matfyz

Computer Graphics Charles University

Základy počítačové grafiky NPGR003

CGG MFF UK Praha

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

Vector graphics

© 2014, Saylerman

Vector graphics

Interactive editing

- splines†, free-form drawing

Colors*

Vector image format*

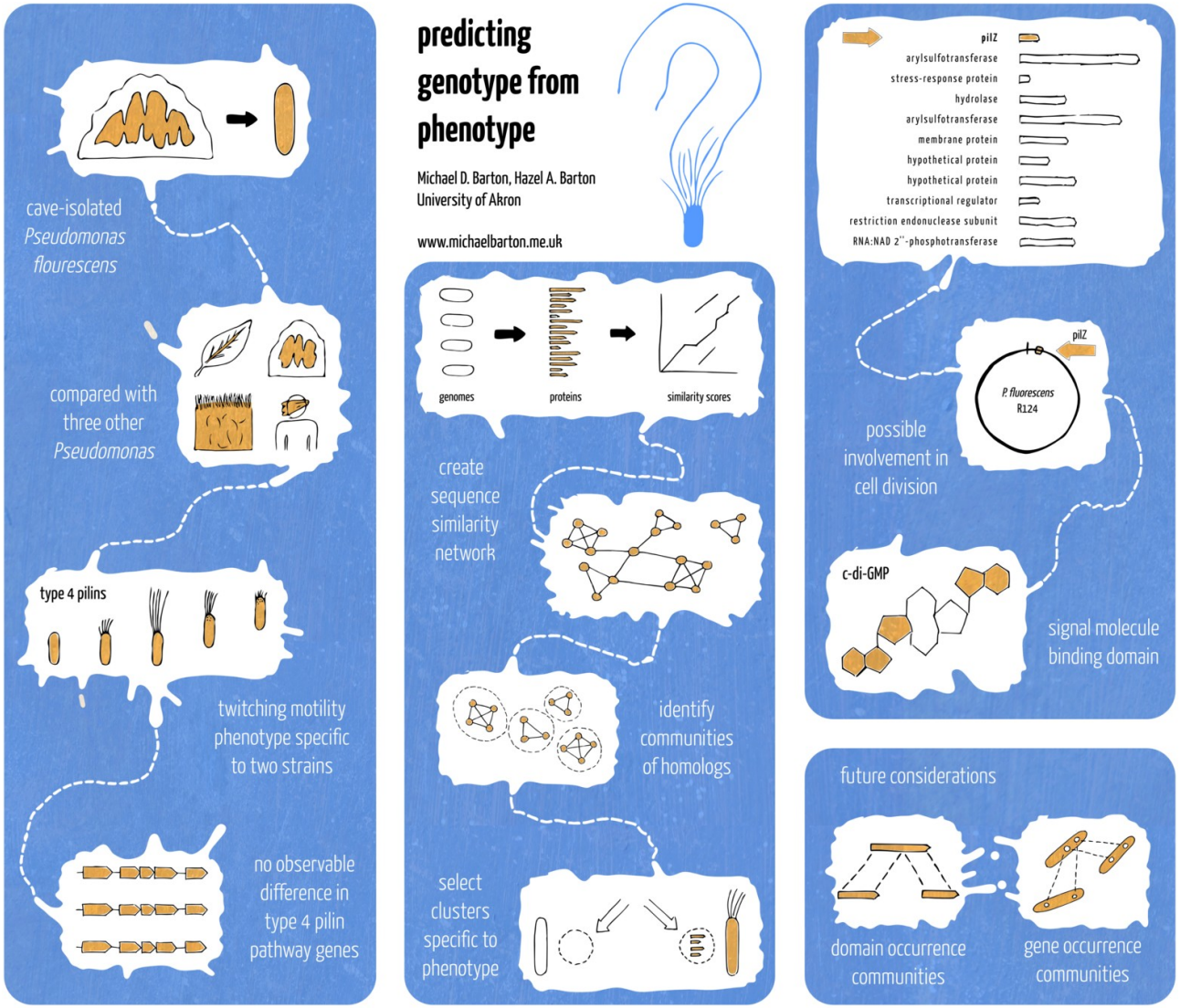
- SVG, PDF, EPS, DXF, AI

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*

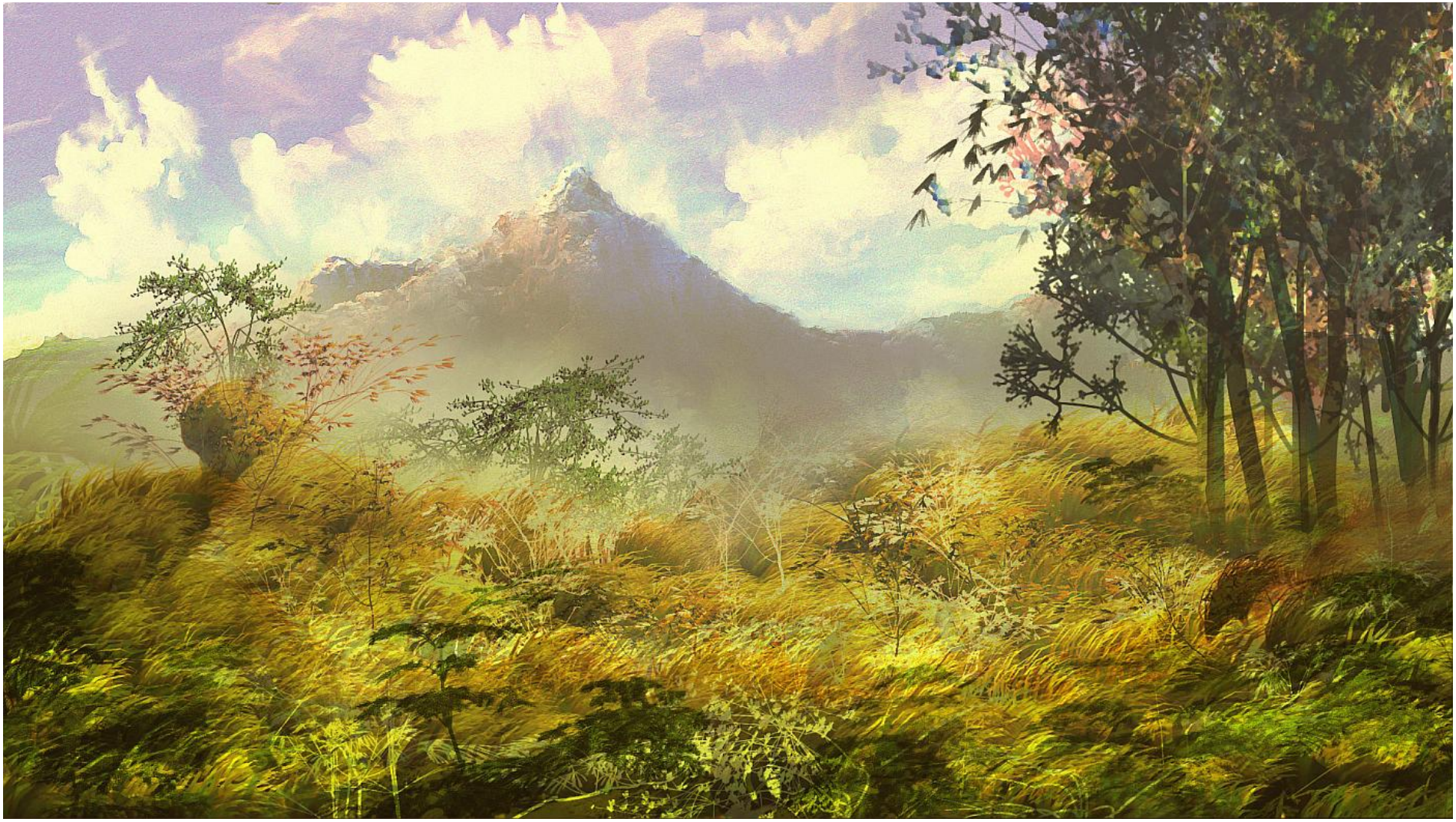
- RGB to CMYK

Digital halftoning*

Digital painting, 2D effects

© Corel Painter, Hahin

Digital painting tools



© Dan Ritchie (PD Particles)

Digital painting

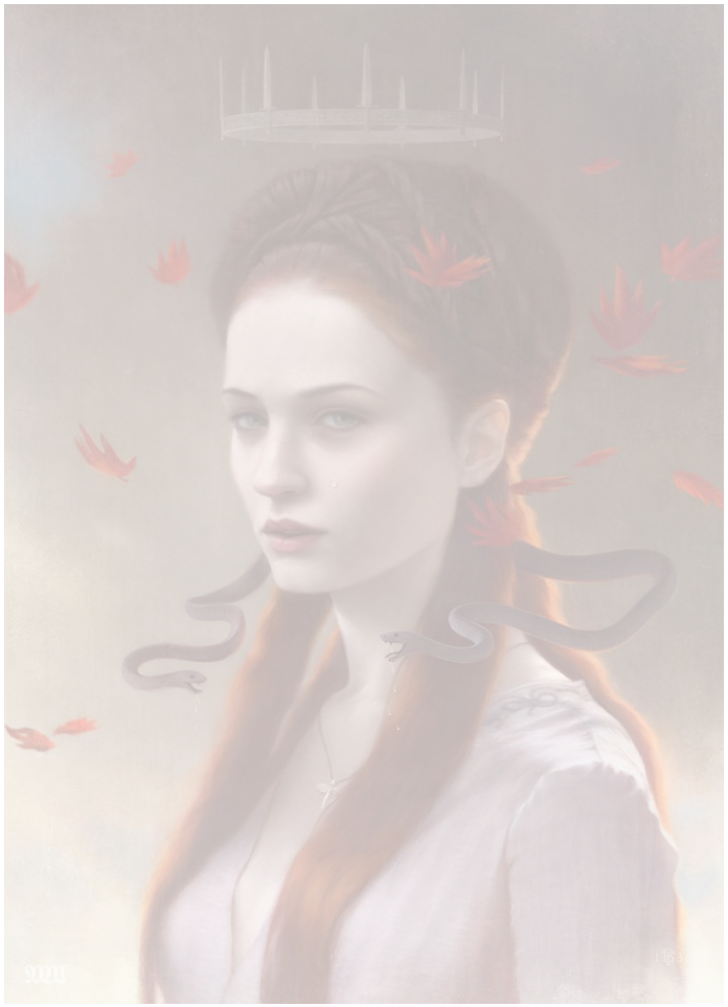
Interactive editing

- 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 enhancement, 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“

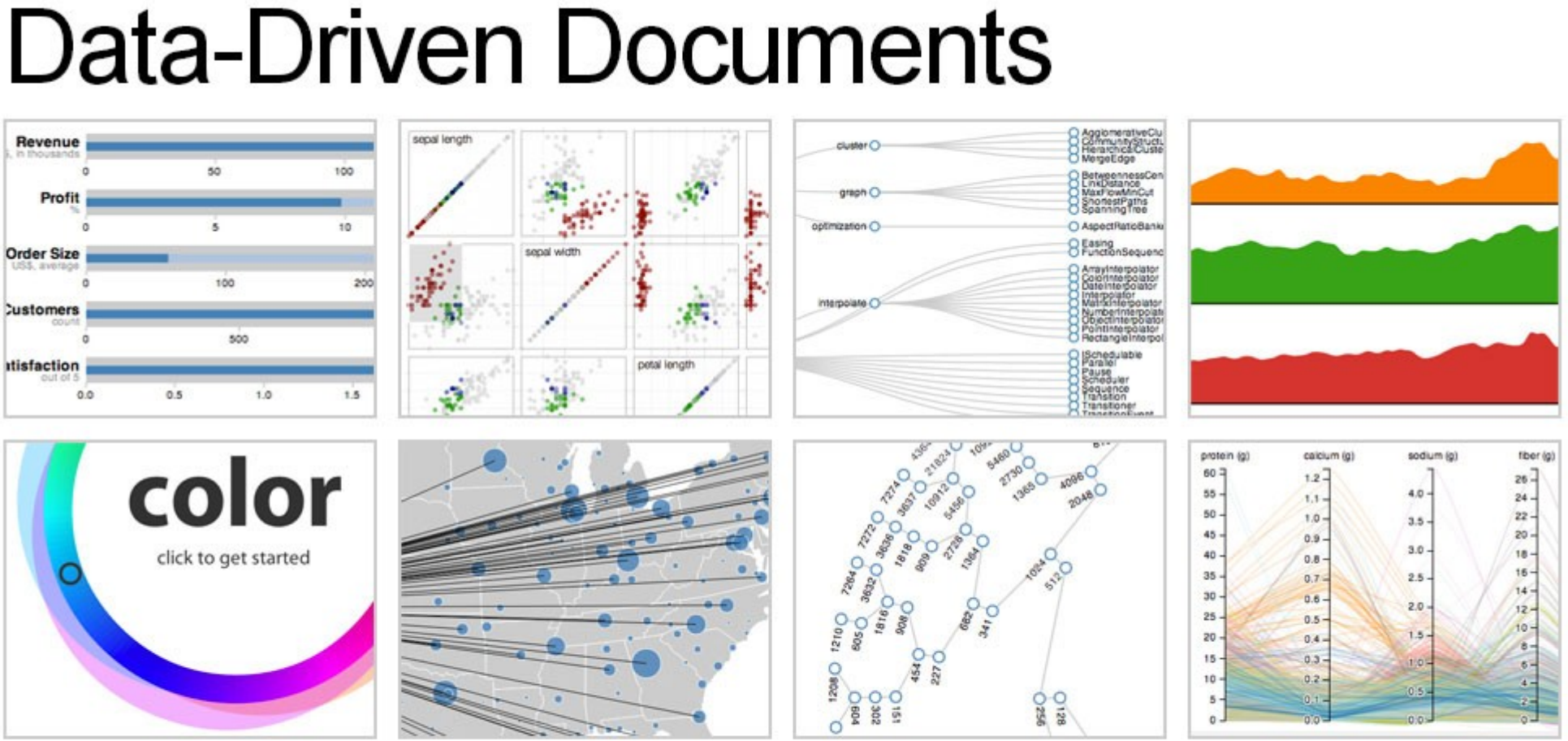
Colors*

HDR image format*

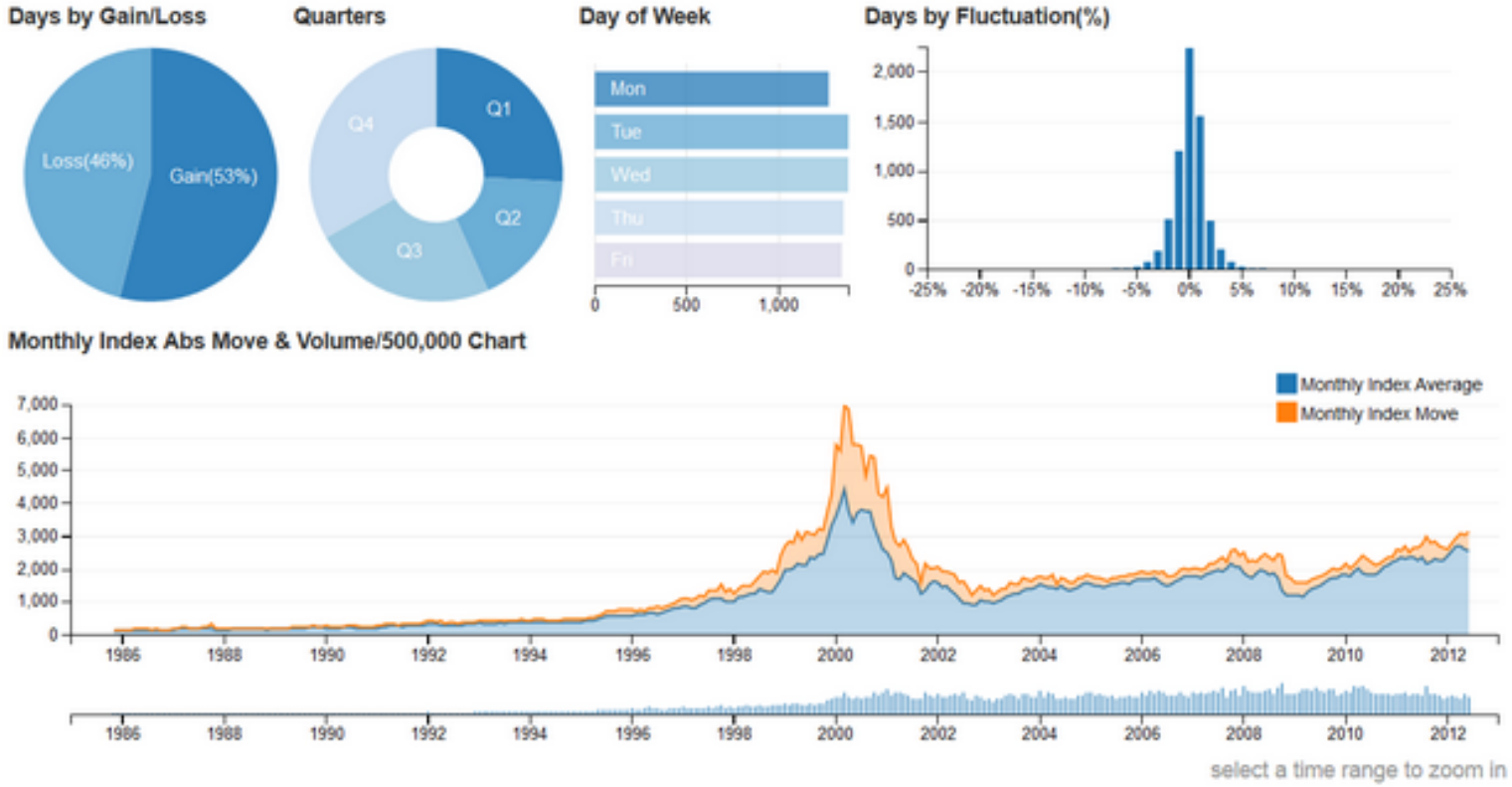
- HDR, EXR, PFM

Tone-mapping*

Web design, data visualization



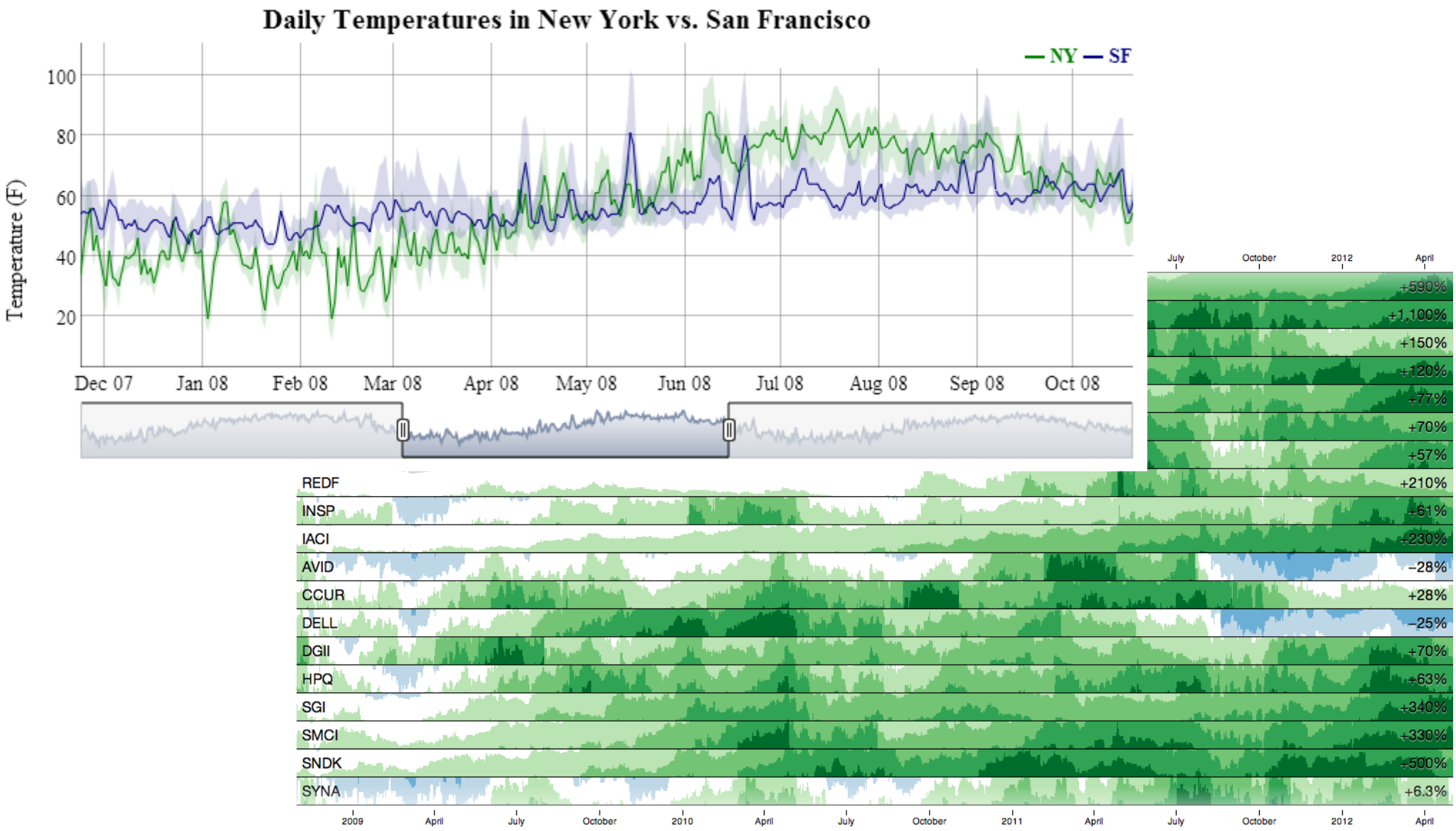
Web design, data visualization



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

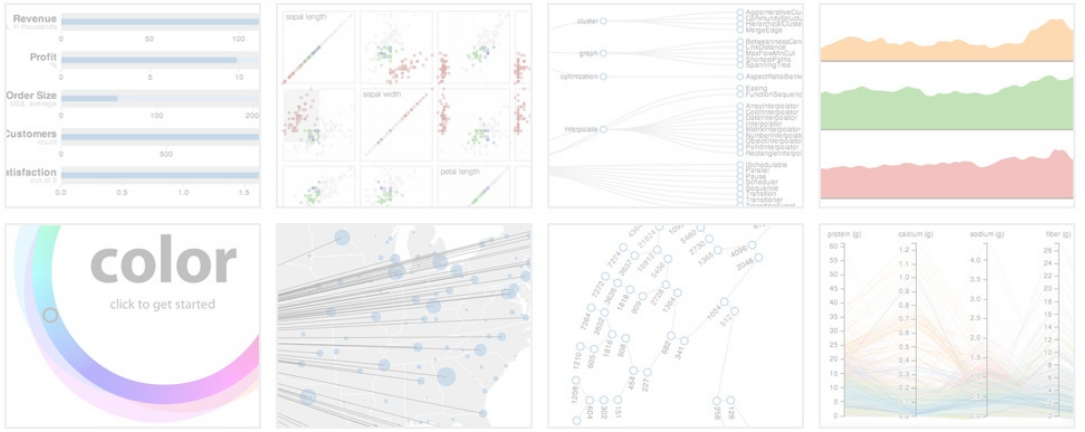
Date	Open	Close	Change	Volume
2012/06				
06/18/2012	2570.98	2592.52	21.54	15407330
06/19/2012	2606.43	2620.83	14.40	17714840

Interactive data on web



Modern web

Data-Driven Documents



HTML5†, CSS3†

- JavaScript
- templates, WordPress

Interactivity†

Data-Driven Documents†

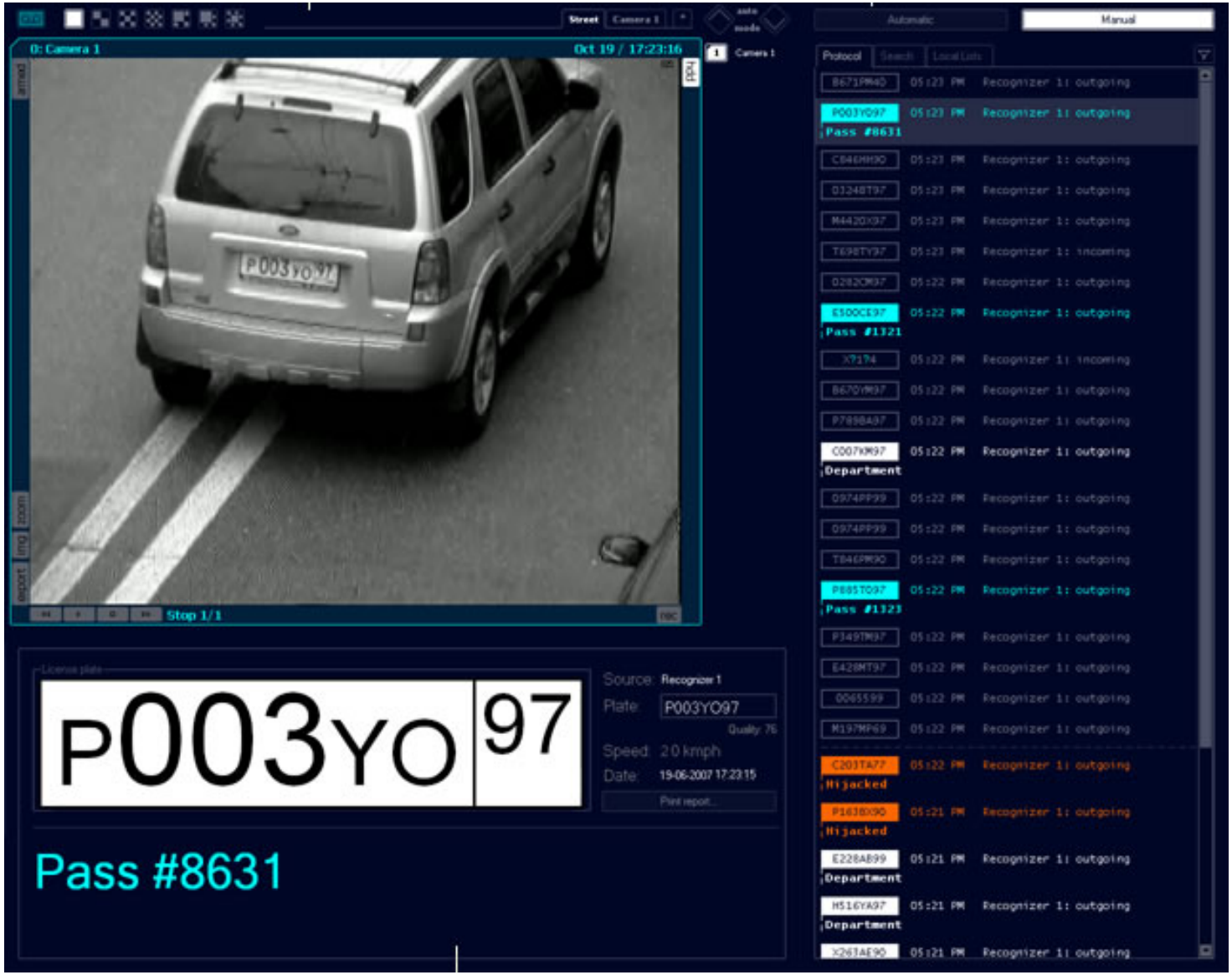
- d3.js library

WebGL for 3D†

- interactivity

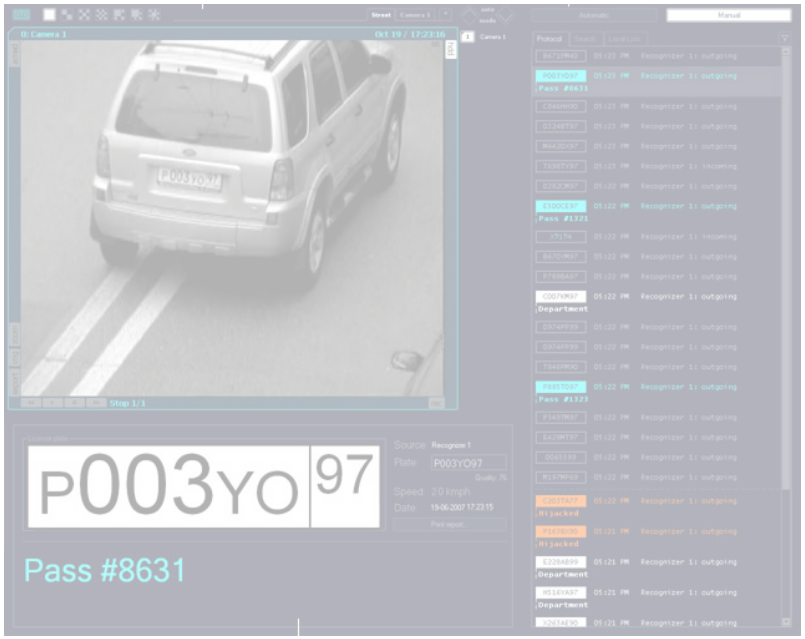
Video, 360-degree video

License-plate recognition



© Smart Security Camera, Inc.

License-plate recognition



Real-time image acquisition

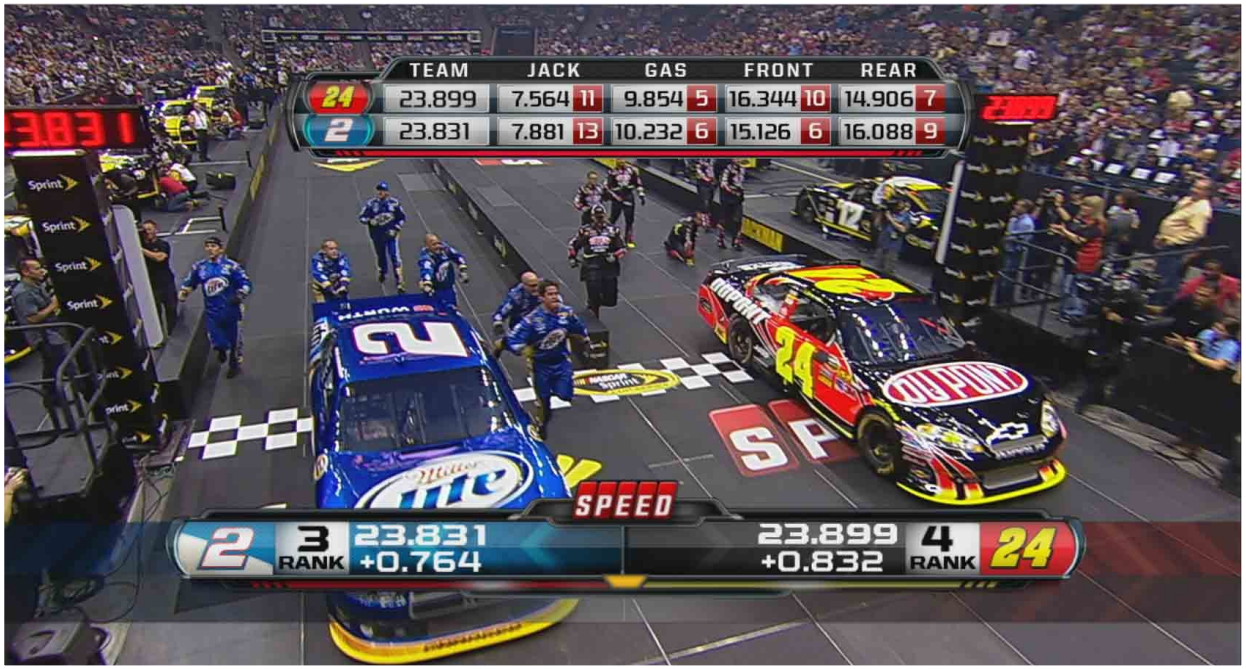
Plate segmentation†

Image warping†

Glyph recognition†

Speed measurement…?

Sport live on TV



Sport live on TV

Vector graphics*

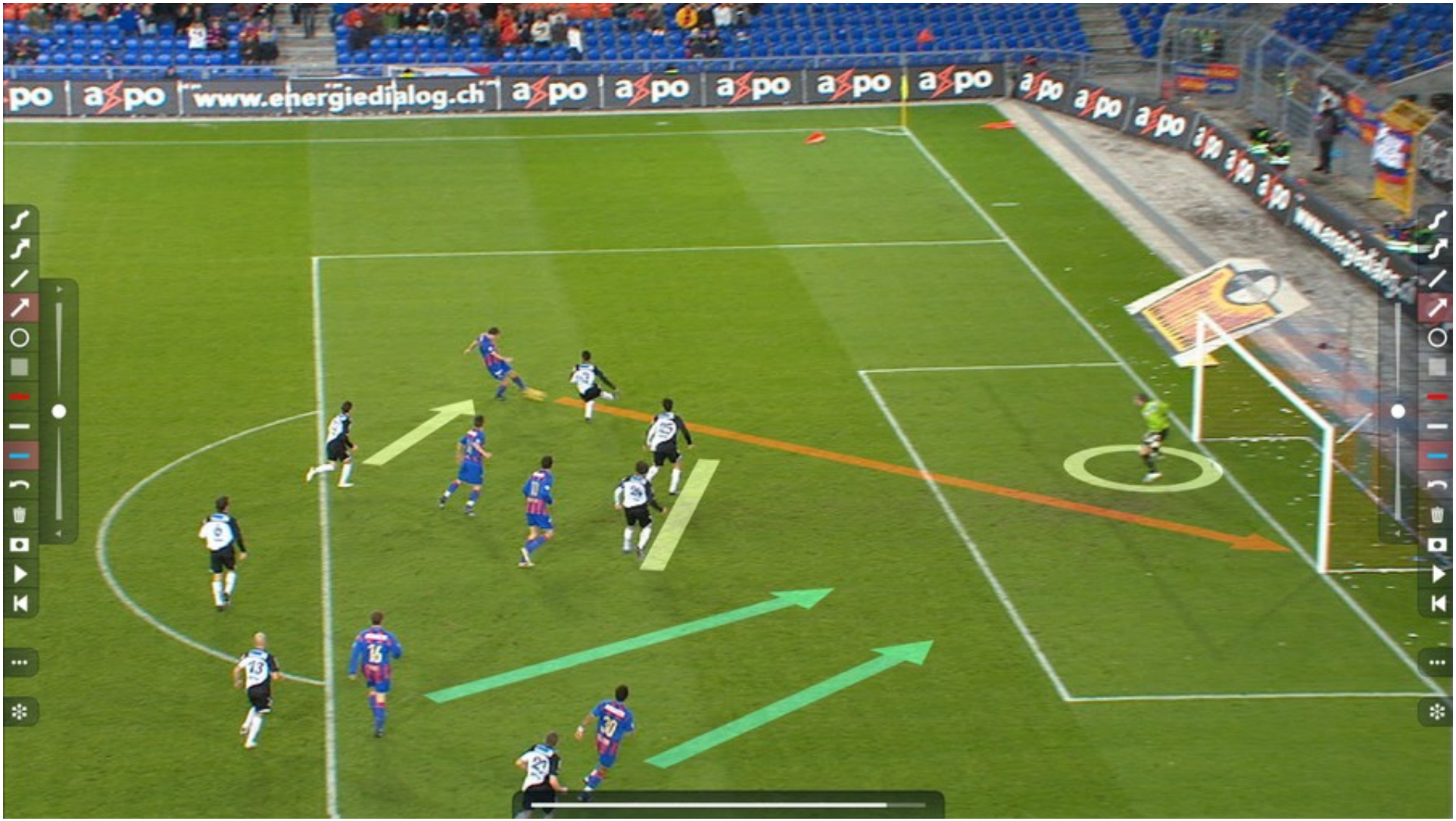
- real-time!

Transparency*

Real-time video signal composition

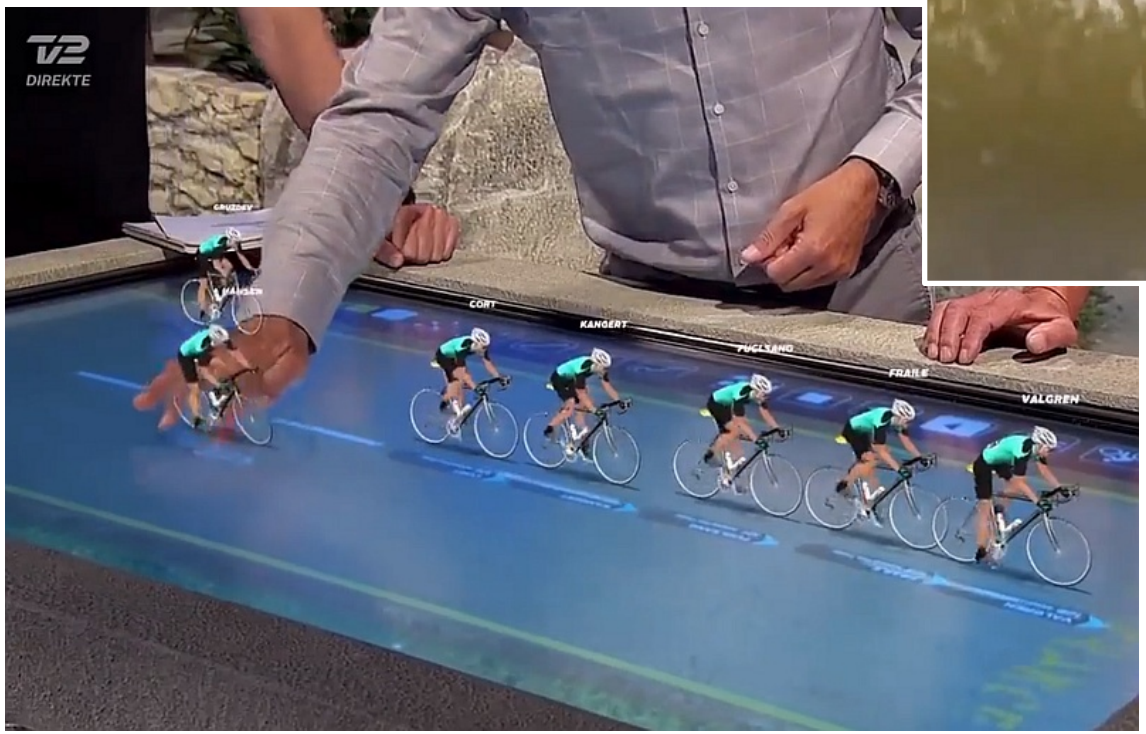
- real-time video compression†

„Next-generation“ sport TV



Augmented reality broadcasting

© The Weather Channel



© TV 2

„Next-gen“ sport TV

3D computer vision†

- camera calibration
- object recognition, segmentation

3D „extra“ model*

- augmented reality

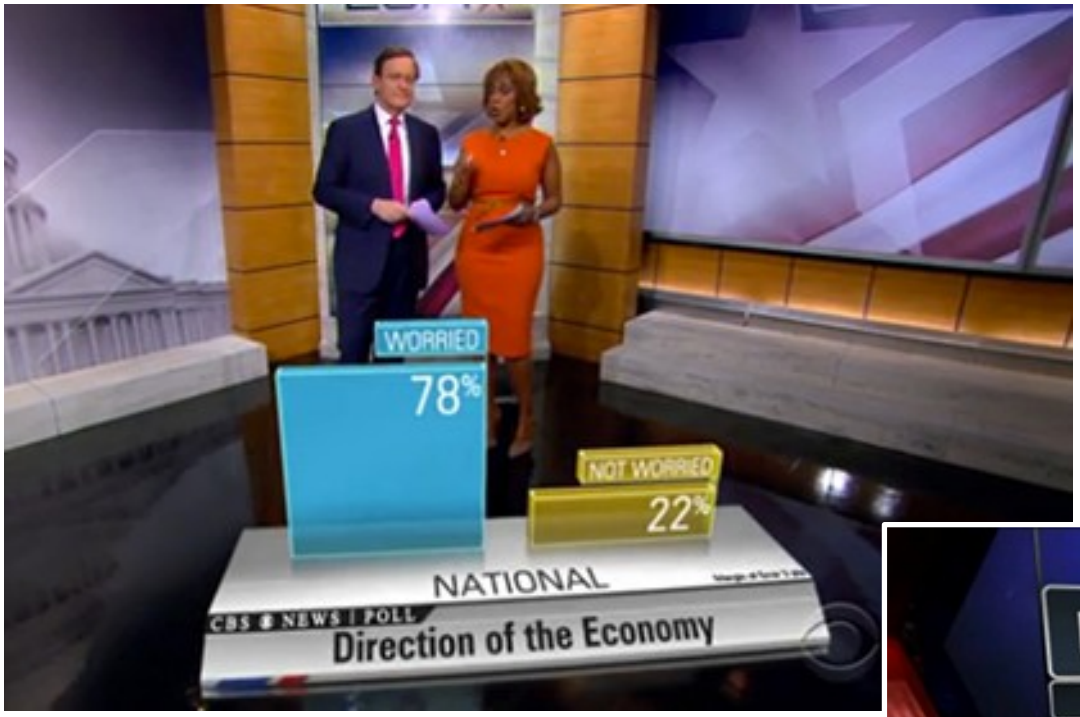
Real-time interaction?

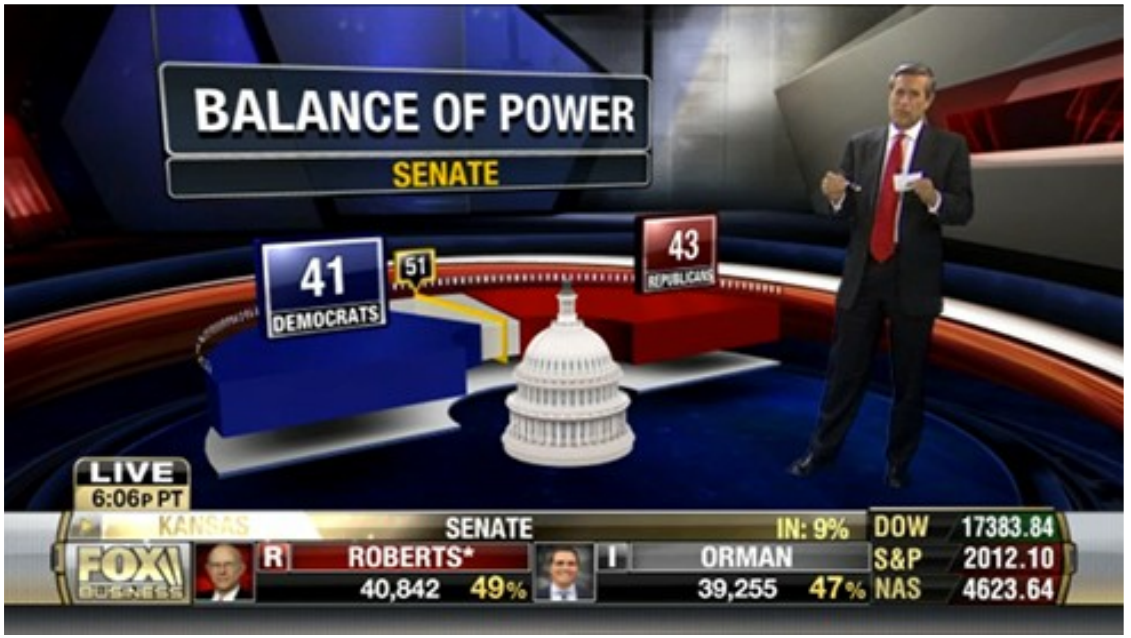
- reporter in a studio…

Real-time video composition

- layers, transparency*
- video compression†

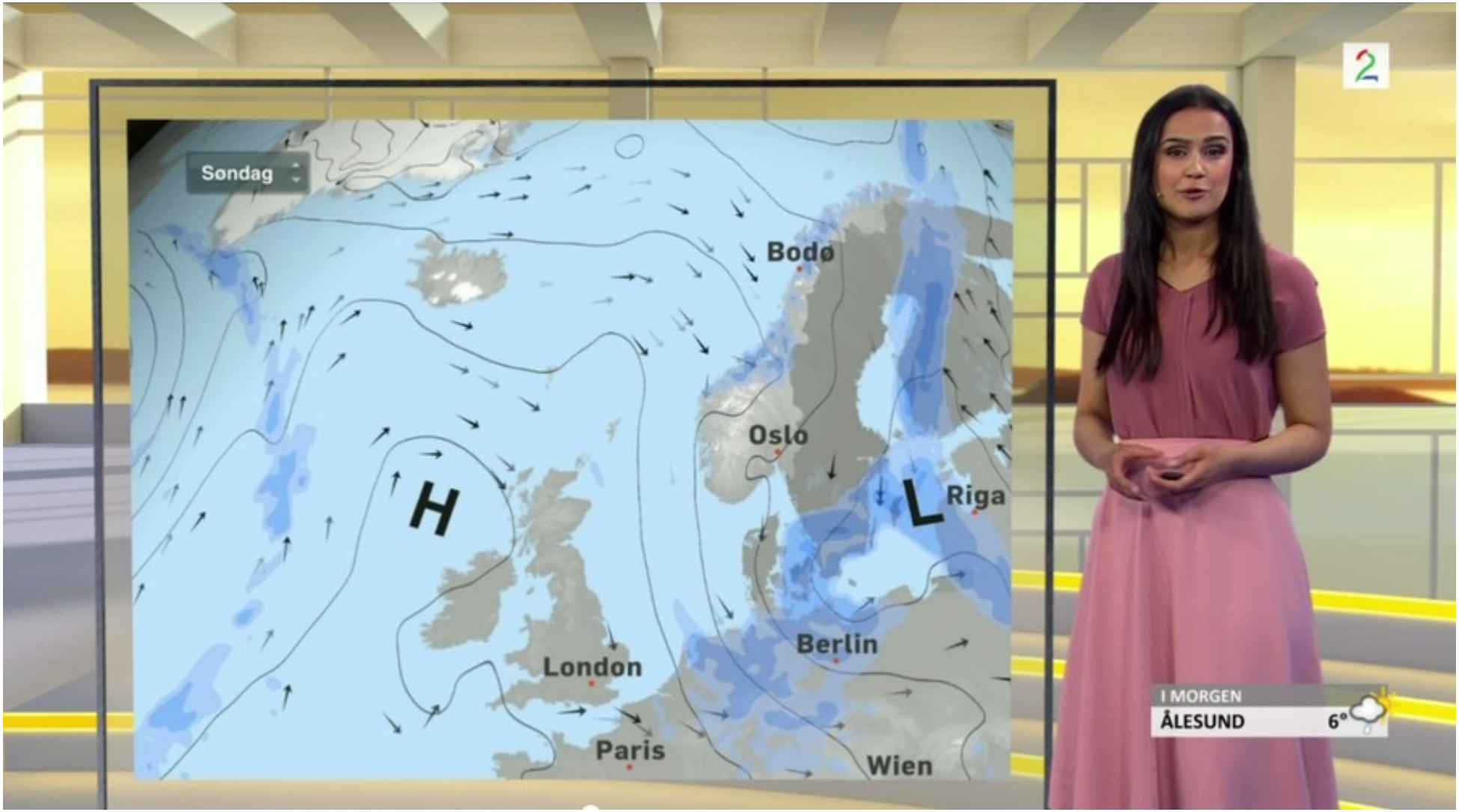
Virtual TV studio





© 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…)

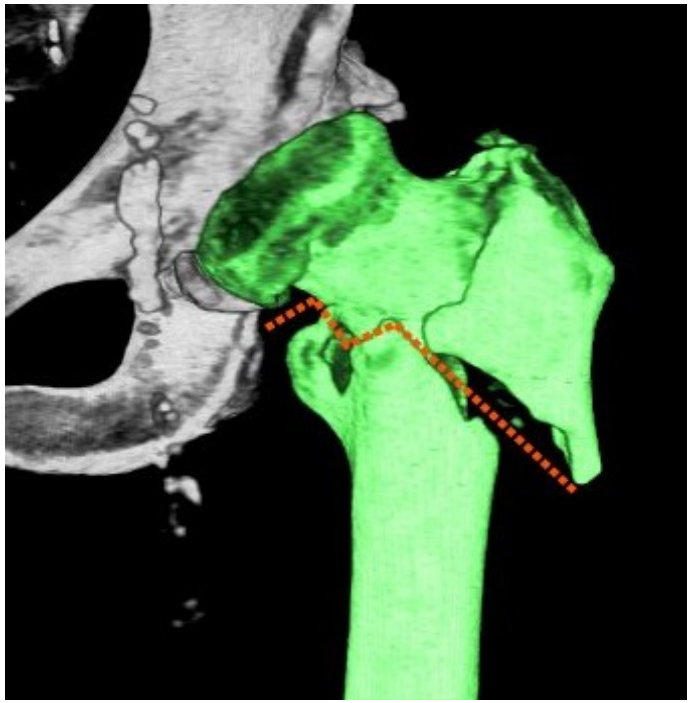
Real-time video composition

- layers, transparency*

Video compression†

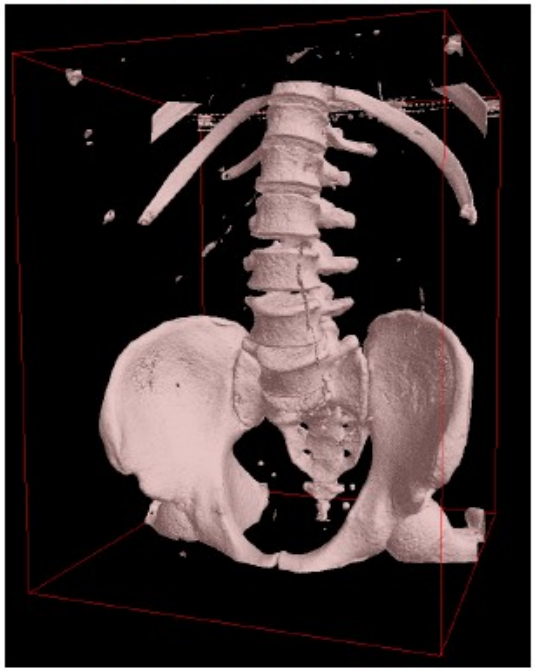
- all in real-time

Medical data

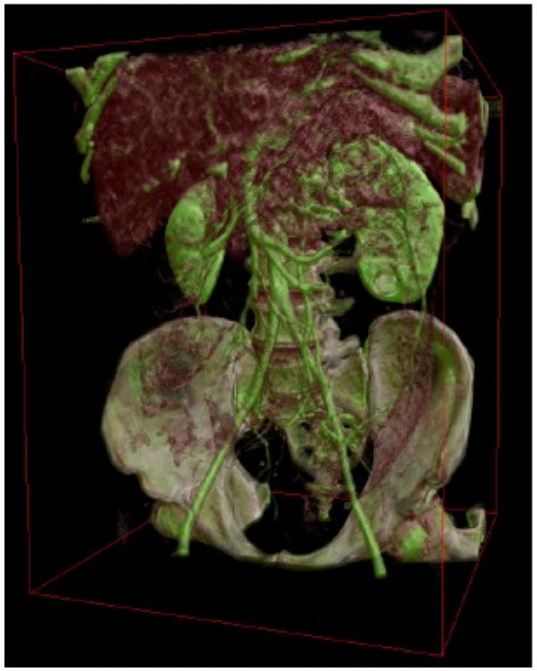


(a) Maximum intensity projection

(b) Density integration

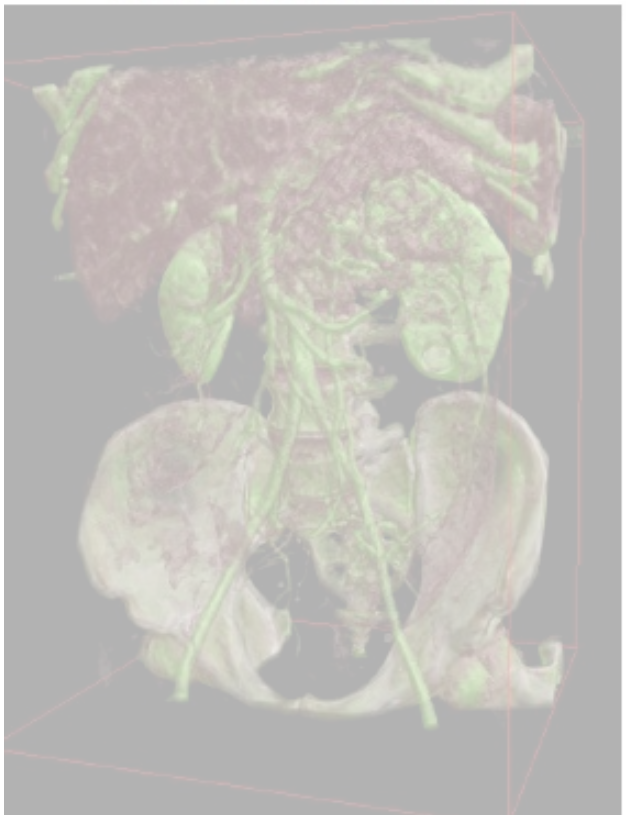


(c) Isosurfaces



(d) 1D transfer function

Medical data



Volume data acquisition†

- Computer Tomography
- Magnetic Resonance Imaging…

Data enhancement†

- de-noise, contrast (CUDA†, GPU†)

Segmentation†

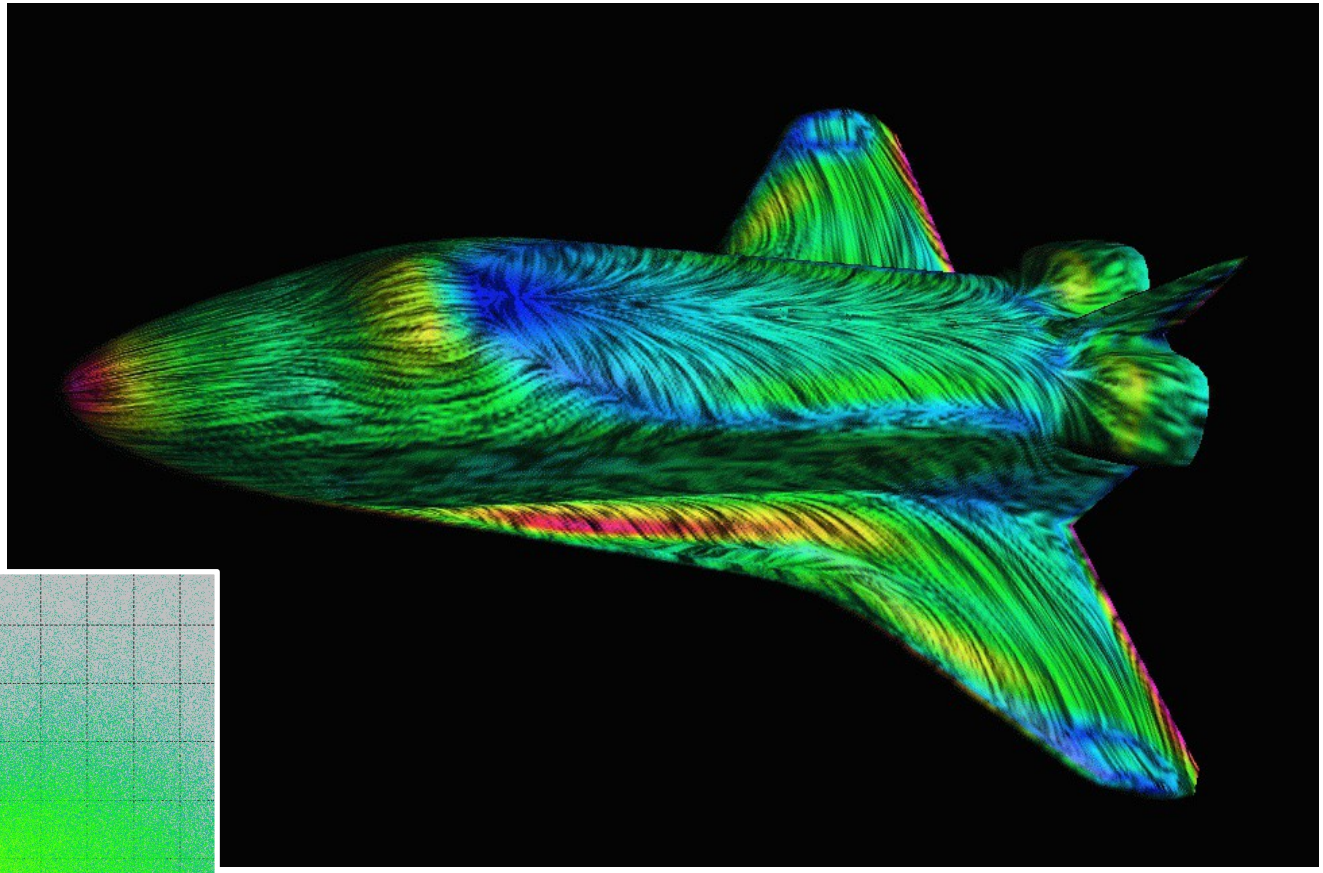
- organs, vessels, bowels (CUDA†, GPU†)

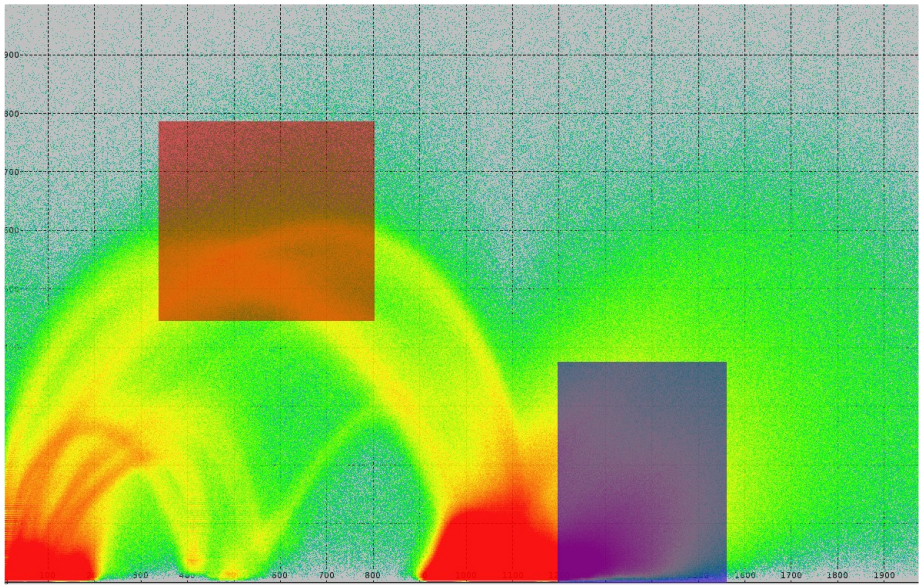
Real-time volume rendering†

- ray-casting on GPU

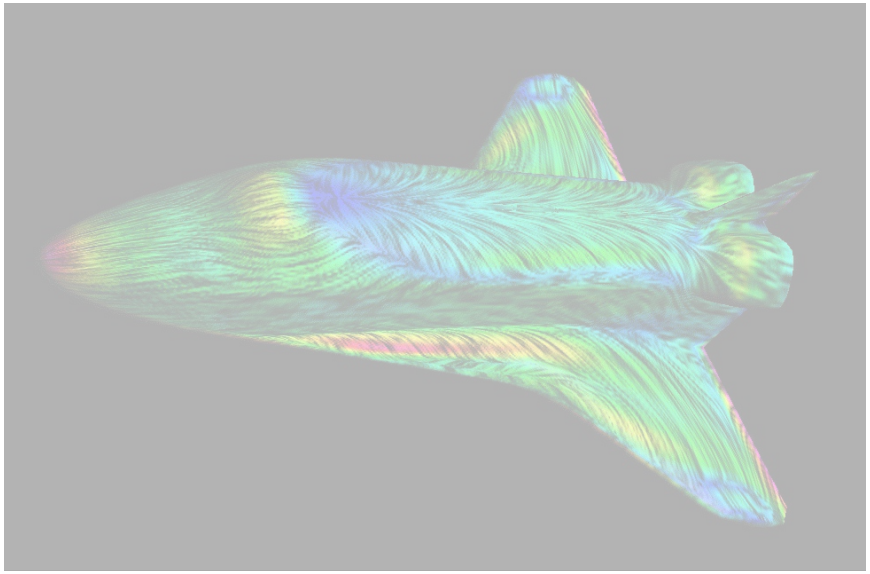
Measurements…

Scientific visualization





Scientific visualization



Data acquisition†

- numeric simulation
- measurements…

Visualization primitives†

- streamlines, arrows…

Real-time rendering†

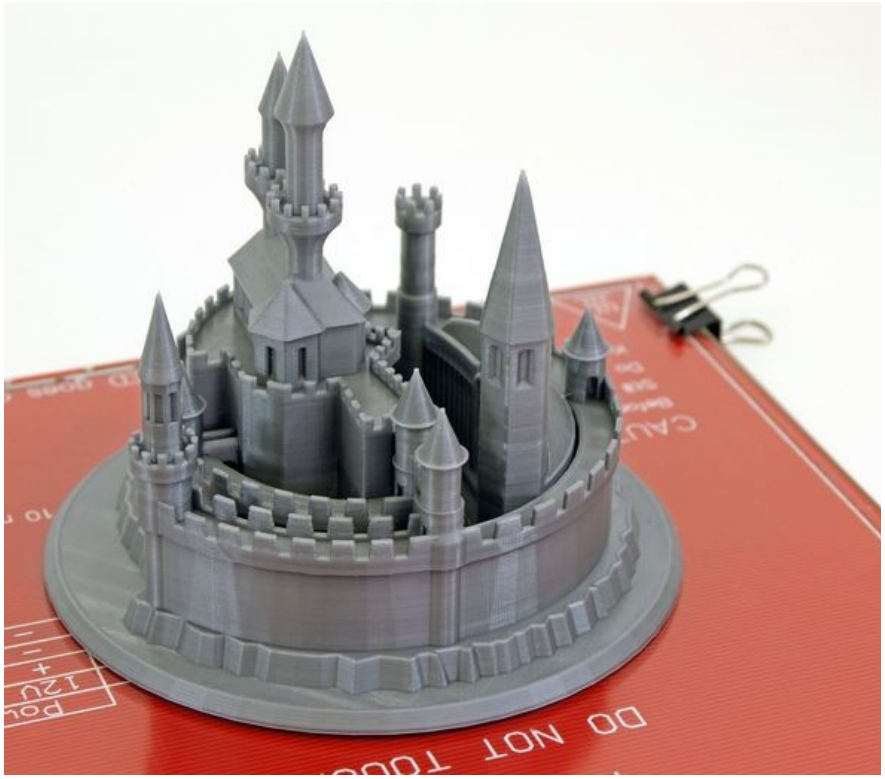
- vanilla 3D or full volume rendering (CUDA†, GPU†)

Interaction†

- „steering“

Measurements…

3D printing



© 2016, Prusa Research

3D printing

3D model editor†

- CSG, triangle-mesh…

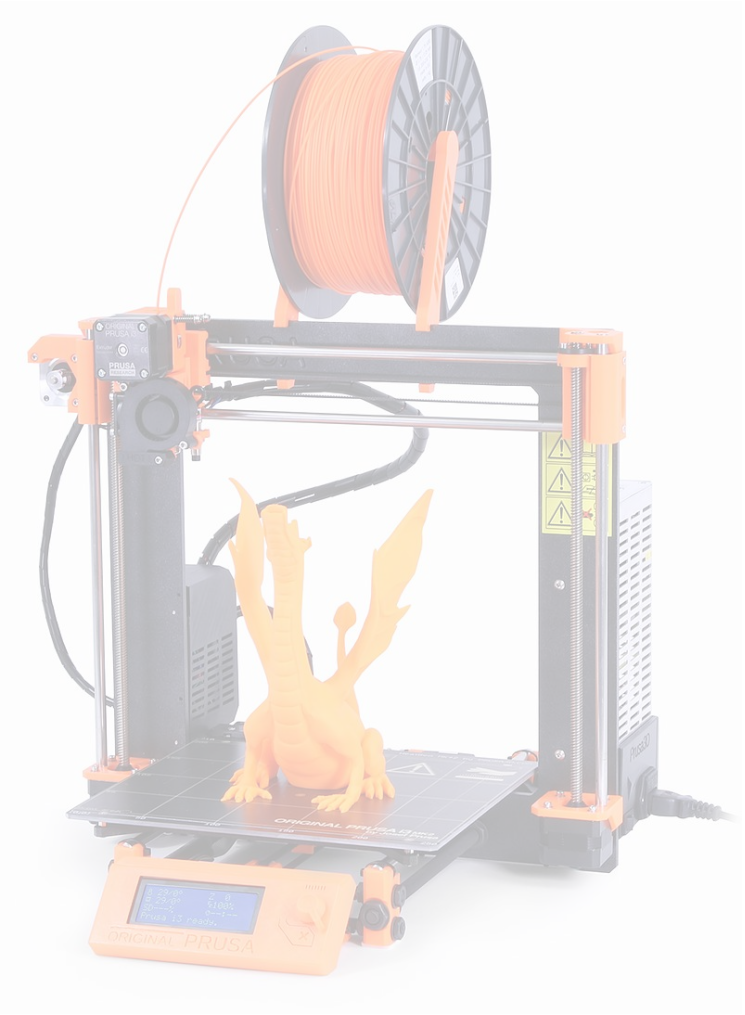
„Rendering“, rasterization

- similar to 2D rasterization*

Geometric optimization

- stiffness simulation?

Appearance modeling



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

© 1995, Pixar Animation Studios

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†

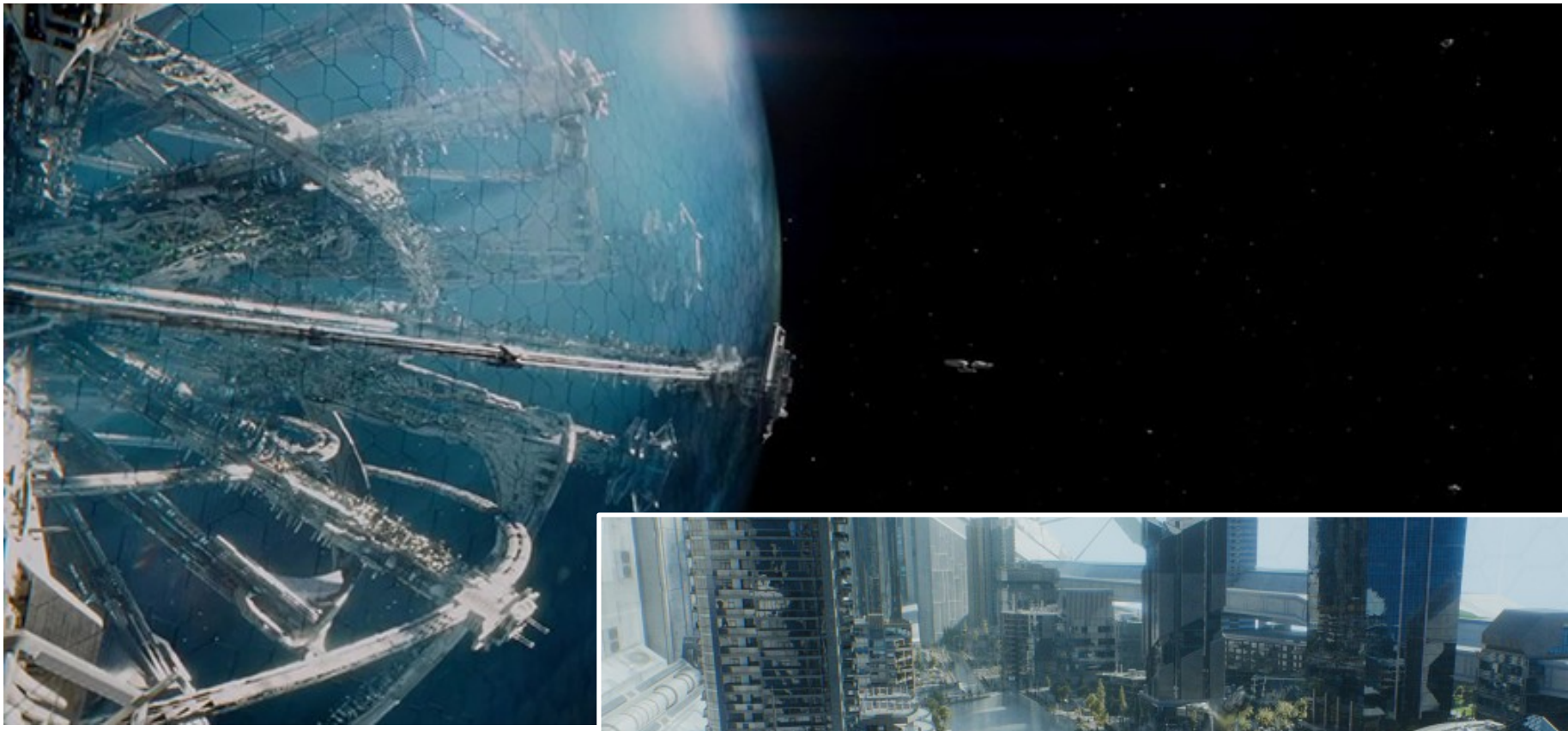
- off-line

CGI in film – Elysium

© 2013, TriStar Pictures

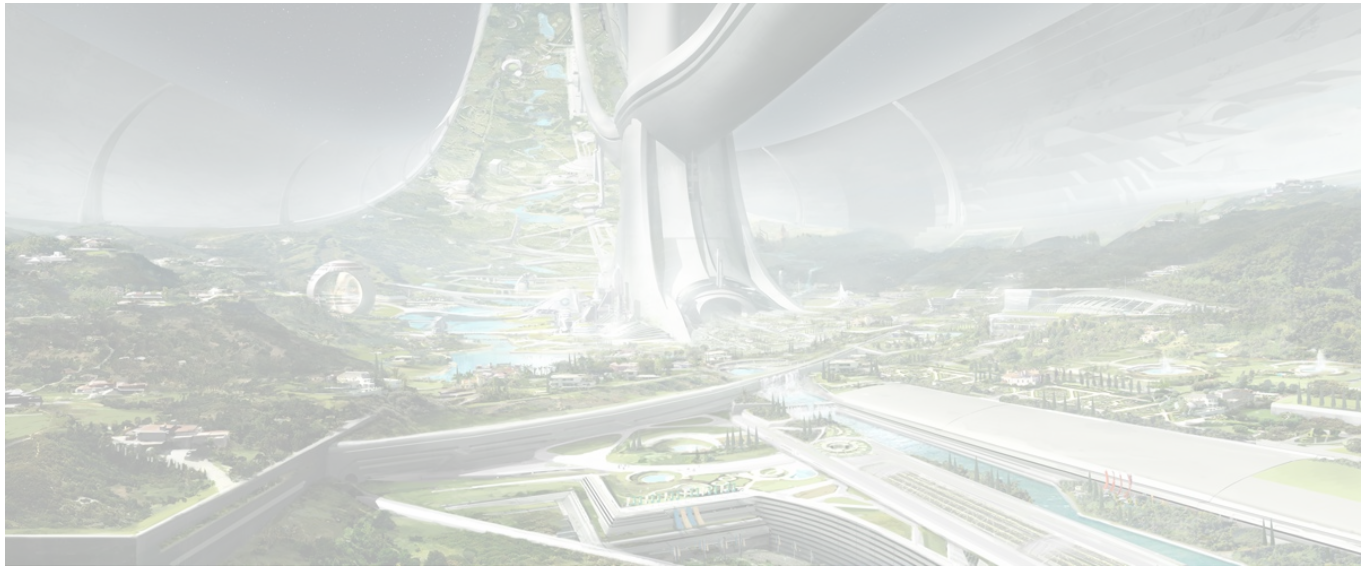
CGI in film – Star Trek into Darkness

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!

- including 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

VFX – Tron Legacy (color scheme)

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

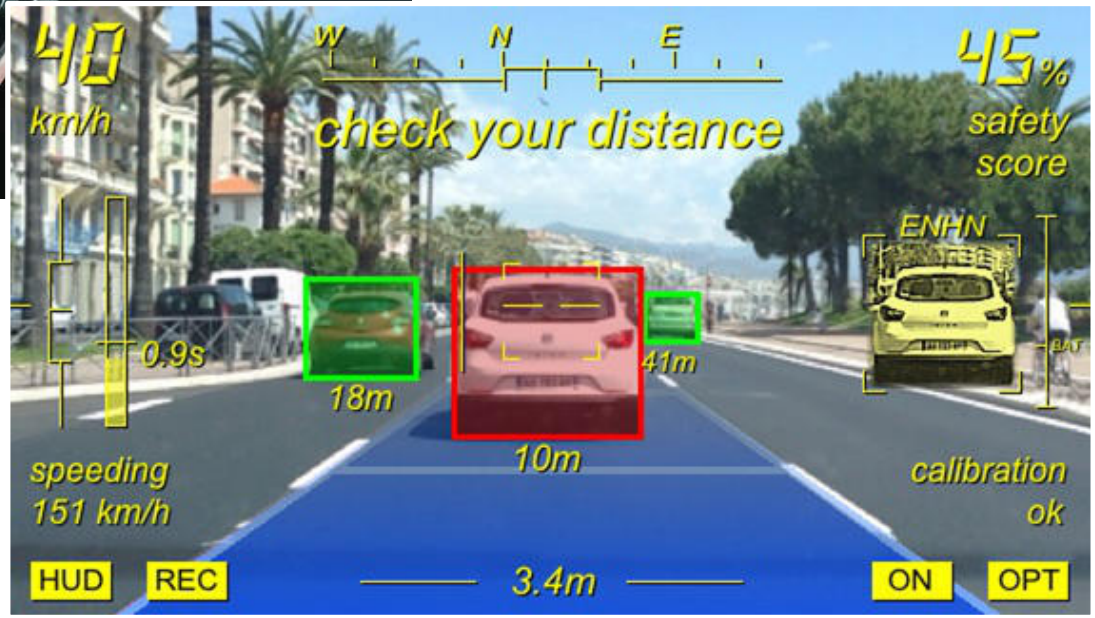
Video-compression†

- off-line

Self-driving car

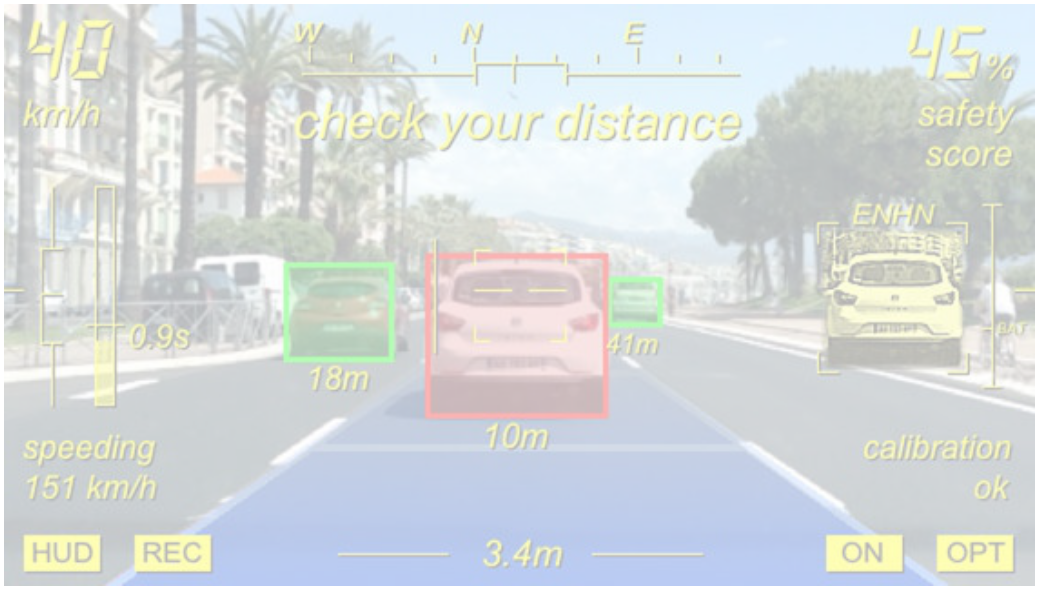
© Tesla Motors ?

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)

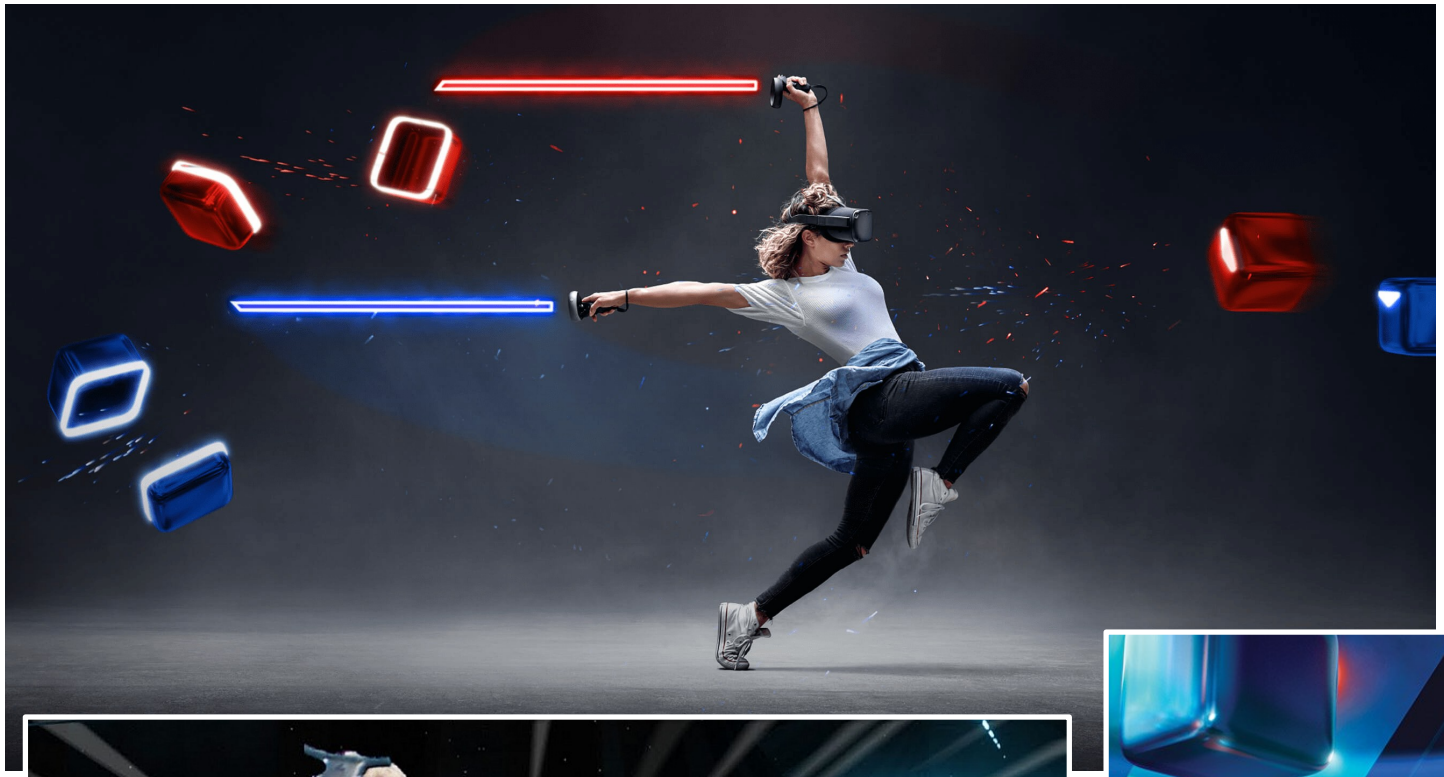
Videogame – Kingdom Come: Deliverance

© 2016-2017 Warhorse Studios

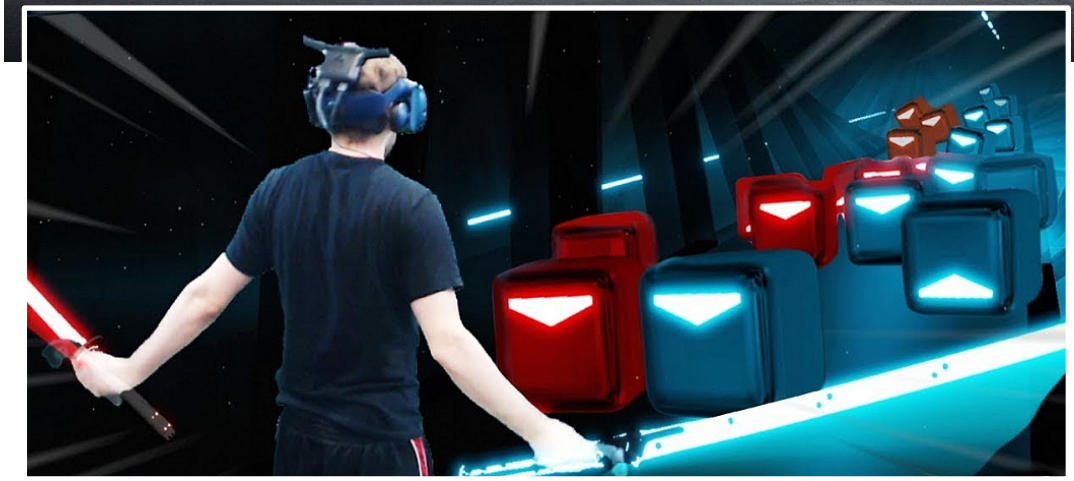
Videogame – Overwatch

© 2016, Blizzard Entertainment

Videogame – Beat Saber



© Beat Games (Meta)



Videogame – Euro Truck Simulator 2

Videogame – Euro Truck Simulator 2

Videogame – Euro Truck Simulator 2

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Videogame – Euro Truck Simulator 2

Videogame – Euro Truck Simulator 2

Videogame – Euro Truck Simulator 2

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†

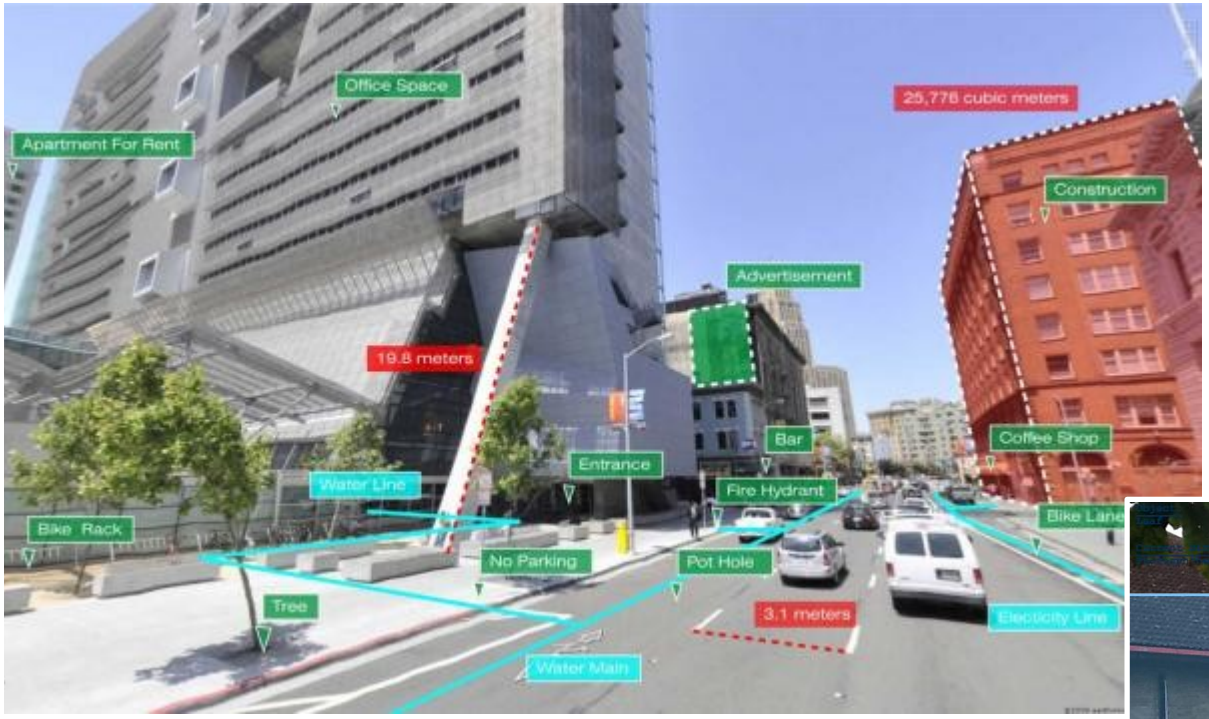
Multiplayer

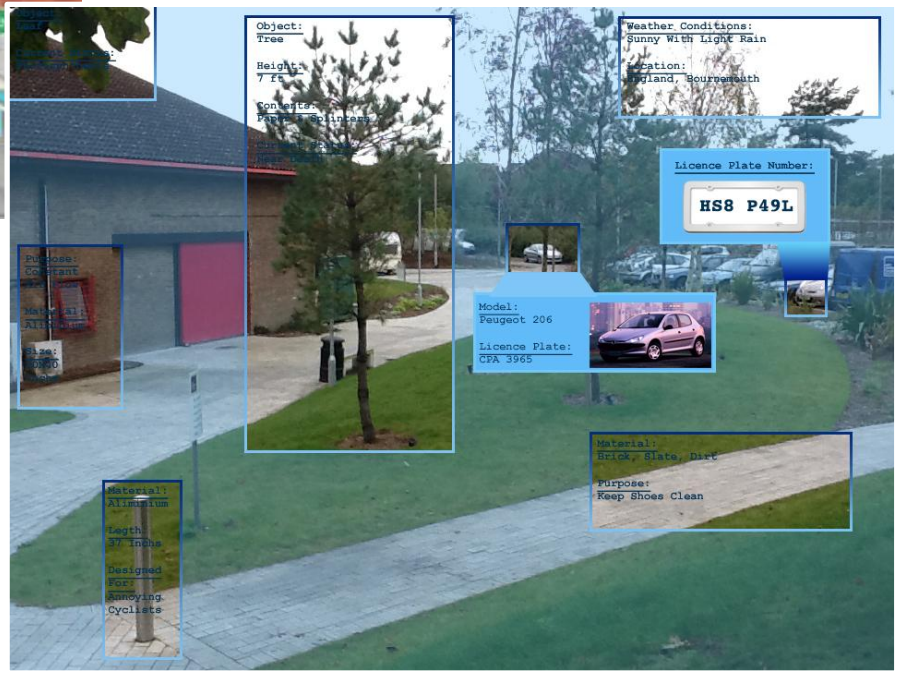
- LAN layer, lag compensation…

Virtual reality – „Cave“

© 2011, Land Rover

Augmented reality – „Smart glasses“





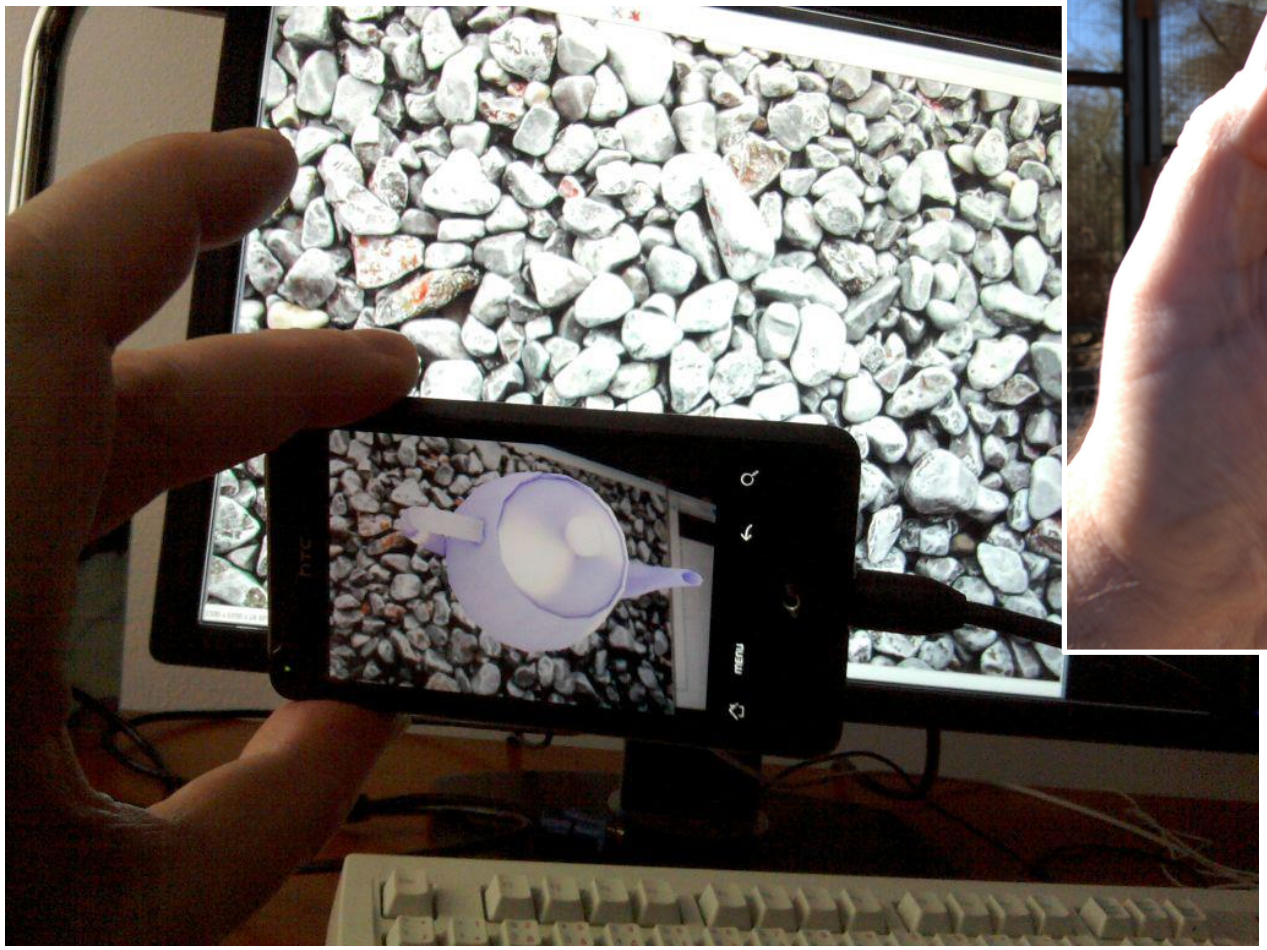
© Google, Stormy's Media Mountain

Augmented reality – „Smart glasses“

© 2016, Epson (Moverio BT 300)

Augmented reality – military

Augmented reality – phone

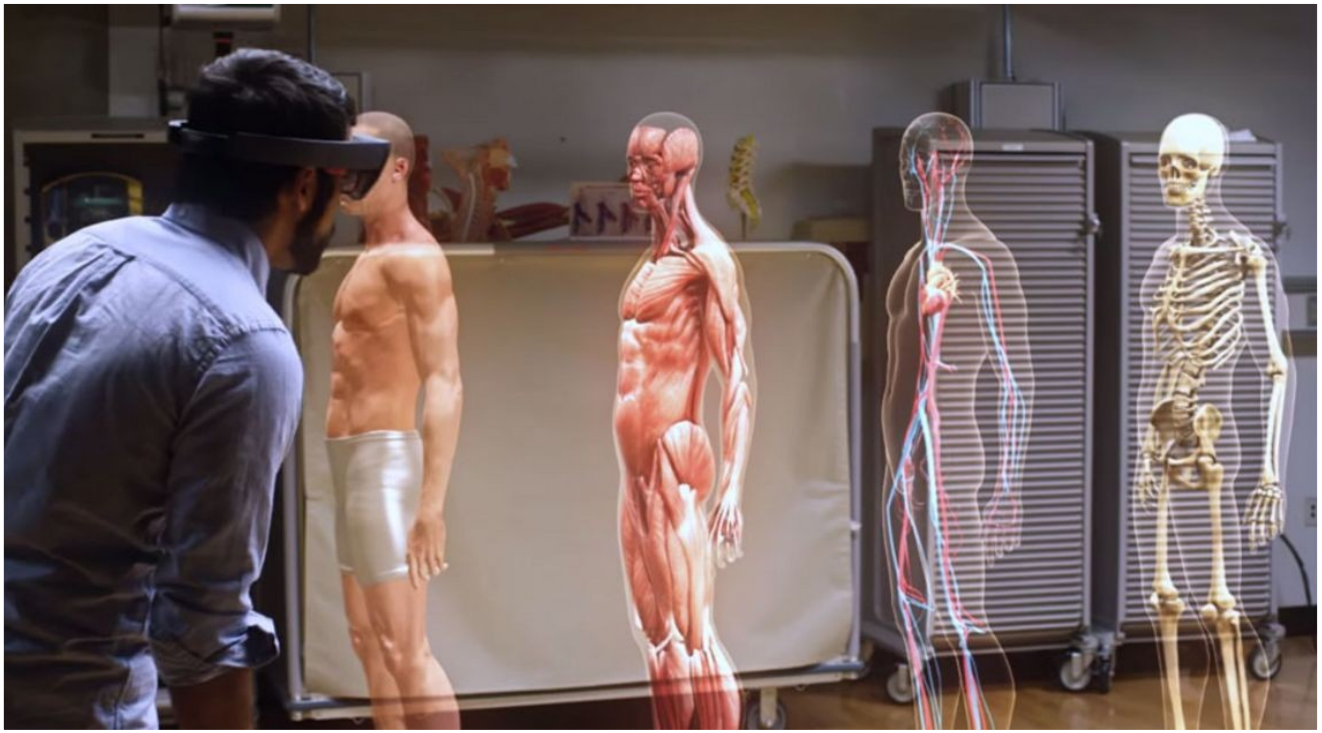


© 2012, JP

Augmented reality – tablet

© RE'FLEKT GmbH

Augmented reality – HoloLens



© 2016 Microsoft

Augmented reality – HoloLens

Augmented reality

Virtual 3D scene*

3D position†

- computer vision („inside-out tracking“…)
- accelerometers, gyroscopes, magnetometers

Real-time rendering*†

- GPU, shaders†
- no lags can be tolerated!

Interactivity†

- computer vision† (hand gestures), discrete controllers…

Základy počítačové grafiky NPGR 003

Zimní semestr 2/2 Z, Zk

Obsah a forma

Základy 2D i 3D grafiky

- navazují na ni
  - » Fotorealistická grafika (NPGR004) v LS
  - » Realtime grafika na GPU (NPGR019) v LS

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 (2)

- barevné vidění, barevné prostory (RGB, CMYK, HSV), zobrazování barev, půltónování a rozptylování

Kódování rastrových obrázků (1)

- kódování, grafické formáty (JPEG+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+lab)

Základy animace (1)

- rotace, trajektorie, interpolační křivky

Zobrazování 3D scén, stínování, viditelnost (2)

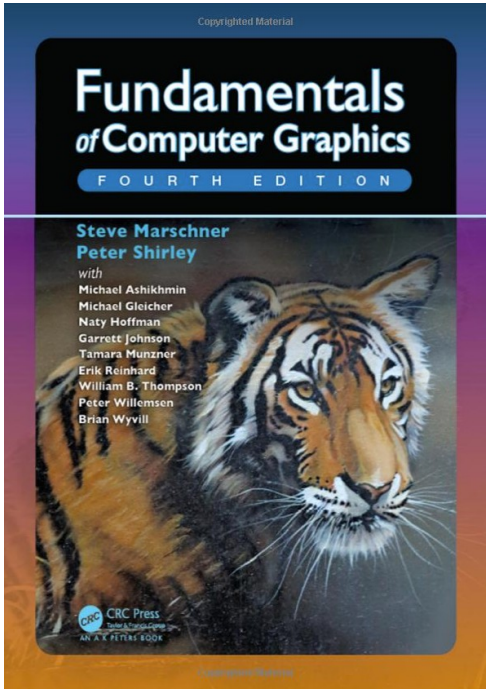
- příklady algoritmů na viditelnost, základy stínování a renderingu, vrhání a sledování paprsku (ray-tracing)

Literatura (CZ)

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

Literatura (US)

S. Marschner, P. Shirley: ***Fundamentals of Computer Graphics***, 4rd edition, A K Peters / CRC Press, 2015



J. Foley, A. van Dam, S. Feiner, J. Hughes: ***Computer Graphics, Principles and Practice***, 2nd edition in C, Addison-Wesley, 1995

Předpoklady

Základní kurs programování

- algoritmy, datové struktury

Základy programování v jazyku C#

- nejsou potřeba detaily jazyka ani knihovny
- na cvičeních budete mít připraveny návody pro vaši práci
- budete moci používat AI asistenty

Základní kurs matematické analýzy a lineární algebry

Užitečné adresy

Aktuální informace na WWW

- https://cgg.mff.cuni.cz/prednasky.cz.php
- https://cgg.mff.cuni.cz/~pepca/
- https://cgg.mff.cuni.cz/~pepca/lectures/npgr003.current.cz.php

Podpora pro cvičení

- https://github.com/pepcape/NPGR003-25/

Facebook CGG

- https://www.facebook.com/CGGMFF

Další vhodné grafické předměty (ZS)

Seminář z počítačové grafiky a vidění: 0/2, NPGR005

Introduction to Colour Science: 2/0, NPGR025 (Alexander Wilkie)

Geometrické modelování: 2/2, NPGR021 (Zbyněk Šír)

Digitální zpracování obrazu: 3/0, NPGR002 (Jan Flusser, ÚTIA AV ČR)

3D počítačové vidění: 2/2, NPGR001 (Václav Hlaváč, CIIRC)

Strojové učení v počítačovém vidění: 2/2, NPGR035 (Elena Šikudová)

Doporučení pro nadšence

HiVisComp

Konference **HiVisComp**

- každoročně v zimě (s lyžováním), setkávají se tam počítačoví grafici a fanoušci příbuzných oborů z ČR, Slovenska, Německa, Rakouska…
- **https://www.hiviscomp.cz/**

Studentská konference **CESCG**

CESCG

- prezentují se studentské příspěvky a projekty
- Slovensko, Rakousko, ČR, Německo, Francie…
- **https://cescg.org/**