

Computer Vision and Virtual Reality Introduction

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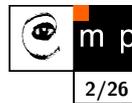
<http://cmp.felk.cvut.cz>

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Talk Outline

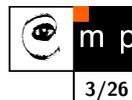
- ◆ Introduction
- ◆ What can be done with cameras?
- ◆ Course admin, grading . . .

Motivation



- ◆ Cameras become part of our lives . . .
- ◆ . . . computer vision algorithms become ubiquitous

Computer Vision for Virtual Reality



Virtual Reality

- ◆ closely related to Computer Graphics

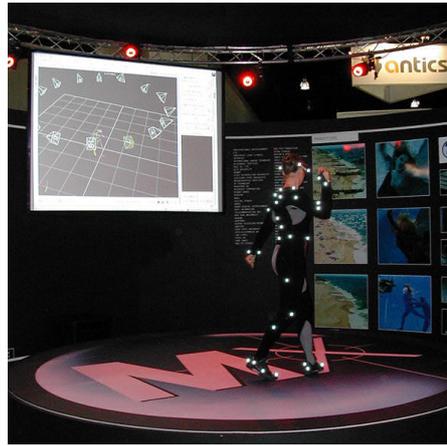
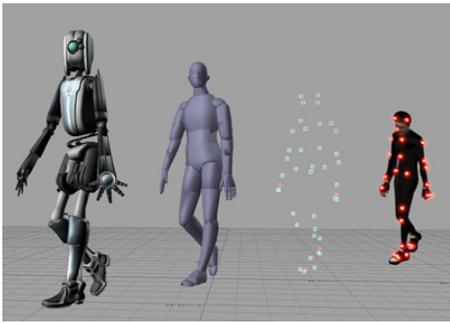
- ◆ computer games 

- ◆ flight simulators 

- ◆ head mounted displays 

- ◆ movie industry, Gollum 

It is relatively clear how to make a virtual landscape, city, rigid objects. But how to **animate** the Gollum? An how to put him in a real world?



Computer Vision for Virtual Reality

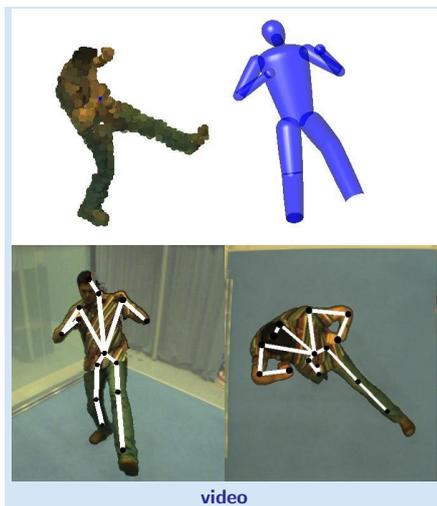
Computer Vision

How the can machines **see**? What does it mean to **see**?

- ◆ image or video understanding
- ◆ object recognition in images/videos
- ◆ object reconstruction from images
- ◆ object tracking, camera tracking, motion capture

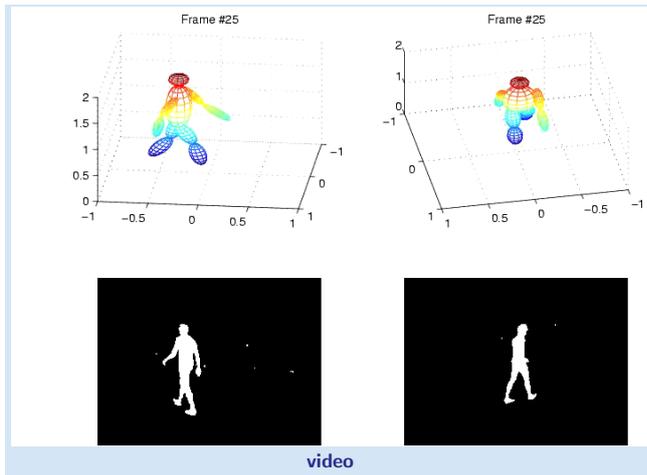
It is not clearly defined. However, . . .

Markerless Motion Capture



Full body tracking from volumetric data [6]

Markerless Motion Capture



Model fitting to multiple 2D projections

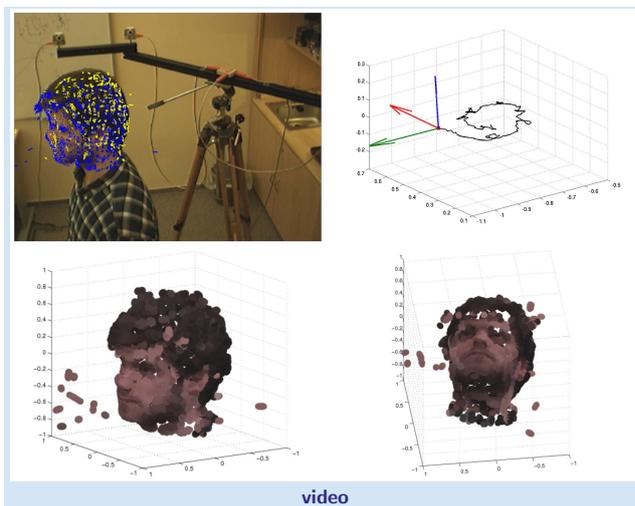
Kindly provided by CMP; details in [10]; MultiCam project <http://cmp.felk.cvut.cz/projects/multicam>

Multicamera systems — surveillance



Kindly provided by CMP, MultiCam project <http://cmp.felk.cvut.cz/projects/multicam>

Multicamera systems — models for recognition



Kindly provided by CMP; details in [11]; MultiCam project <http://cmp.felk.cvut.cz/projects/multicam>



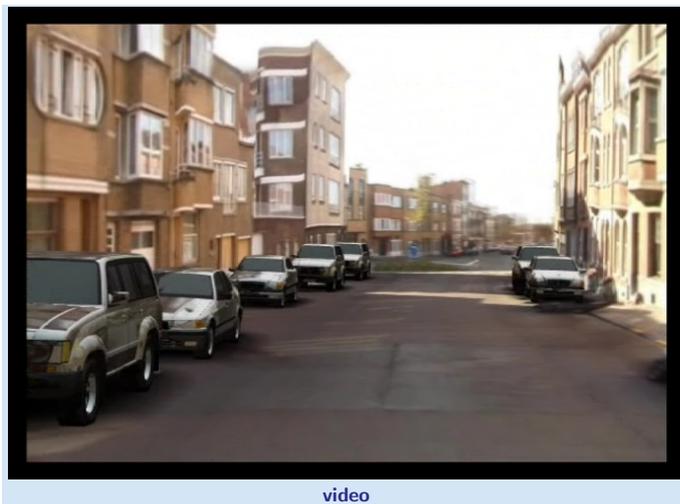
Kindly provided by CMP; MultiCam project <http://cmp.felk.cvut.cz/projects/multicam>

Augmentation of real scenes



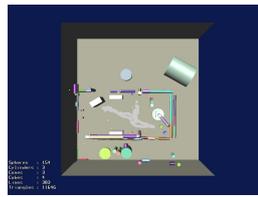
Video kindly provided by CVLAB at EPFL, tracking reference [9]

Next generation of navigators



Facade reconstruction and car detection [2]

Industrial application



The IST-2000-28764 project Service and Training. through Augmented Reality (STAR)

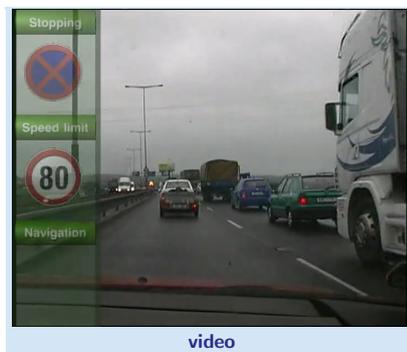
3D reconstruction from photos



- ◆ Just unorganized set of photos.
- ◆ Nothing else is required.
- ◆ Capture object of interest from different viewpoints

Kindly provided by CMP, see <http://cmp.felk.cvut.cz/demos/Reconstruction/demo3DPVT06/> or <http://cmp.felk.cvut.cz/demos/Reconstruction/demoCVPR05/>

Computer vision helps drivers . . .



Cars can have a miniature camera behind the frontal glass.
Connected computer recognizes traffic signs in real time

. . . but officers too — License plate recognition



Kindly provided by Eyedea recognition

Computer Vision for Virtual Reality



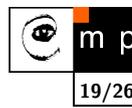
Kindly provided by CMP; Benogo project <http://cmp.felk.cvut.cz/projects/benogo>

Virtual Window into Reality



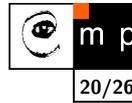
Kindly provided by CMP; Benogo project <http://cmp.felk.cvut.cz/projects/benogo>

What algorithms (skills) are needed?



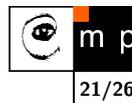
- ◆ Connect cameras to computer(s) and acquire images, as **synchronously** as possible.
- ◆ **Calibrate** the setup—compute camera positions and their imaging parameters.
- ◆ **Motion** segmentation. Find what belongs to the scene and what/who is moving.
- ◆ **Detect** and **track** objects or persons of interest.

Notes about the course



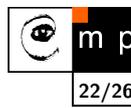
- ◆ rather high level aspect of computer vision
- ◆ very little about image processing (colors, interpolation, sharpening, . . .). Let me know if something will not be clear to you. Please consider that I do not know about your background.
- ◆ think about your particular interests and let me know about.

Language peculiarities



- ◆ English is the working language of the course.
- ◆ You may call me Tomas.
- ◆ In case you want to discuss something in private. Please note I understand German quite well and some French, too.

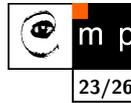
To do:



Please send very soon an email to svoboda@cmp.felk.cvut.cz from the email address you will be using. Include the following information.

- ◆ Subject: XE33PVR::your_name
- ◆ Your full name.
- ◆ How should I call you. Usually, I use the christian name however, I will respect your preferences.
- ◆ Branch of your study at your home university.

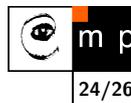
Grading



- ◆ Closed book written exam at the end (60 minutes) 50%
- ◆ Practical assignments during the courses 50%

Details on the subject [homepage](#).

Further Reading



A good reference book about image processing and computer vision is [7]. The book is accompanied with practically oriented programming book [8]¹ Few copies available at the [CMP library](#)². Some copies also present at th [Faculty library](#)³.

The book [5] is the ultimate reference about geometry of multiple views. It is a must read for anyone who wants to seriously use cameras for 3D computing.

Details about matrix decompositions used throughout the lectures can be found at [4]. Still, many useful insights about the math contains also the appendices of [5].

Alternative reading about computer vision is [3]. The book [1] may serve as an introduction into tracking. There will be some additional references to journal and conference papers. The most important journals are IEEE Pattern Analysis and Machine Intelligence (PAMI) and International Journal of Computer Vision (IJCV). Top three conferences are International Conference on Computer Vision (ICCV), European Conference on Computer Vision (ECCV) and Computer Vision and Pattern Recognition (CVPR).

¹Source codes available at: <http://visionbook.felk.cvut.cz>.

²<http://cmp.felk.cvut.cz/library/>

³<http://knihovny.cvut.cz/>

- [1] Andrew Blake and Michael Isard. *Active Contours : The Application of Techniques form Graphics, Vision, Control Theory and Statistics to Visual Tracking of Shapes in Motion*. Springer, London, Great Britain, 1998. On-line available at <http://www.robots.ox.ac.uk/~contours/>.
- [2] N. Cornelis, B. Leibe, K. Cornelis, and L. Van Gool. 3d city modeling using cognitive loops. In *Video Proceedings for CVPR 2006 (VPCVPR'06)*, June 2006.
- [3] David A. Forsyth and Jean Ponce. *Computer Vision : A Modern Approach*. Prentice Hall, Upper Saddle River, NJ, USA, 2003.
- [4] Gene H. Golub and Charles F. Van Loan. *Matrix Computation*. Johns Hopkins Studies in the Mathematical Sciences. Johns Hopkins University Press, Baltimore, USA, 3rd edition, 1996.
- [5] Richard Hartley and Andrew Zisserman. *Multiple view geometry in computer vision*. Cambridge University, Cambridge, 2nd edition, 2003.
- [6] R. Kehl, M. Bray, and L. Van Gool. Full body tracking from multiple views using stochastic sampling. In *2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, pages 129–136, June 2005.
- [7] Milan Šonka, Václav Hlaváč, and Roger Boyle. *Image Processing, Analysis and Machine Vision*. Thomson, 3rd edition, 2007.
- [8] Tomáš Svoboda, Jan Kybic, and Václav Hlaváč. *Image Processing, Analysis and Machine Vision. A MATLAB Companion*. Thomson, 2007.
- [9] Luca Vacchetti, Vincent Lepetit, and Pascal Fua. Stable real-time 3d tracking using online and offline information. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 26(10):1385–1391, 2004.
- [10] Karel Zimmermann and Tomáš Svoboda. Probabilistic estimation of articulated body model from multiview data. In Peter Kneppo and Jiří Hozman, editors, *IFMBE Proceedings EMBEC'05, 3rd European Medical and Biological Engineering Conference*, pages 1–6, Prague, Czech Republic, November 2005. International Federation for Medical and Biological Engineering.
- [11] Karel Zimmermann, Tomáš Svoboda, and Jiří Matas. Multiview 3D tracking with an incrementally constructed 3D model. In *Third International Symposium on 3D Data Processing, Visualization and Transmission*, Chapel Hill, USA, June 2006. University of North Carolina.

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