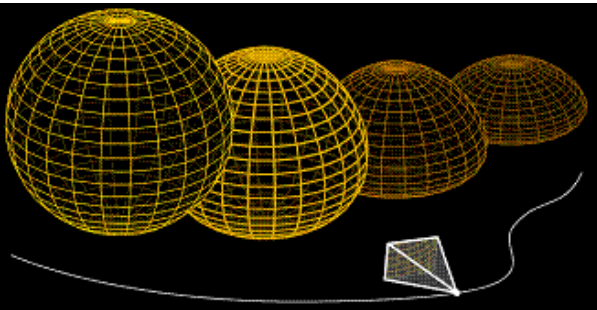


Tutorial Schedule

Tuesday

9:30 – 10:00
Taxonomy of deformations

10:00 – 10:30
Template-based image 3D reconstruction

10:45 – 12:30
Non-rigid Structure from Motion -1st part

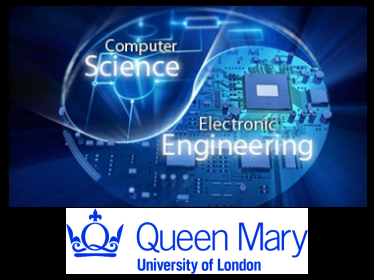
14:30 – 16:15
Non-rigid Structure from Motion – 2nd part

16:30 – 17:00
Hyperparameter selection

17:00 – 17:30
Conclusions and Discussions

2nd Tutorial on

Computer Vision in a Non-Rigid World

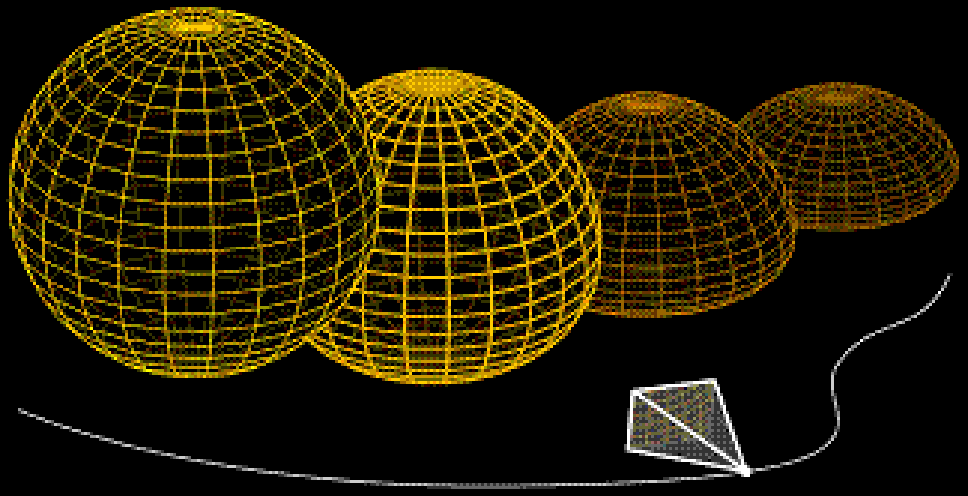


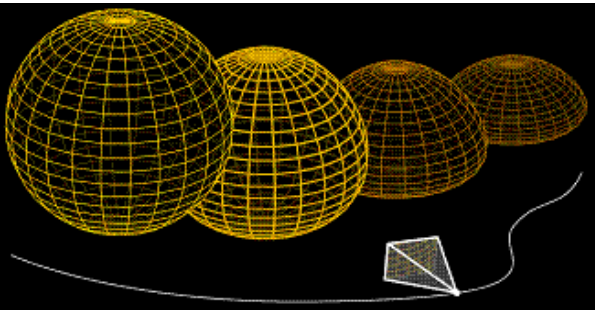
Dr. Lourdes Agapito

Prof. Adrien Bartoli

Dr. Alessio Del Bue

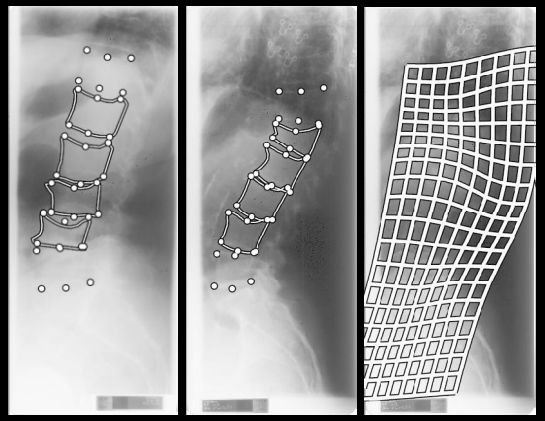
Taxonomy of Deformations



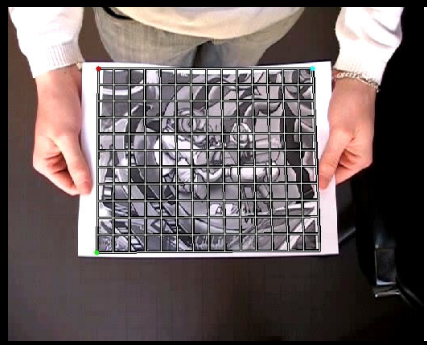


Methods Taxonomy

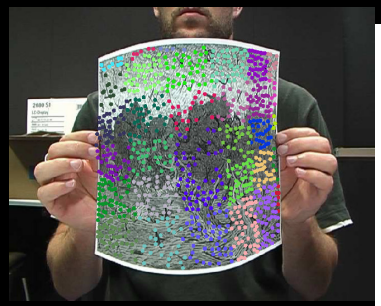
- Image Registration (2D to 2D)

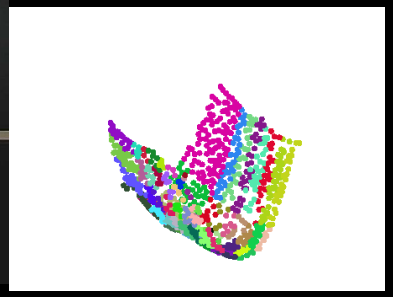


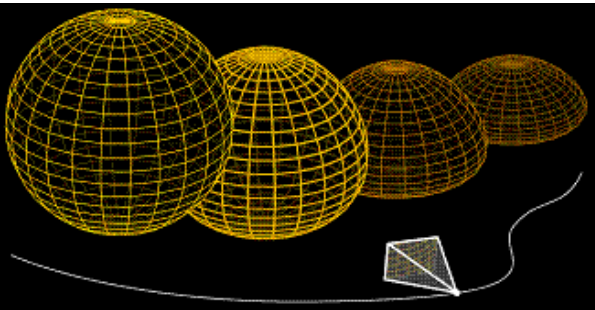
•Template Based Image Reconstruction



•Non-Rigid Structure from Motion





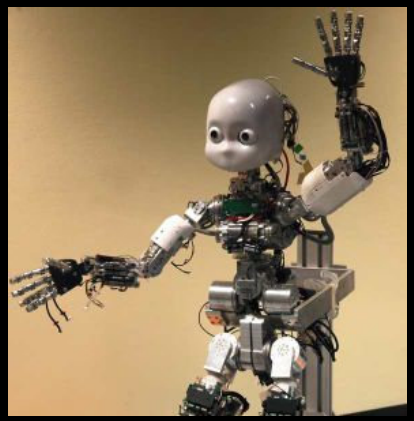


Deformation Classification

Although the methods perform different tasks, they all share the same problem:

Is it possible to define a classification for different priors on the type of deformation?

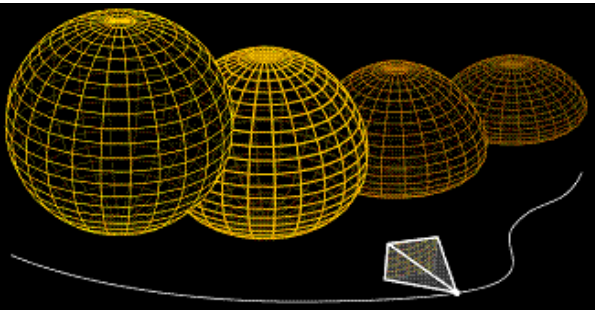
Isometric



Articulated

Extensible

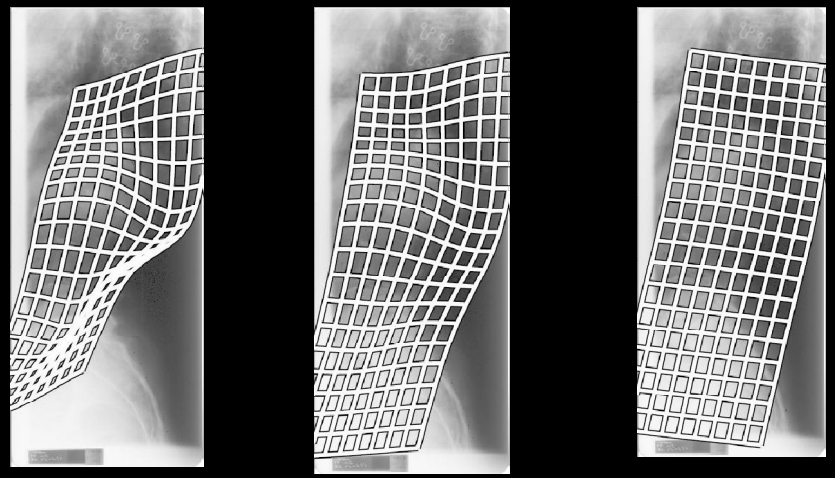
Such set of deformations can be formalised in a mathematical framework?



Ill-posed Problem and Priors

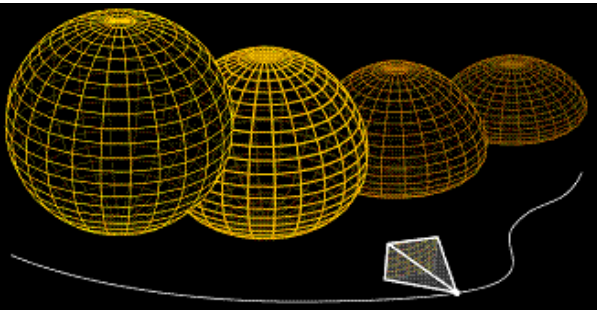
All the available knowledge about the deforming body must be used since the registration and reconstruction of 3D bodies is a strong ill-posed problem

Computationally this amounts to include specific prior information in the algorithms. These priors are customised on the observed deformation in the images.



This case shows the application of a smoothing priors for a registration task. with different strengths. Which is the best smoothing?

Data courtesy of de Bruijneet al.



A Taxonomy of Priors: Statistical Priors

Statistical Priors are in general the most used in NRSfM approaches they can divided in different categories:

- Dynamics

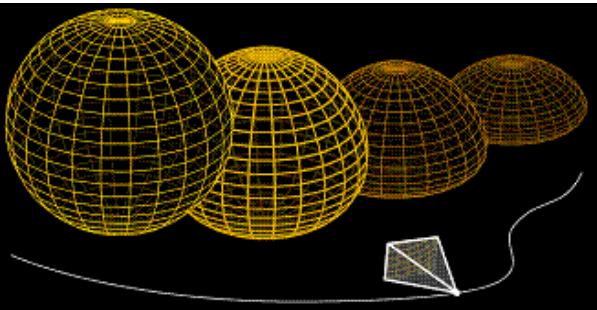
  The temporal variations of the deformation parameters in a new observation is given by a linear transformation of the previously observed state.

- Probabilistic smoothness of deformation

  The parameters controlling the deformation are obtained by sampling a given distribution i.e. Gaussian

- Low rank bases model

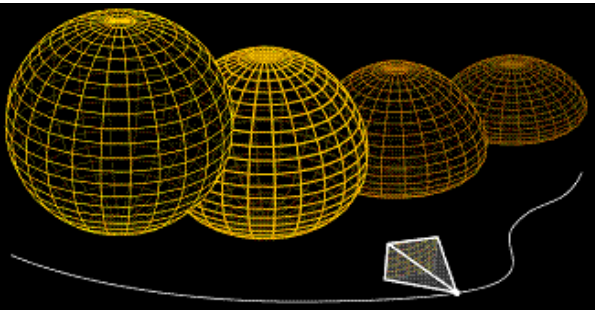
  The overall (global) deformations varies given a finite set of 3D bases. These bases span the all possible deformations of the object



A Taxonomy of Priors: Physical Priors

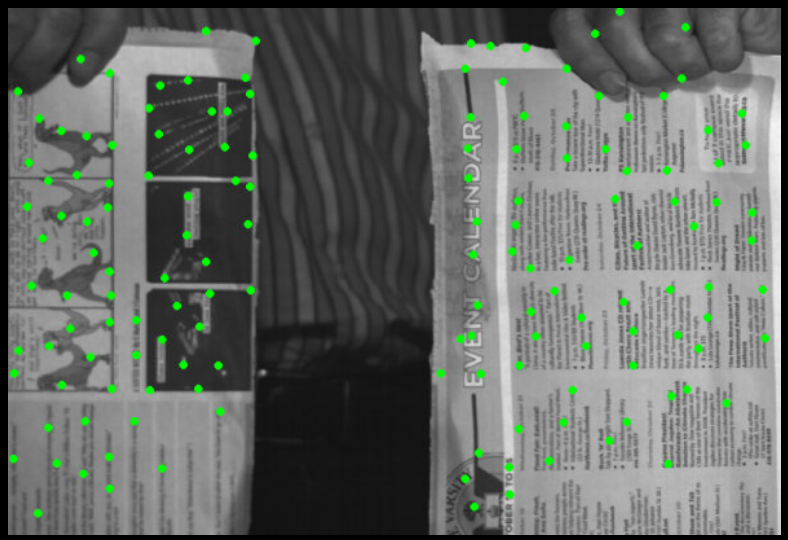
Physical Priors are in general the most used in NRSfM approaches they can divided in different categories:

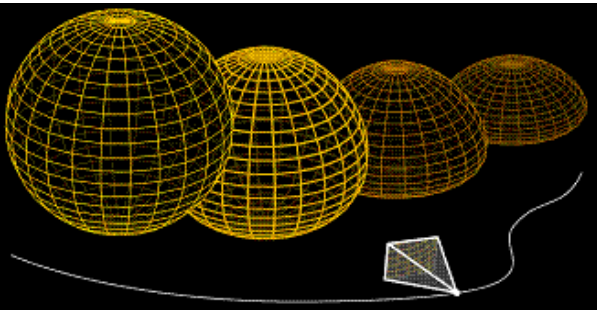
- Single object
  - The images and/or feature points belongs to a single shape
- Isometry
  - Deformations do not vary the intrinsic distance of points lying on the deforming surface
- C_1/ C_0 continuity
  - Different conditions on the surface continuity/smoothness
- Elasticity
  - Deformations are subject to elastic constraints given by specific materials
- Piecewise quadratic/planar
  - A single object can be approximated by a finite series of patches or blocks.
- Known 3D template
  - The 3D surface is known along with the template image.



A Taxonomy of Priors: Physical Priors – Single Object

- Single object (C_0 continuity) /multiple objects
  The images and/or feature points belongs to a single shape deforming





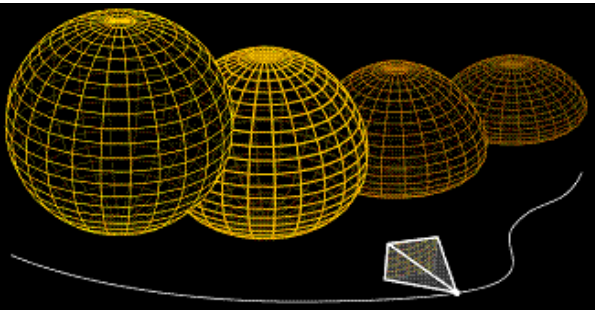
A Taxonomy of Priors: Physical Priors – Isometry/C_1

- C_1 continuity/ surface smoothness

  The surface is smooth and its deformations do not create singularities (i.e. spikes, tears, holes)

- Isometry

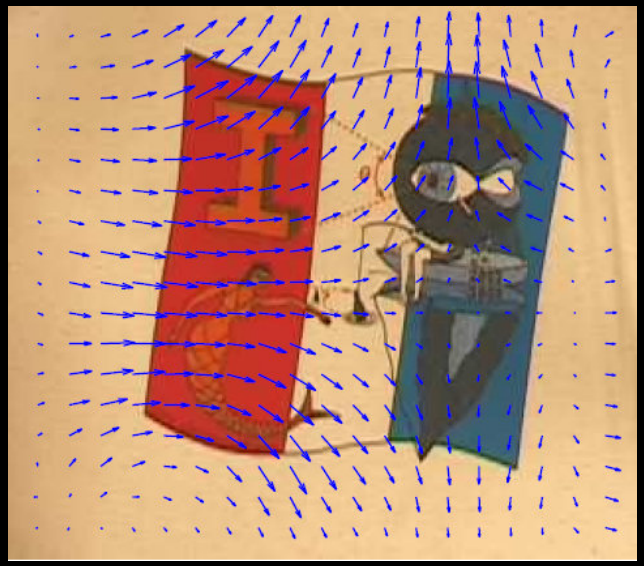
  Deformations do not vary the intrinsic distance of points lying on the deforming surface. The surface is not extensible! The classical case, a sheet of paper.

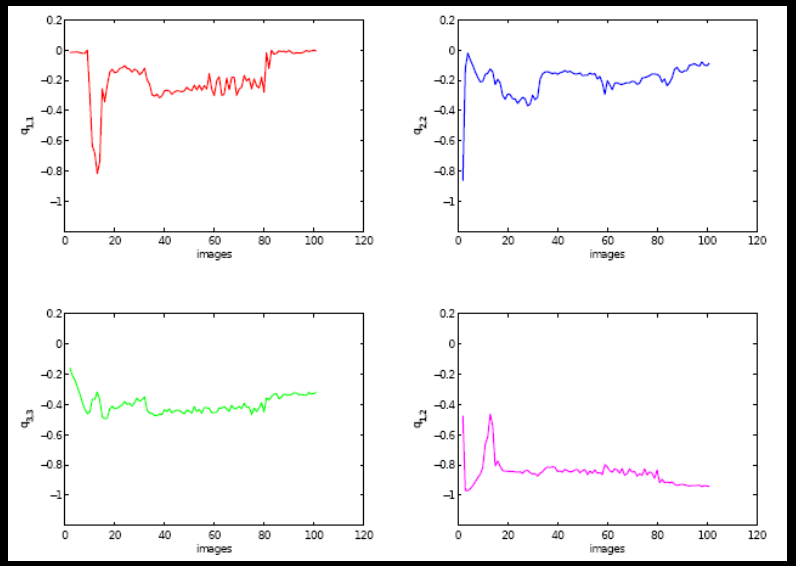


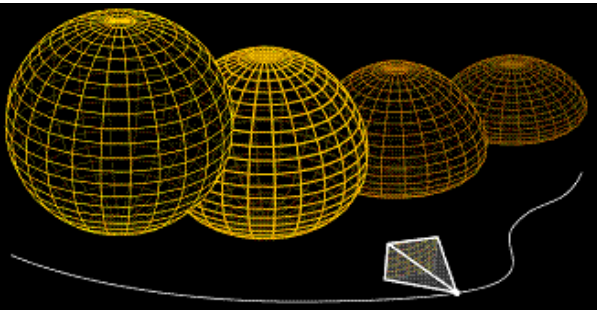
A Taxonomy of Priors: Physical Priors - Elasticity

- Elasticity

  Deformations are subject to elastic constraints given by specific materials. Measure of stiffness can be used such as the Young's modulus, Poisson's ratio.



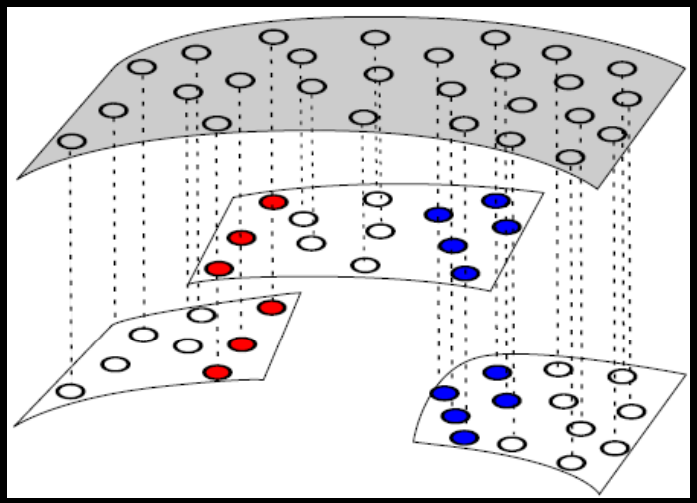




A Taxonomy of Priors: Physical Priors - Piecewise

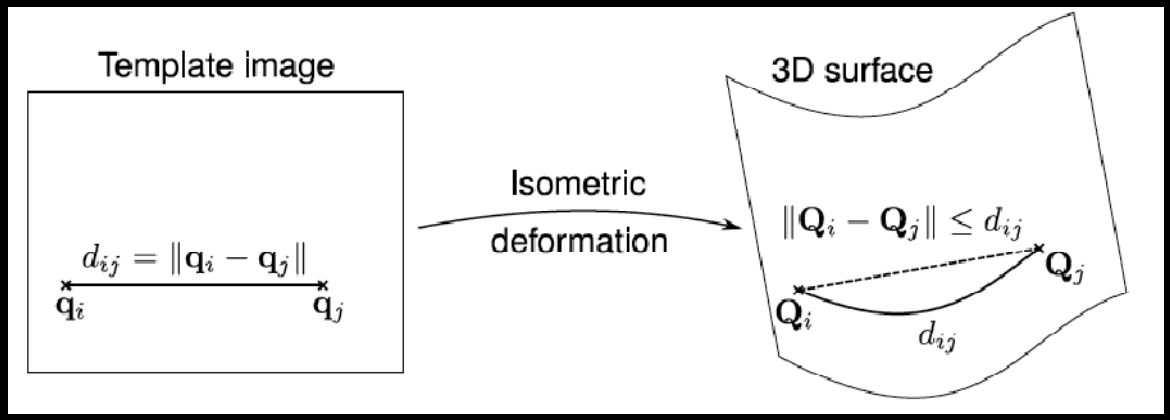
- Piecewise quadratic/planar

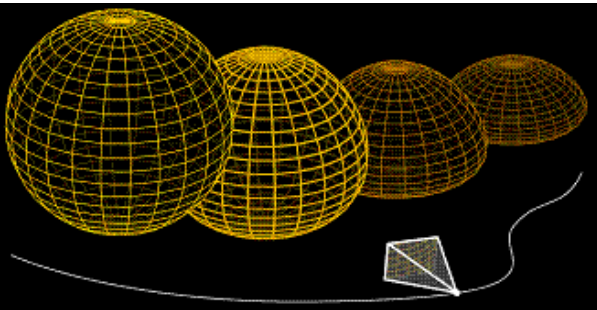
  A single object can be approximated by a finite series of patches or blocks.



- Known 3D template

  The 3D surface is known along with the template image.





A Taxonomy of Priors: Priors and Computation

The mentioned priors can be included in each one of the problems we are going to face in the tutorial.

In general each registration/reconstruction problem deals with the optimisation of a cost function.

In such context priors can be introduced as penalty terms in the optimisation:

$$\min_{R_i\, S_k\, l_{i,k}} \sum_{i\,,\,j} \left\| X_{ij} - R_i \sum_k l_{i,k} S_k \right\|^2 + \lambda \sum_i \left\| B_i - B_{i+1} \right\|^2$$

$$\text{where } B_i = \sum_k l_{i,k} S_k \qquad + \varphi \sum_i \left\| R_i - R_{i+1} \right\|^2$$