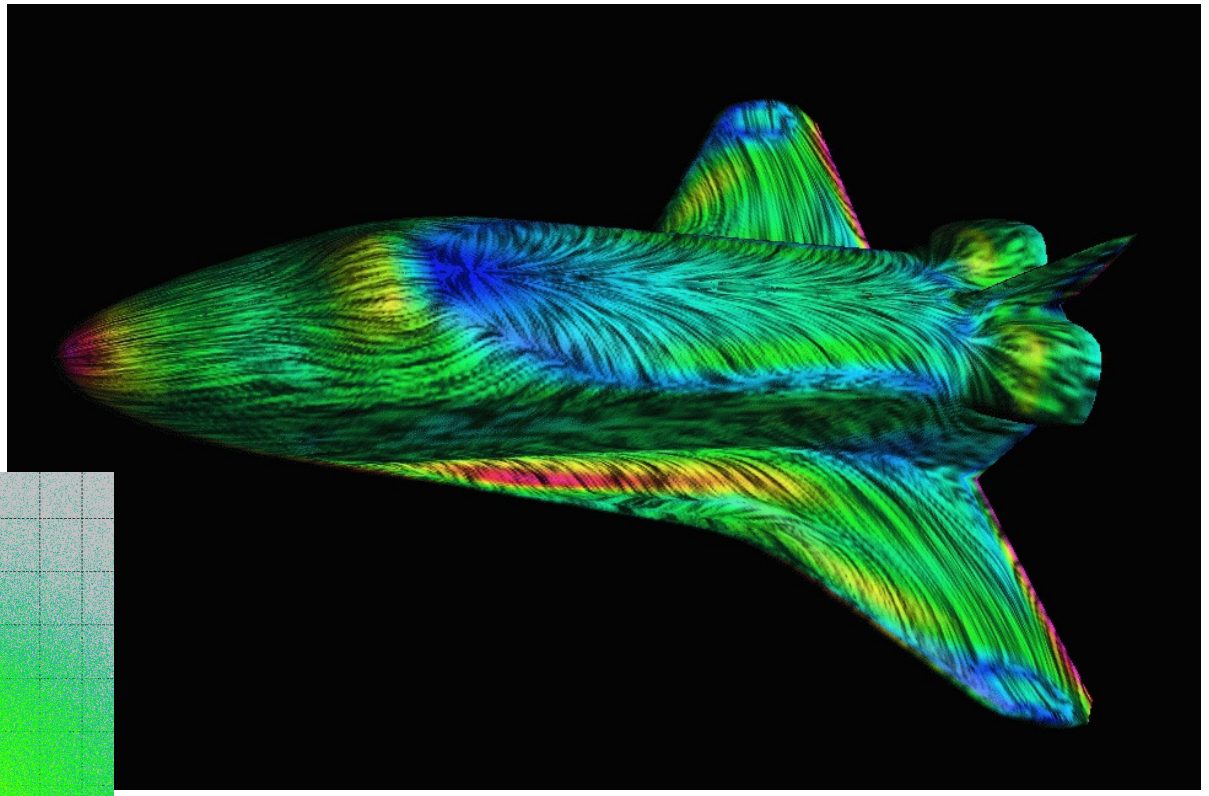
(d) 1D transfer function

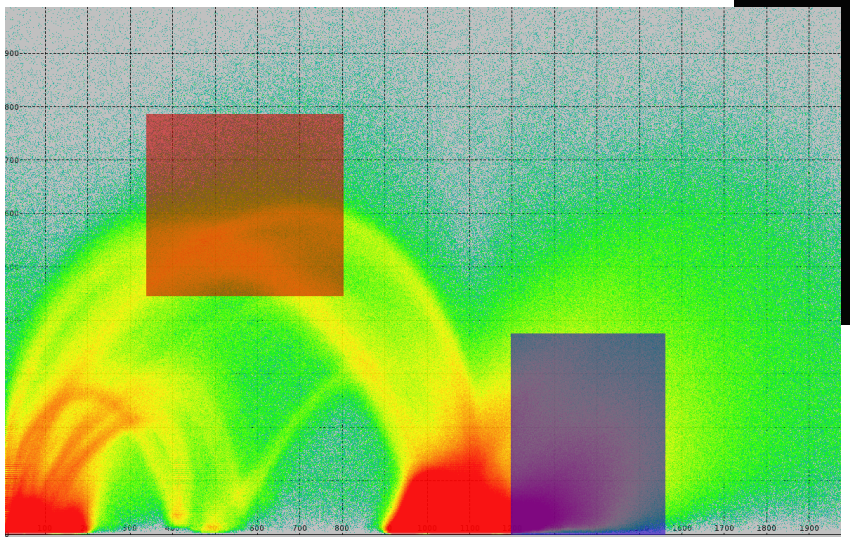
Medical data



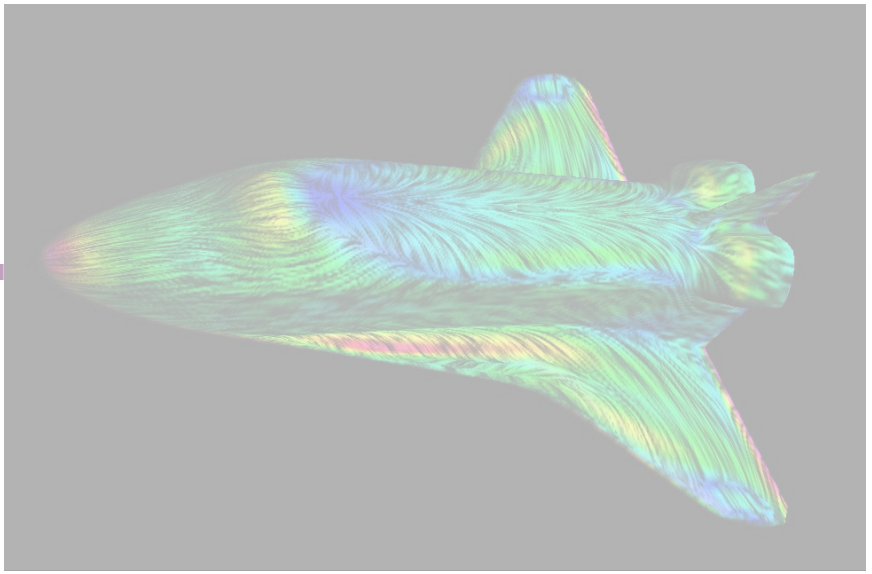
- **volume data acquisition†**
  - Computer Tomography
  - Magnetic Resonance Imaging, ..
- **data enhancement†**
  - de-noise, contrast (CUDA†, GPU†)
- **segmentation†**
  - organs, vessels, bowels (CUDA†, GPU†)
- **real-time volume rendering†**
  - ray-casting on GPU
- **measurements, ..**

Scientific visualization



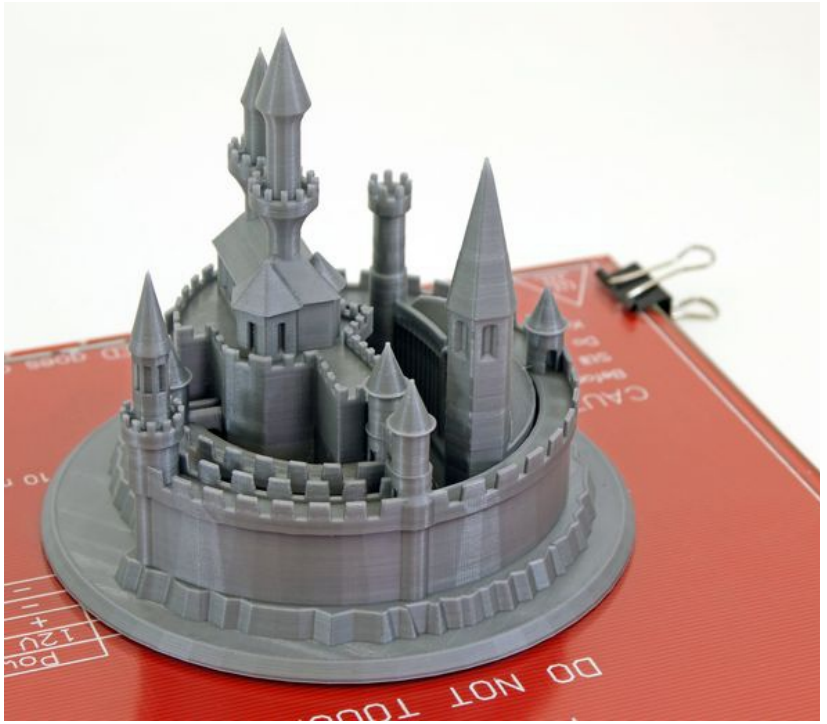


Scientific visualization



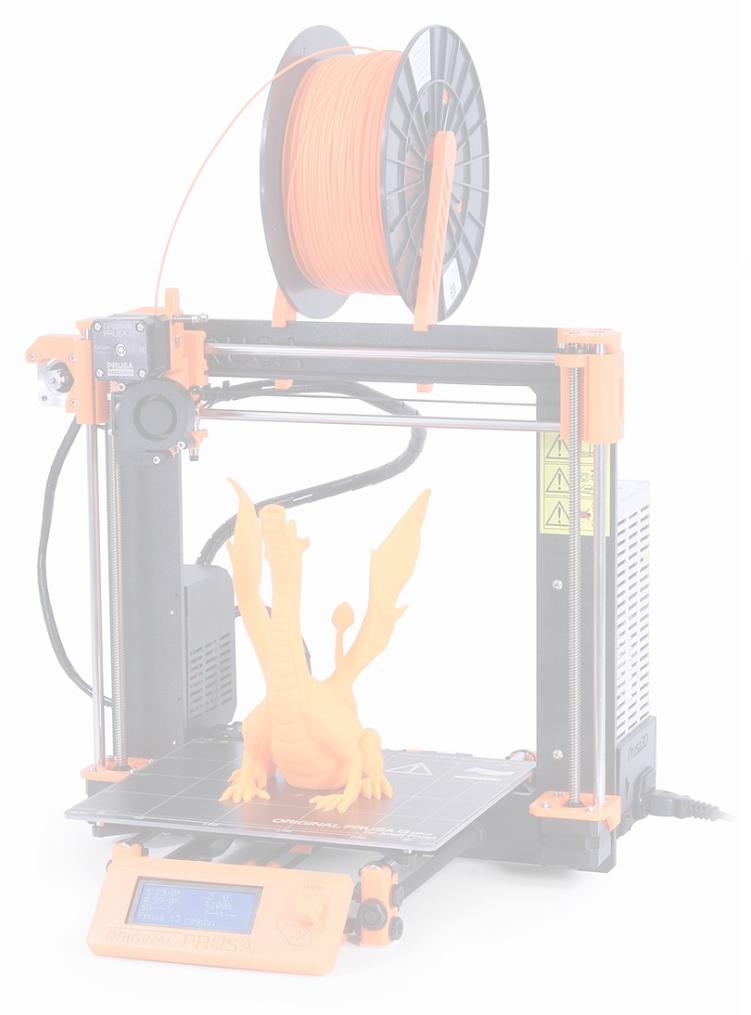
- **data acquisition†**
  - numeric simulation
  - measurements, ..
- **visualization primitives†**
  - streamlines, arrows, ..
- **real-time rendering†**
  - vanilla 3D or full volume rendering (CUDA†, GPU†)
- **interaction†**
  - „steering“
- **measurements, ..**

3D printing



3D printing

- **3D model editor†**
  - CSG, triangle-mesh, ..
- **„rendering“, rasterization**
  - similar to 2D rasterization*
- **geometric optimization**
  - stiffness simulation ?



Realistic rendering – Corona

© Bertrand Benoit, Pavel Stavila

Realistic rendering

- **3D scene model***
- **3D editing†**
  - 3DS Max, Blender, Rhinoceros
- **materials*†**
  - surface appearance, textures†
- **lighting†**
  - primary light sources + global illumination (GI) simulation†
- **HDR results***

Computer animation

© 2007, DreamWorks Animation SKG

Computer animation

© 2007, DreamWorks Animation SKG

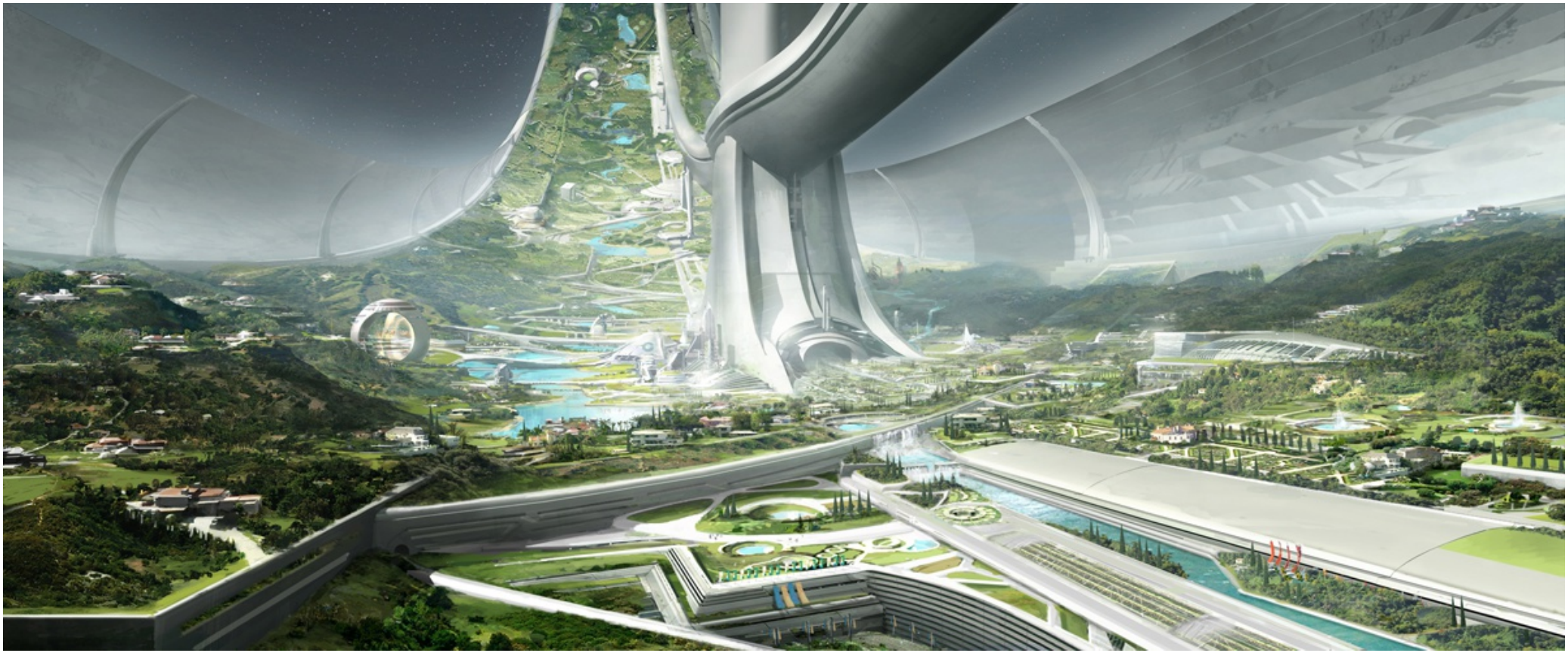
Computer animation

© 2015, Pixar Animation Studios, Walt Disney Pictures

Computer animation

- **3D scene model***
- **3D/animation editing†**
- **realistic rendering*†**
  - off-line (CUDA†, GPU†)
  - materials, textures, appearance models
  - lighting with GI
- **video-compression†**
  - off-line

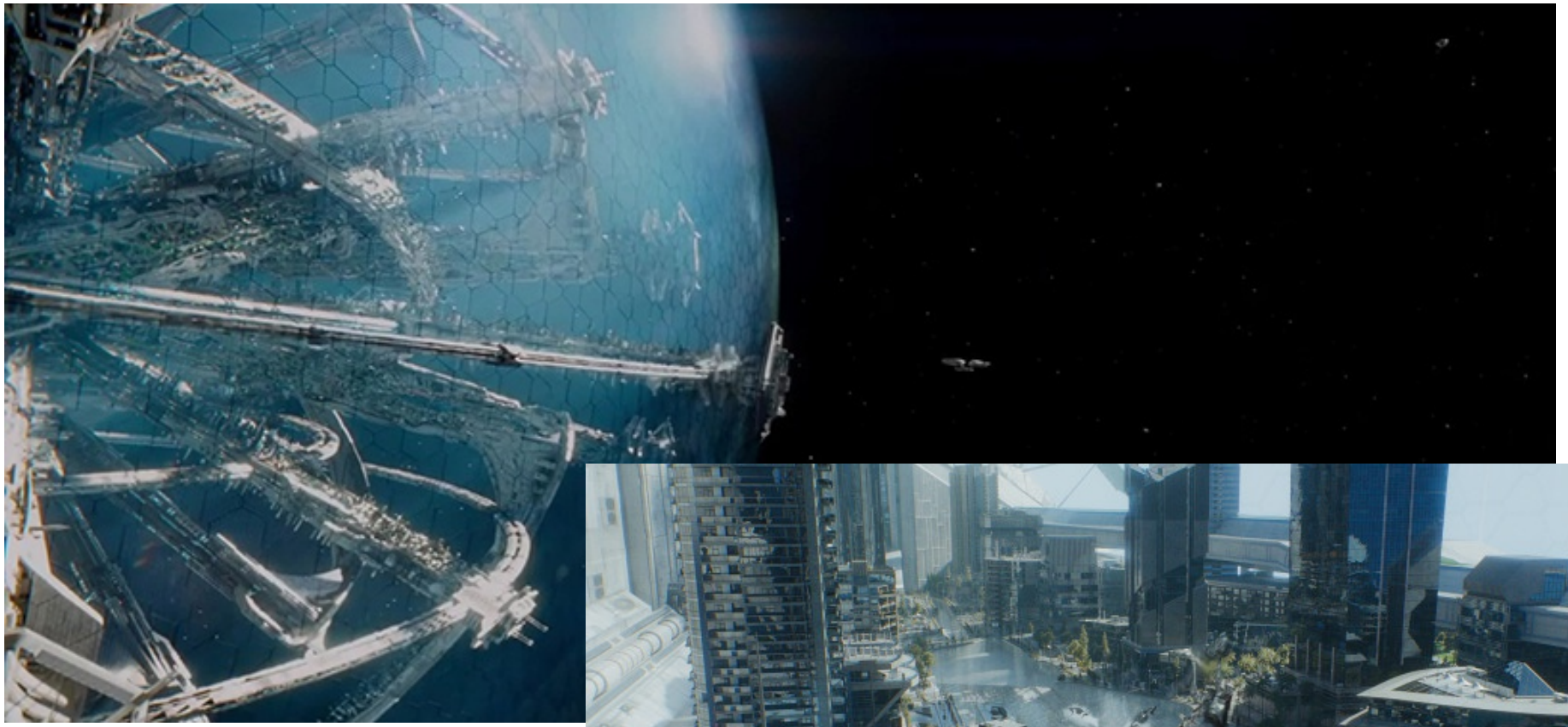
CGI in film – Elysium



© 2013, TriStar Pictures

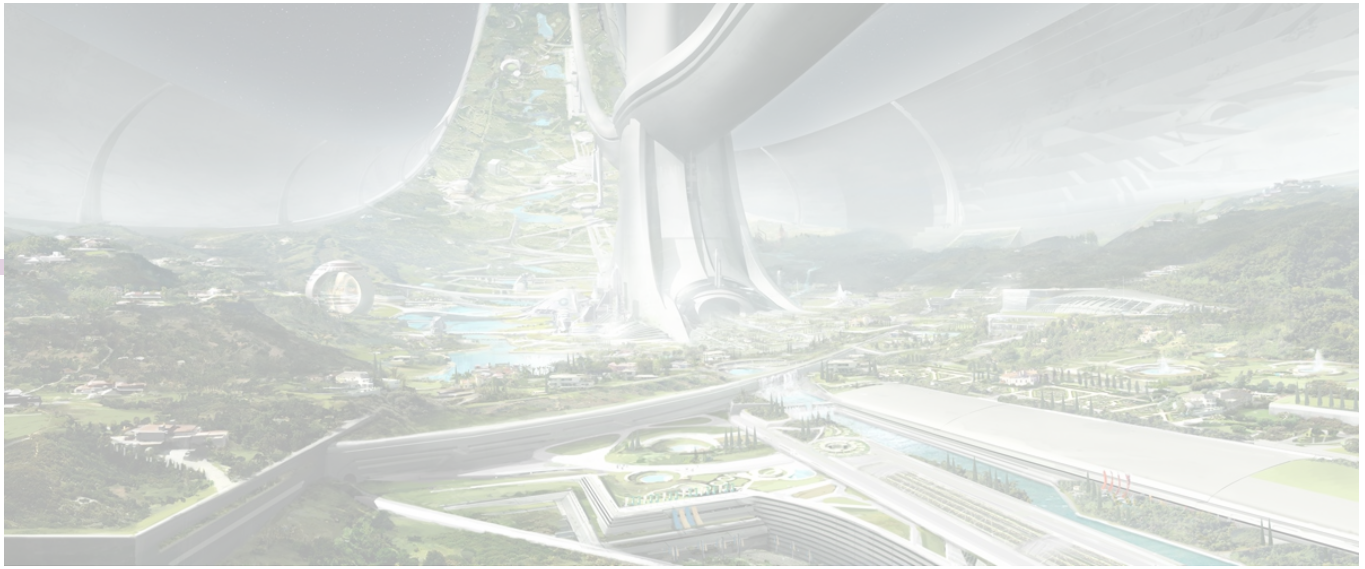
CGI in film – Star Trek into Darkness

CGI in film – Star Trek Beyond



© 2016, Double Negative, Paramount Pictures

CGI in film



- **3D scene model***
- **3D/animation editing†**
- **photo-realistic rendering*†**
  - off-line (CUDA†, GPU†)
  - materials, textures, appearance + global illumination
- **video-compression†**
  - off-line

VFX – The Perfect Storm

The Perfect Storm

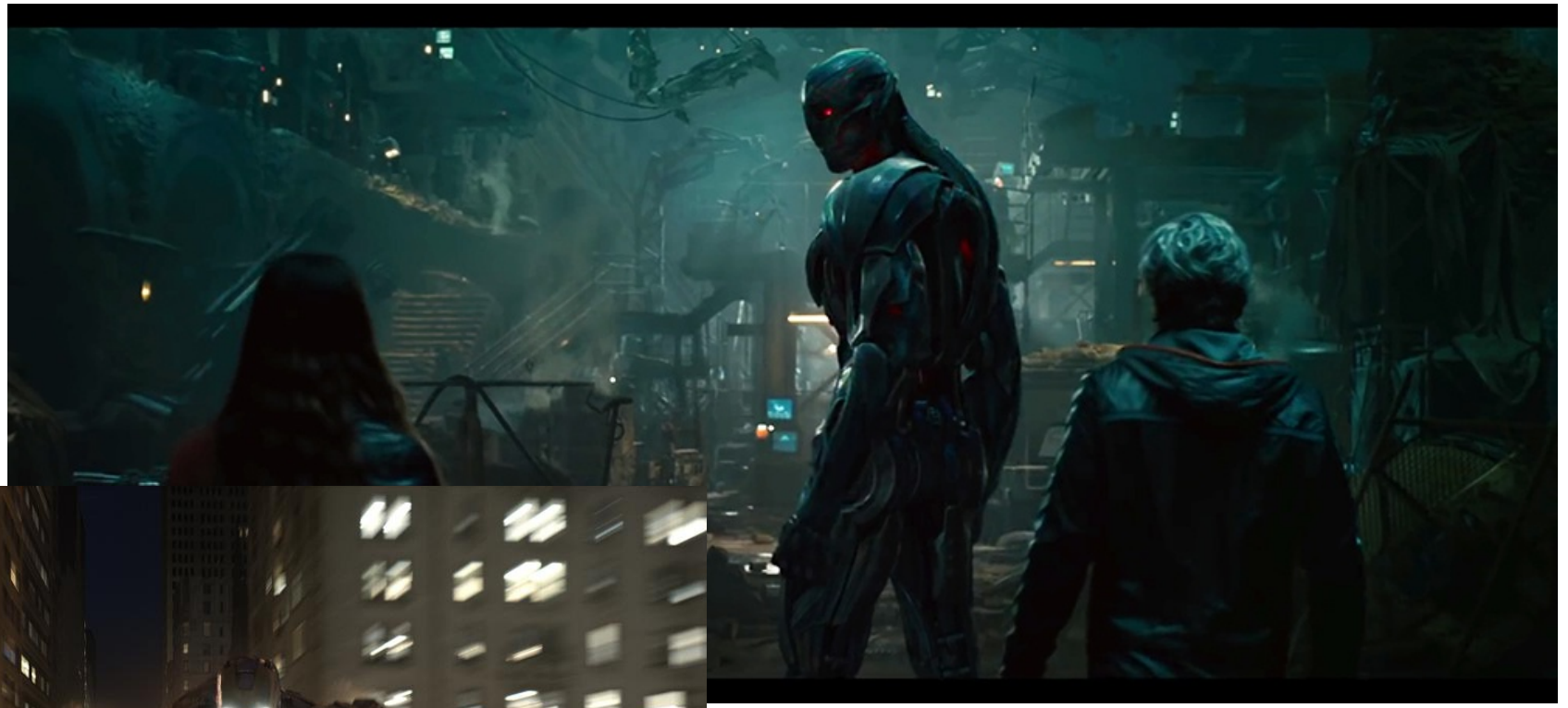
- **numeric ocean-water model!**
  - incl. realistic rendering of water
- **3D/animation editing†**
- **video composition and compression†**
  - off-line

VFX – The Perfect Storm

VFX – Marvel

© Marvel Studios, Paramount Pictures, IL&M, ..

VFX – Marvel



© Marvel Studios, IL&M, ..

VFX – Tron Legacy

© 2010, Disney Enterprises, Inc.

VFX – Tron Legacy

© 2010, Disney Enterprises, Inc.

VFX – Tron Legacy (color scheme)

© 2010, Disney Enterprises, Inc.

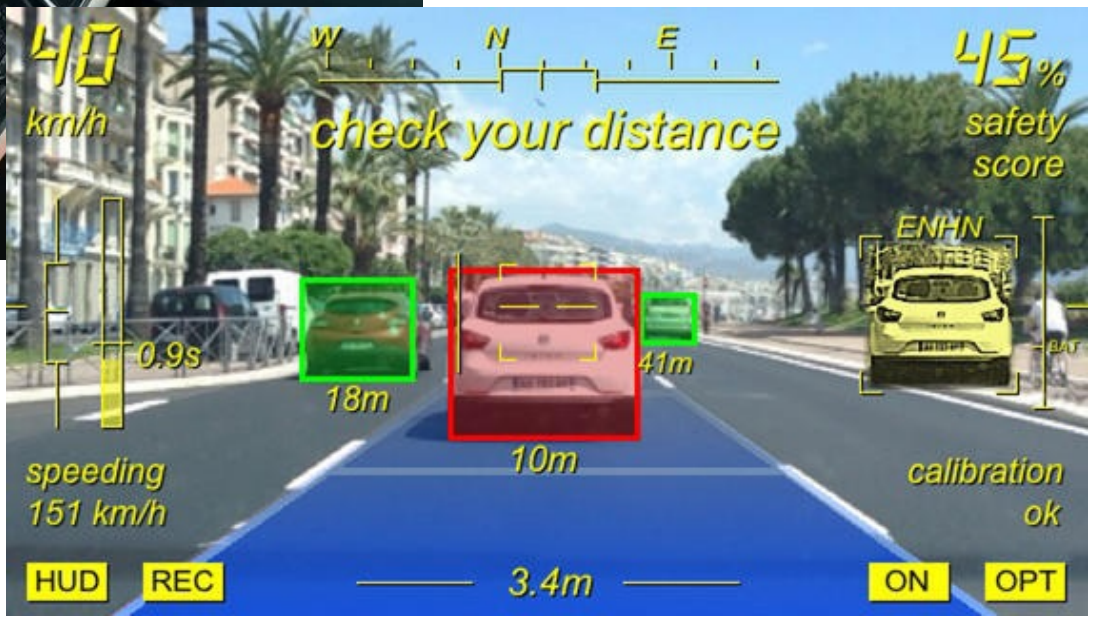
VFX – Tron Legacy

- **motion capture !**
  - incl. green-screen keying
- **3D scene model***
- **3D/animation editing†**
- **photo-realistic rendering*†**
  - off-line (CUDA†, GPU†)
  - materials, textures, appearance + global illumination
- **video-compression†**
  - off-line

Self-driving car

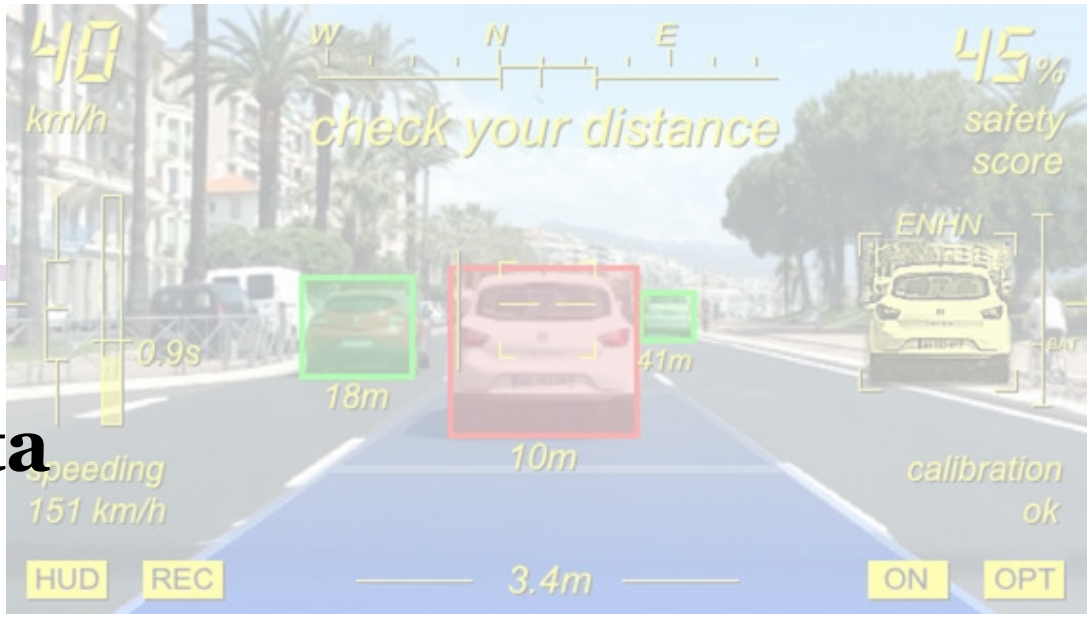
© Tesla Motors ?

Self-driving car



© Volvo

Self-driving car



- **real-time camera data**
- **camera calibration†**
  - as accurate 3D context as possible
- **3D computer vision†**
  - robust!
  - real-time! (no lags)
- **prediction, planning**
  - artificial intelligence
- **actual steering**

Videogame – DayZ (Arma II mod)

Videogame – Kingdom Come: Deliverance

© 2016-2017 Warhorse Studios

Videogame – Overwatch

© 2016, Blizzard Entertainment

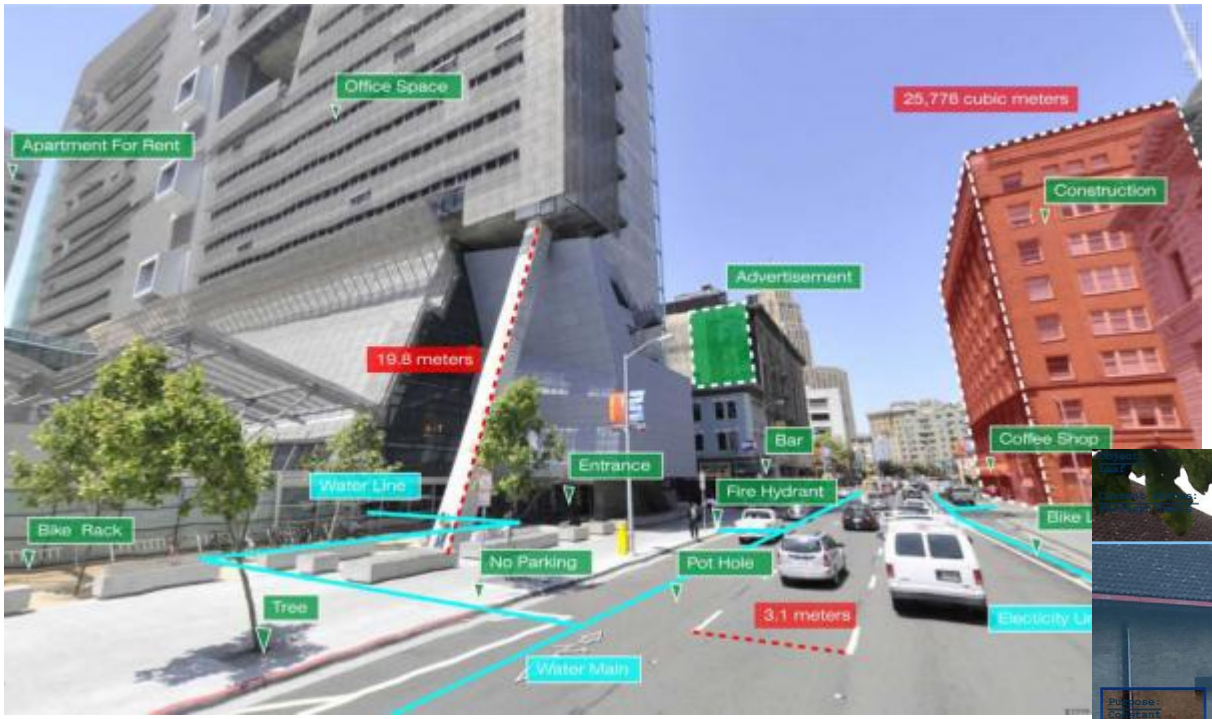
Videogames

- **3D editing, tools**
- **game logic†**
  - interaction among virtual objects
- **user interaction†**
- **real-time rendering†***
  - constant FPS, textures, LoD, GPU shaders†
  - scene virtualization (potentially infinite scene), ..
- **agents, AI players†**
- **multiplayer**
  - LAN layer, lag compensation..

Virtual reality – „cave“

© 2011, Land Rover

Augmented reality – „smart glasses“



© Google, Stormy's Media Mountain

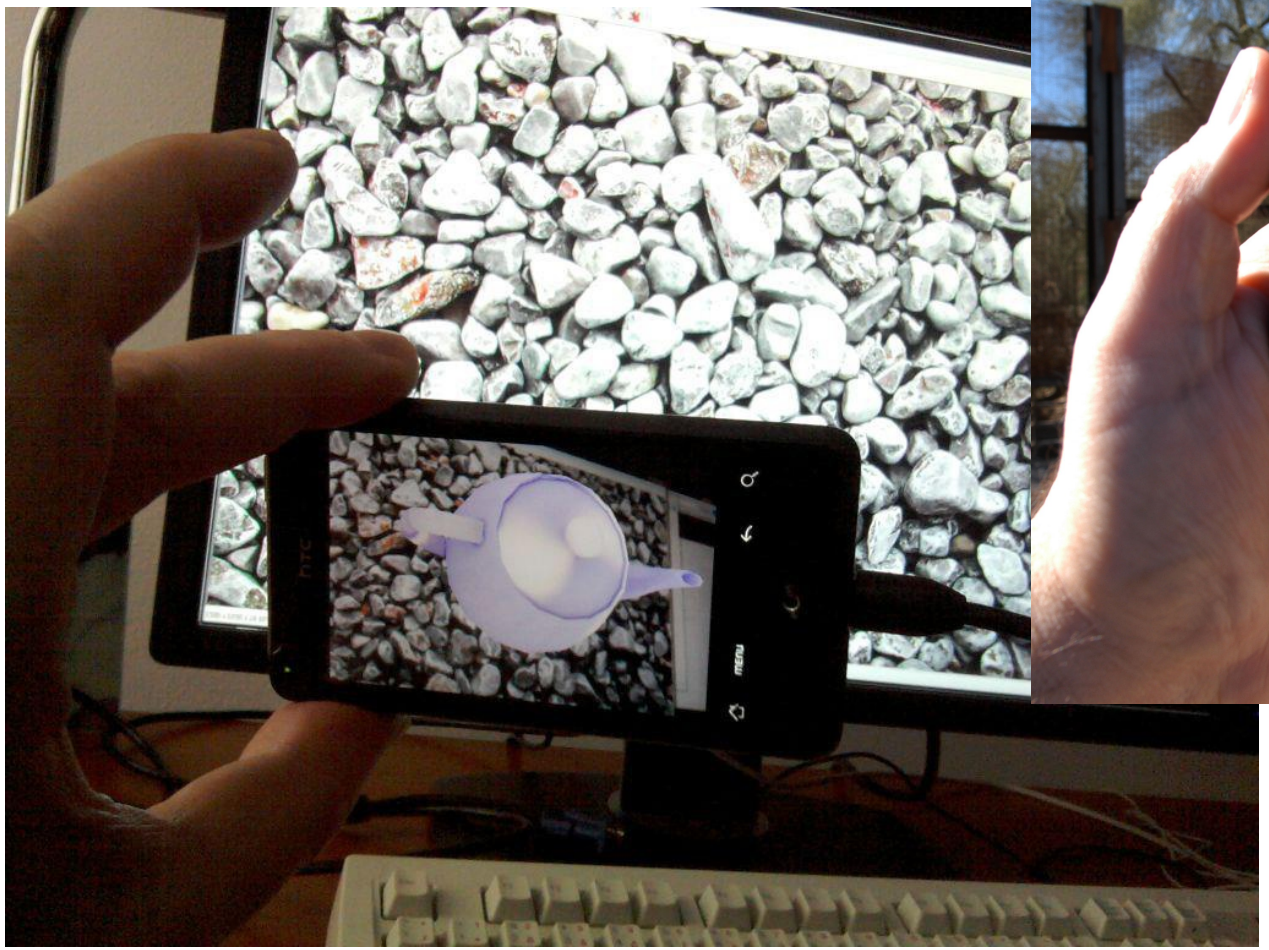
Augmented reality – „smart glasses“

© 2016, Epson (Moverio BT 300)

Augmented reality – military

© 2016, ARA

Augmented reality – phone

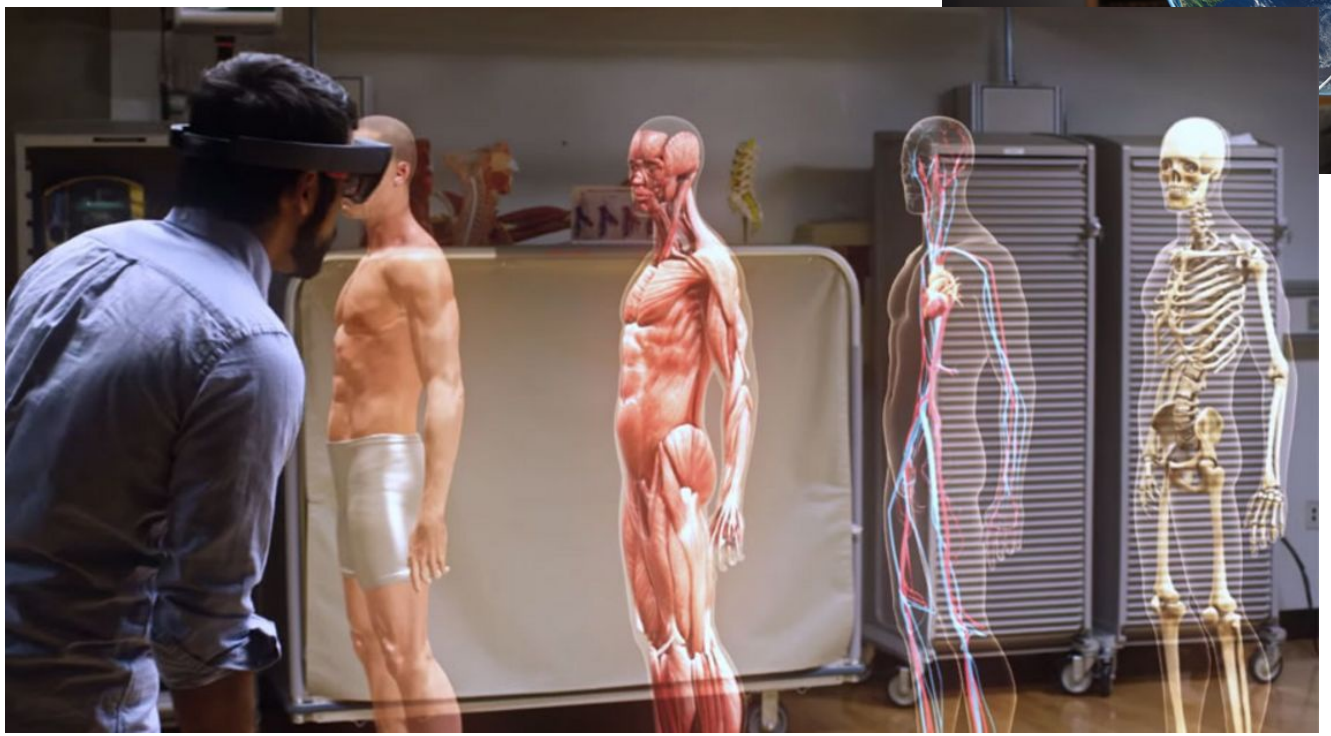


© 2012, JP

Augmented reality – tablet

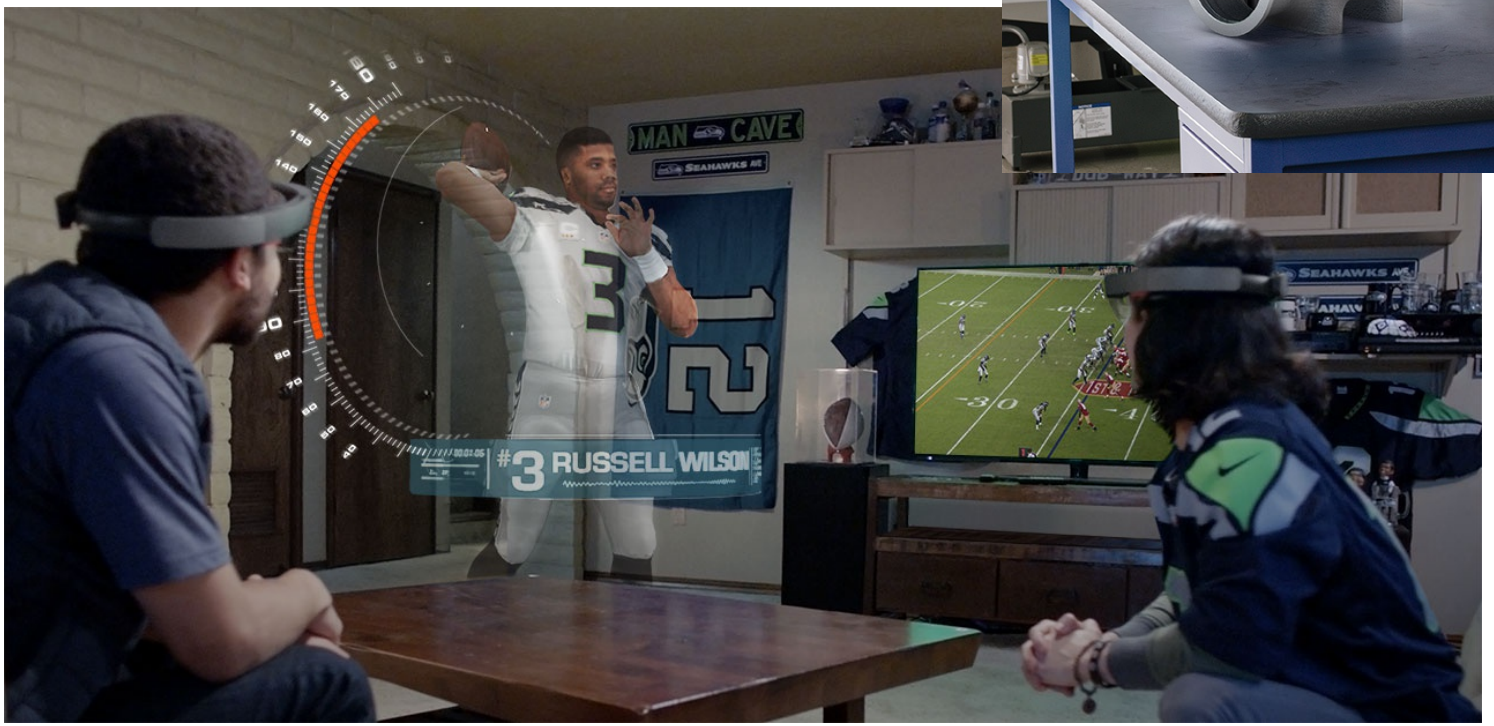
© RE'FLEKT GmbH

Augmented reality – HoloLens



© 2016 Microsoft

Augmented reality – HoloLens



Augmented reality

- **virtual 3D scene***
- **3D position†**
  - with help of computer vision?
- **real-time rendering*†**
  - GPU, shaders†
  - no lags will be tolerated !
- **interactivity†**
  - computer vision† or different..

Počítačová grafika I

NPGR003

ZS 2/2 Z, Zk

Obsah a forma

- **základy 2D i 3D grafiky**
  - navazuje na ni:
    - » Počítačová grafika II (NPGR004), Hardware pro počítačovou grafiku (NPGR019), Pokročilá 2D počítačová grafika (NPGR007), Visualizace (NPGR023)
- **2/2 Z, Zk**
  - přednáška i cvičení jednou týdně
  - cvičení: ukázky a úlohy v C#
  - komplexní hodnocení písemné zkoušky dohromady s výsledky zápočtových úloh

Stručný plán přednášky 2D

- **rastrová a vektorová grafika** (2)
  - rastrový obraz, průhlednost, HDR grafika, operace s rastrovými obrázky, vektorový formát SVG
- **barvy, jejich vnímání a zobrazování** (3-4)
  - barevné vidění, barevné prostory (RGB, CMYK, HSV), zobrazování barev, půltónování a rozptylování
- **kódování rastrových obrázků** (1)
  - kódování, grafické formáty (JFIF, GIF, PNG, ..)
- **rastrové kreslení** (1)
  - kreslení úseček, křivek, vyplňování, ořezávání..

Stručný plán přednášky 3D

- **matematika pro 3D grafiku** (1)
  - lineární transformace, homogenní souřadnice, projekce
- **reprezentace 3D scén** (1)
  - výčtové, objemové a povrchové reprezentace, hierarchie
- **úvod do OpenGL** (1)
- **zobrazování 3D scén, viditelnost** (2-3)
  - příklady algoritmů na viditelnost, základy stínování a renderingu, vrhání paprsku

Literatura (CZ)

- **Jiří Žára, Bedřich Beneš, Jiří Sochor, Petr Felkel**: ***Moderní počítačová grafika***, 2. vydání, Computer Press, Brno, 2005, ISBN: 80-251-0454-0

Literatura (US)

- **J. Foley, A. van Dam, S. Feiner, J. Hughes**: ***Computer Graphics, Principles and Practice***, 2nd edition in C, Addison-Wesley, 1995
- **Peter Shirley**: ***Fundamentals of Computer Graphics***, 3rd edition, A K Peters, 2009

Předpoklady

- **základní kurs programování**
  - algoritmy, datové struktury
- **základy programování v jazyku C#**
  - nejsou potřeba detaily jazyka ani knihovny
  - na cvičeních budete mít připraveny šablony pro jednotlivé úlohy
- **základní kurs matematické analýzy a lineární algebry**

Užitečné adresy

- aktuální informace na **WWW:**
  - **http://cgg.mff.cuni.cz/prednasky.cz.php**
  - **http://cgg.mff.cuni.cz/~pepca/**
- podpora pro cvičení:
  - **http://cgg.mff.cuni.cz/~pepca/grcis/**
  - **svn://cgg.mff.cuni.cz/grcis/trunk/**
- Facebooková stránka CGG:
  - **http://www.facebook.com/CGGMFF**

Další vhodné grafické předměty (zima)

- **Speciální seminář z poč. grafiky:** 0/2, NPGR005
- **Geometrické modelování:** 2/2, NPGR021 (Z. Šír)
- **Digitální zpracování obrazu:** 3/0, NPGR002 (Jan Flusser, ÚTIA AV ČR)
- **Počítačové vidění a inteligentní robotika:** 2/0, NPGR001 (Václav Hlaváč, FEL ČVUT)
- **Praktikum z počítačového vidění:** 0/2, NPGR034 (Elena Šikudová)
- **Introduction to Colour Science:** 2/0, NPGR025 (Alexander Wilkie, KSVI)
- **Interaktivní 3D grafika na webu:** 2/2, NPGR012 (Jiří Žára, FEL ČVUT)

Doporučené akce pro zájemce

- Konference **HiVisComp**
  - každoročně v zimě (s lyžováním), setkávají se tam počítačoví grafici a fanoušci příbuzných oborů z ČR, Slovenska a okolí
  - **31. 1. - 3. 2. 2018** (Nízké Tatry)
  - **http://www.hiviscomp.cz/**

CESCG

- Studentská konference **CESCG**
  - prezentují se studentské příspěvky a projekty
  - Slovensko, Rakousko, ČR, Německo, Francie, apod.
  - **http://www.cescg.org/**