Univerza v Ljubljani

Advanced CV methods
Introduction

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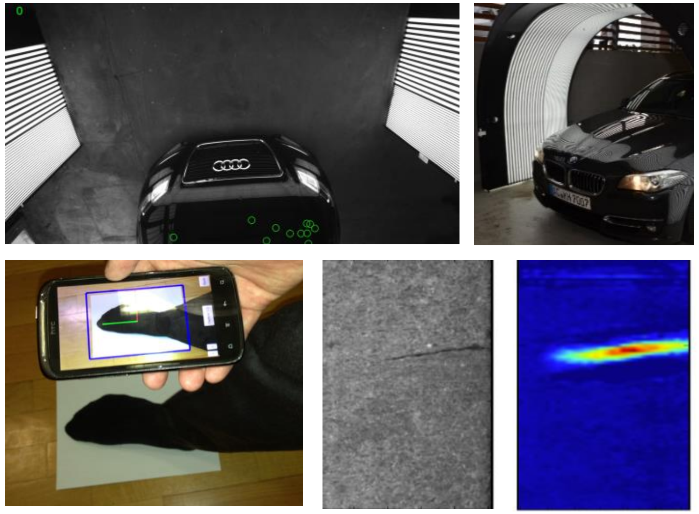
About the lecturer

- Matej Kristan
- Visual Cognitive Systems Laboratory (ViCoS)
- Email: matej.kristan@fri.uni-lj.si
- Homepage: http://www.vicos.si/People/Matejk
- Other resources:
  - Sicris: a brief bibliography at Sicris
  - Researchgate: https://www.researchgate.net/profile/Matej_Kristan
  - Google scholar: http://scholar.google.com/citations?user=z_8FrEYAAAAJ&hl=en

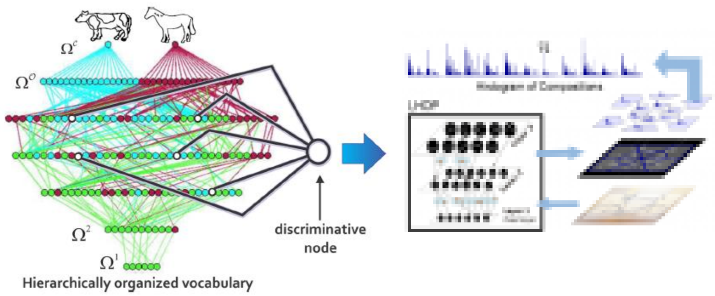
Research interests

0. Industrial R&D



1. Deep structured networks

Tabernik et al., CVPR2017; Tabernik et al., CVIU 2015 ; Kristan et al., SCIA 2013 ; Tabernik et al., ICVS 2013 ; Tabernik ICPR 2012; Tabernik et al IJCV 2019

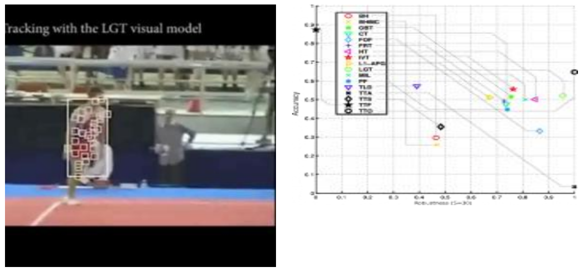


2. Robotic vision

Uršič et al., IJRR 2017;
Uršič et al., ICRA 2016 ;
Mandeljc et al., ICRA 2016 ;
Skočaj et al., TETA 2016;
Kristan et al., IEEE TCYB 2016;
Uršič et al., IJRAS 2013 ;
Kristan et al., IMAVIS 2013;
Uršič et al., IROS 2012
Skočaj et al., EPIROB 2010

3. Visual tracking

Čehovin et al., ICCV2017;
Lukežič et al., CVPR 2017;
Lukežič et al., IEEE TCyb 2017
Kristan et al., IEEE TPAMI 2016 ;
Čehovin et al., IEEE TIP 2016 ;
Čehovin et al., WACV2016 ;
Kristan et al., ICCV-W 2015 ; Kristan et al., ECCV-W 2014 ; Čehovin et al., IEEE TPAMI 2013 ; Kristan et al., ICCV-W 2013 ; Kristan et al., IEEE SMCB 2010 ; Kristan et al., PR 2009 **;** Kristan et al., CVIU 2009 ;

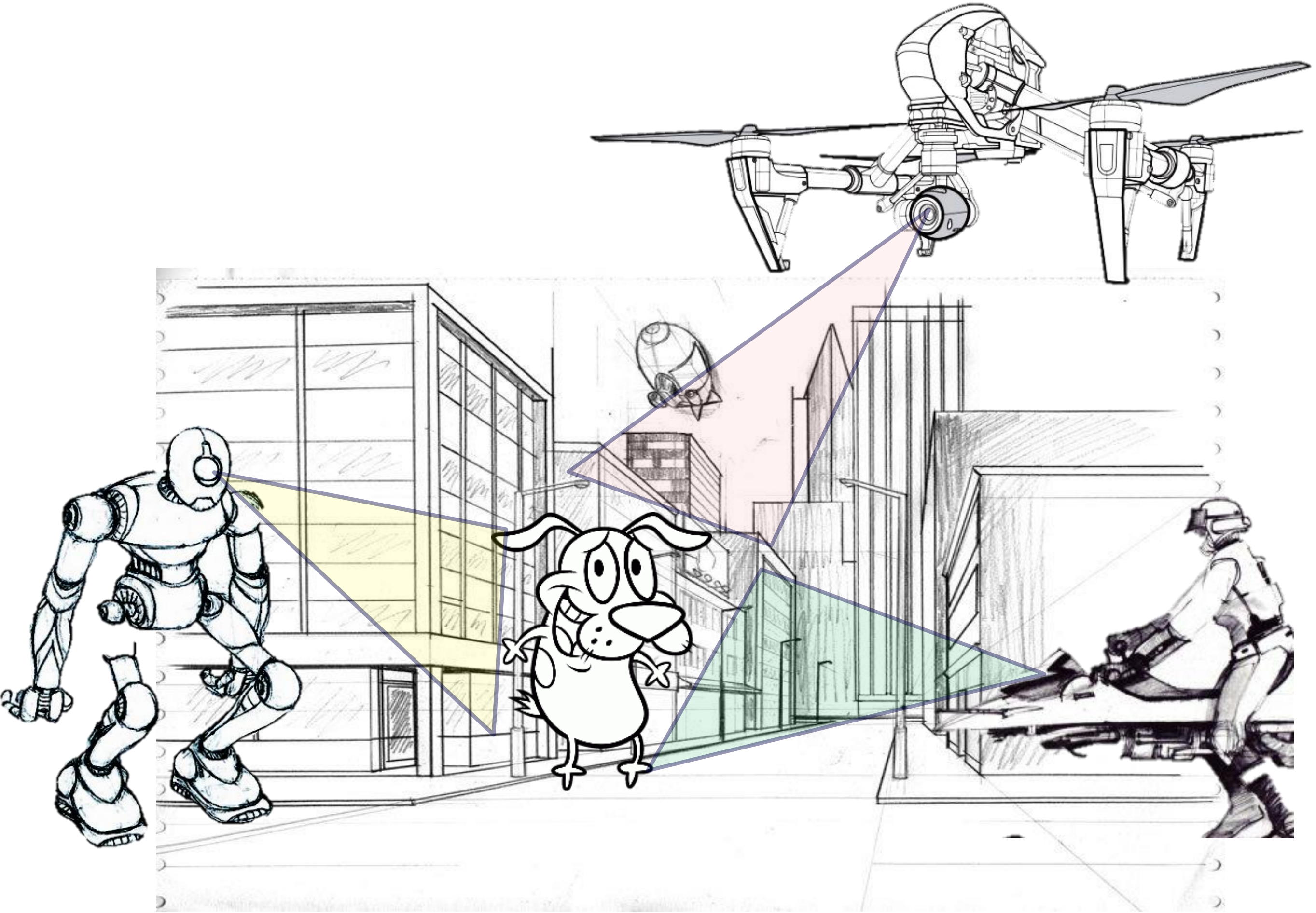


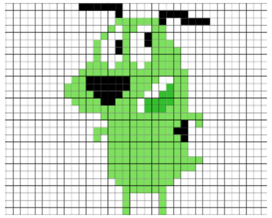
What will this course be about?

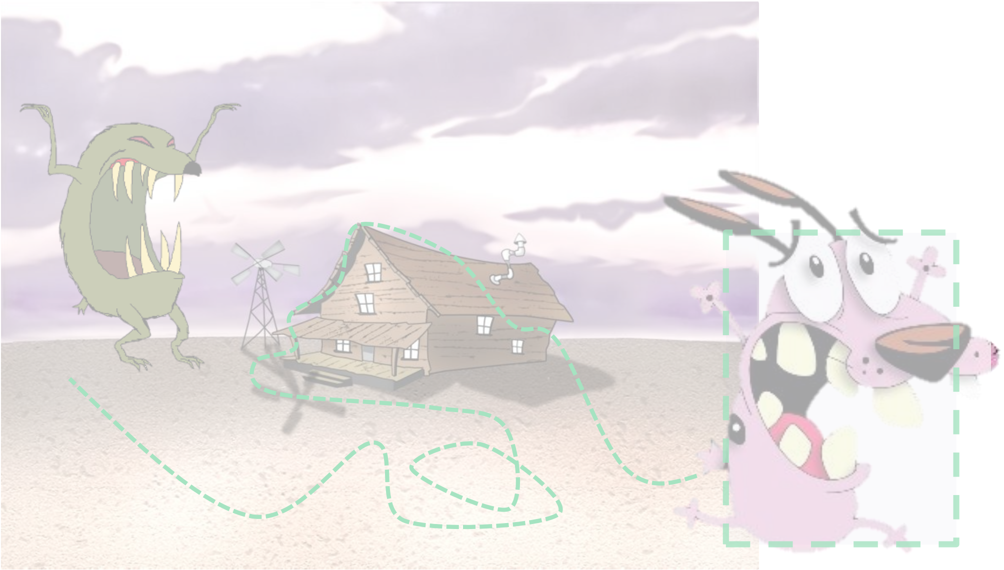
- Motion perception and Tracking

- Currently hot topics in CV as well as industry

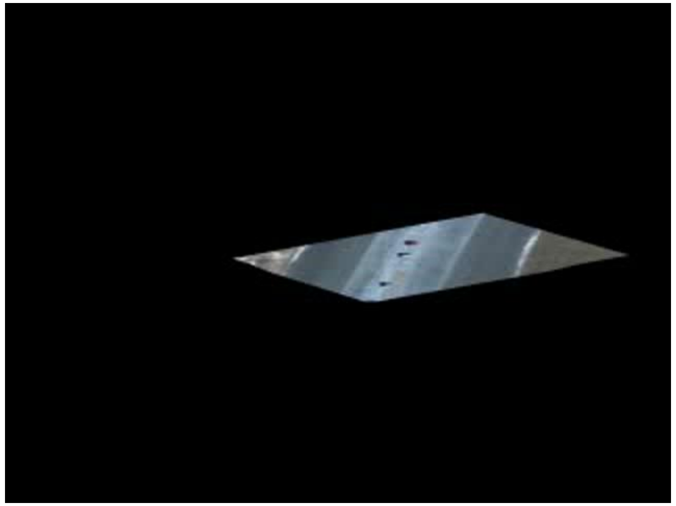
A huge application potential







Application examples



SaadAli , Mubarak Shah ISR2006

Perazzi et al., CVPR 2016

Čehovin, Kristan and Leonardis, IEEE TPAMI 2013

Kristan et al. CVIU 2009

Many Challenges in Visual Object Tracking

- Short-term Visual Object tracking challenges:
  - VOT2013, VOT2014, VOT2015, VOT2016, VOT2017,VOT2018, VOT2019, VOT2020?
- Long-term Visual Object tracking challenge 2014
- Multi object tracking challenge (MOT2015)
- Change detection challenge 2011-2014
- KITTI auto-moto challenge:

  car and pedestrian tracking
- VideoNet

  … and much more

Advanced Methods in Computer Vision

DETAILS ABOUT THE COURSE

Main topics

1. Low-level motion estimation techniques
2. Tracking regions by generative models
3. Tracking regions by discriminative models
4. Bayesian recursive filtering
5. Deep-learning-based trackers
6. Long-term tracking
7. Visual tracking performance evaluation

Tentative!
May change

Required background

- Programming
- Basic algebra and vector/matrix calculus

  (basic, but good foundations)
- Basic probability and statistics

  (basic, but good foundations)
- Basics in signal processing / computer vision desired

  (will provide the references to the relevant literature)

Lectures

- First-hand insights on the topics
  - Ask questions!
- Will cover main concepts and go over the necessary derivations

- Attend the lectures and make your own notes!
- Literature:
  - Lecture slides (void of derivations)
  - Major conference or journal papers

Lab / Assignments

mag. Alan Lukežič

- Learn theory by implementing it!
- Python (potentially C/C++)

- Complete 5 assignments
  - Implement what you learned at lectures
  - Two-week assignments, brief directions, individual work required
  - Not guided, consultations available
  - More information at the Lab (Alan will give you details)

The A, B and C of the course

- A: 5 lab assignments
  - Further details at the lab exercises
- B: ~6 homework assignments
  - To help you follow the lectures
- C: Written exam
  - Mainly theory + basic computations

Final grade: A*0.5 + C*0.4 + B*0.2

NOTES:
Positively pass all assignments in (A) – required
Pass the written exam (C) – required
Homework (B) – not required, but desired

ACVM course Gantt diagram

13 lectures (Canceled on: 30.4.)

~ 6 home works (very lightweight)

week1 week3 week5 week7 week9 week11 week13

Assignments (two weeks effort!)

Assignment1 (~5.3.)

Assignment2 (~19.3.)

Assignment3 (~2.4.)

Assignment4 (~16.4.)

Assignment5 (~30.4.)

Where to find state-of-the-art?

Two top journals of CV: (Source: Cobiss.si)

- Transactions on Pattern Analysis and Machine Intelligence, TPAMI, IF 17.7
- International Journal of Computer Vision, IJCV, IF 6.071

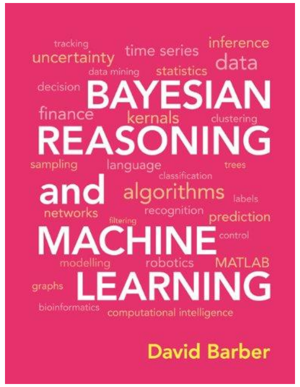
Top conferences: (Source: Microsoft academic research)

- CVPR - Computer Vision and Pattern Recognition
- ICCV - International Conference on Computer Vision
- ECCV - European Conference on Computer Vision
- FGR - IEEE International Conference on Automatic Face and Gesture Recognition
- BMVC - British Machine Vision Conference
- WACV - Workshop on Applications of Computer Vision
- ACCV - Asian Conference on Computer Vision

Some textbooks/handbooks

- General CV: Computer Vision Models
  - (freely available)
  - Prince: Linear algebra: Appendix C

- Probability: Bayesian Reasoning and Machine Learning
  - (freely available)
  - Vectors, matrices, gradients: Appendix A



- Some readily computed matrix-vector derivatives
  - The matrix cookbook (freely available)

Preliminaries on deep learning

- Deep learning is an elementary methodology in computer vision
- Towards the end of semester a lecture on trackers based on CNN
- You are required to be familiar with general neural networks and have a grasp of the basic ideas behind the CNNs.
- If you're not familiar, familiarize yourself:
  CS231n: Convolutional Neural Networks for Visual Recognition
  http://cs231n.stanford.edu/syllabus.html
  - Lecture 4 (basics of neural nets)
  - Lecture 5 (convolutional neural networks)
  - Lecture 6 - Lecture 9 (training the networks and some relevant architectures)

Today – getting on the same page

- Have a look at linearization
  - Most of you should be familiar with this, but I will not assume that
- Get some homework (4 exercises)
  - Turn in the homework by next week (see the e-classroom for exact date)
  - Submit via e-classroom
- Promise more fun in the following lectures ☺

Advanced computer vision methods

LINEARIZATION IN A NUTSHELL

A task often encountered

- Have a parametric model.
- Find parameters of the model to best fit the data.

- A fitting example:

  By how much should be expand/shirk Stan to best fit Olio?

Parameterized Stan’s face

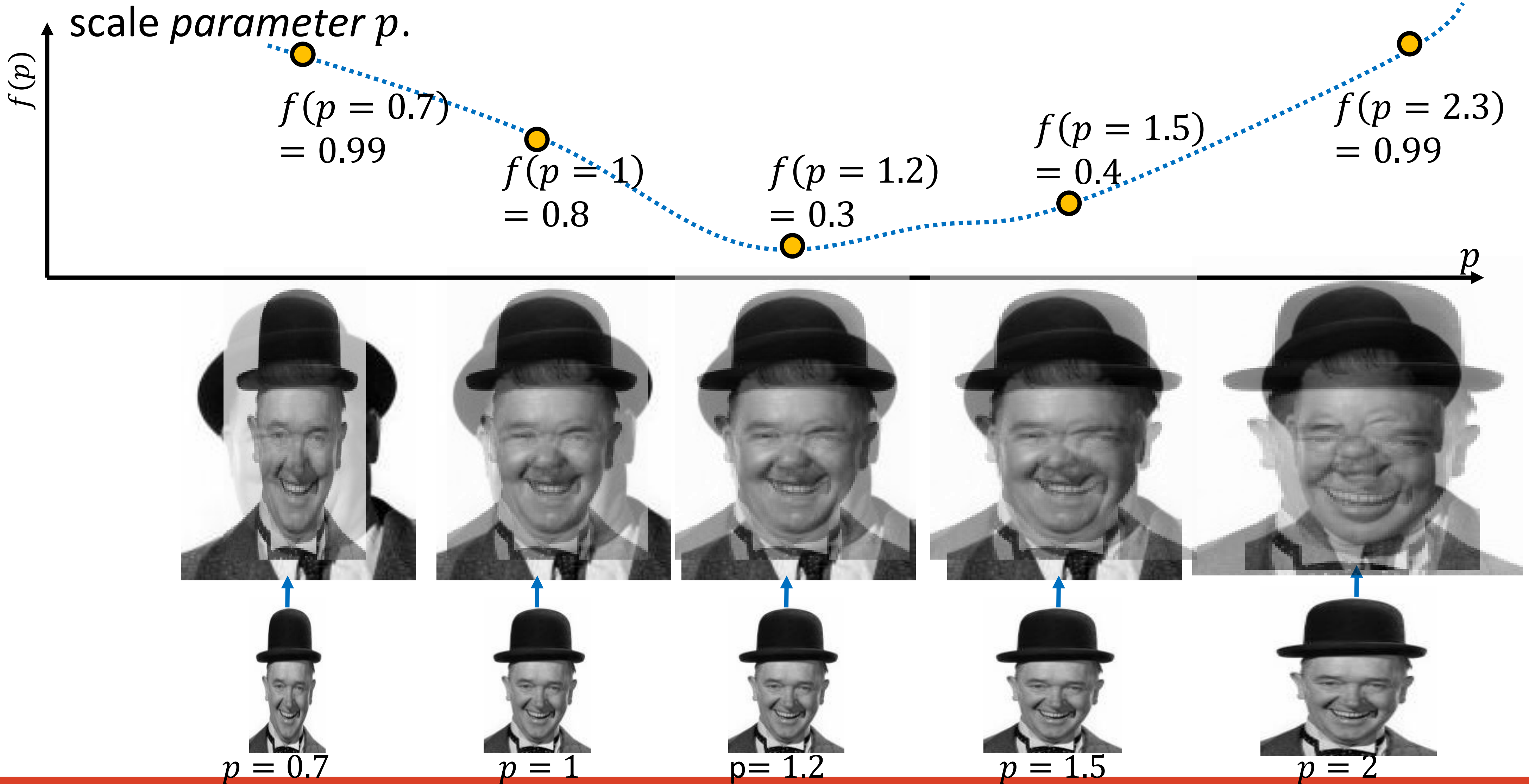
- Stan’s width parameterized by a scale factor p.

$p = 0.7$ $\quad$ $p = 1$ $\quad$ $p = 1.2$ $\quad$ $p = 1.5$ $\quad$ $p = 2$

- Now we need to compare Stan’s warped face to Olio’s face…

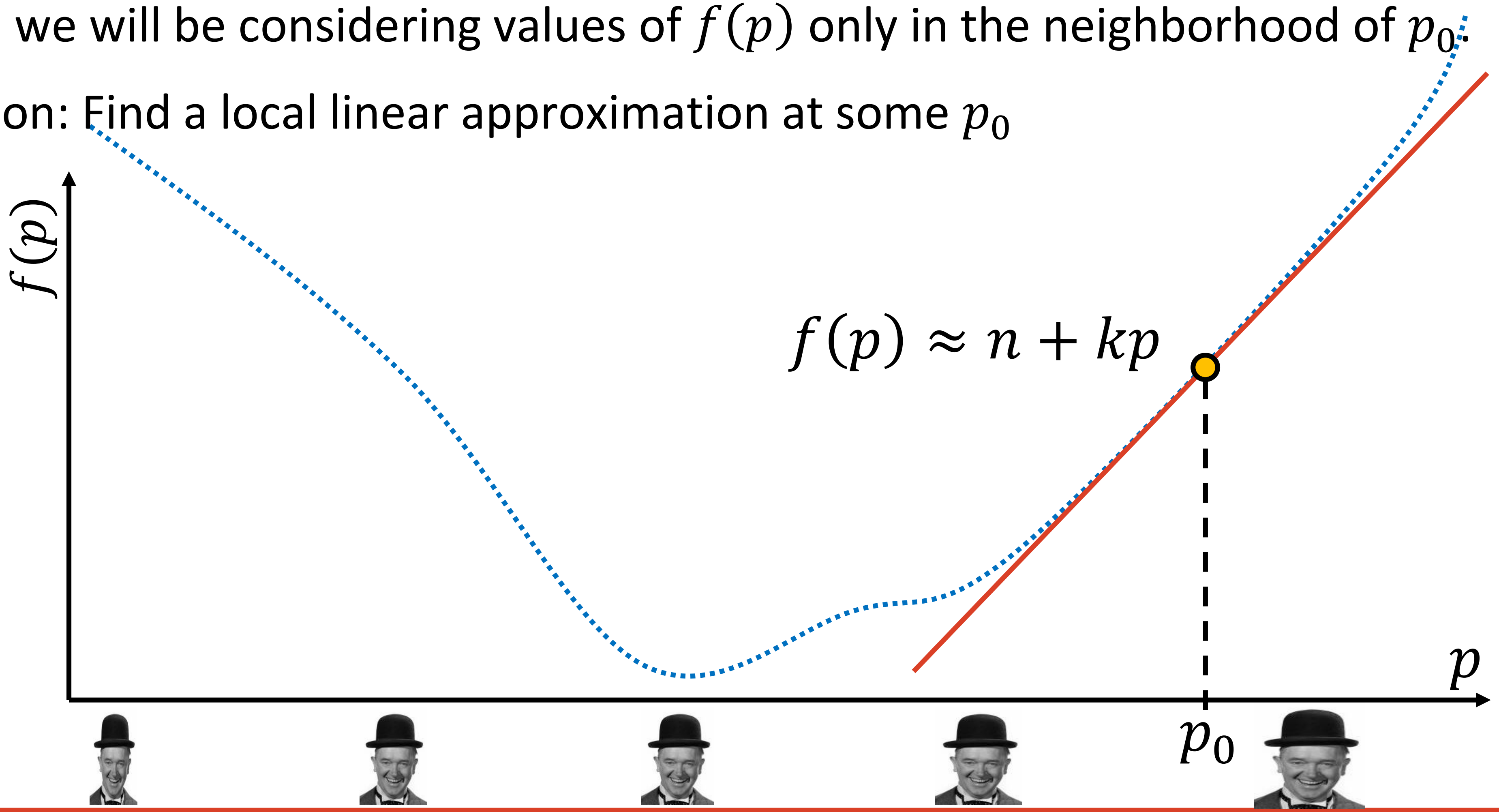
Parameterized Stan's face

- Difference $f(p)$ between Stan's face deformed by p and Olio's face depends on the scale *parameter* p.



Parameterized Stan's face

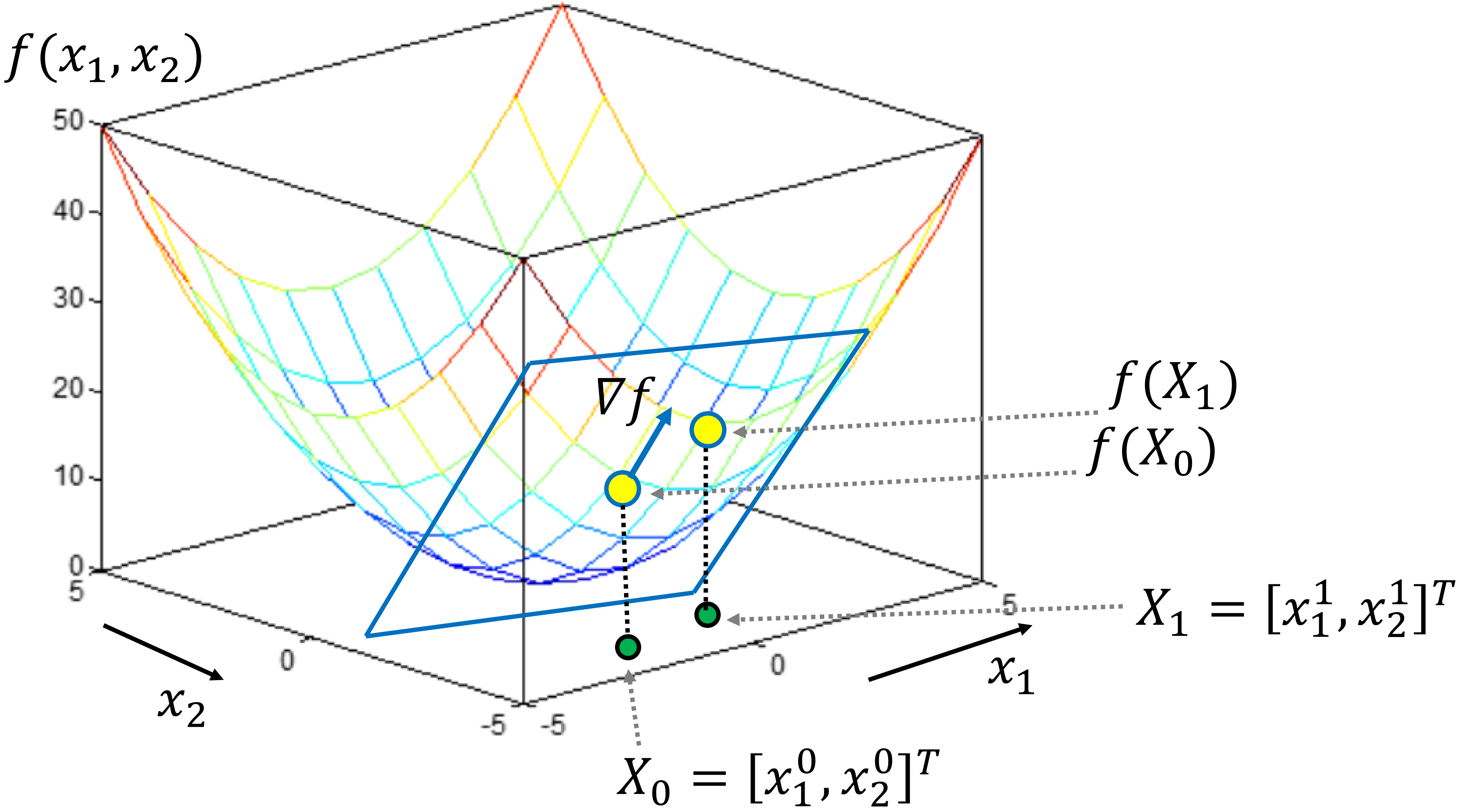
- Often we will want to use the function $f(p)$ in our computations, but working with nonlinear functions can complicate calculations.
- Often we will be considering values of $f(p)$ only in the neighborhood of p_0.
- Solution: Find a local linear approximation at some p_0



General problem emerges

- Given a nonlinear function $f(x(\boldsymbol{p}))$ parameterized by some parameters $\boldsymbol{p} = [p_1, p_2, \dots, p_n]$, what is the linear approximation at a neighborhood of parameters $\boldsymbol{p_0}$?
- Linearize by Taylor expansion
  (ignore higher-order terms).
- See notes that you took at lectures.

Multivariate gradient



Linearization by Taylor expansion

- To brush up on Taylor expansion and linearization, see "Bayesian Reasoning and Machine Learning" Appendix A, Section 29.2
- For explanation of the gradient and partial derivatives, specifically, equation (29.2.4) for linearization by Taylor expansion.
- Interactive examples of multivariate derivatives: http://mathinsight.org/linear_approximation_multivariable