OUTLINE FOR CIMPA 2021 TALKS

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Structure of Lectures using mp4 Files

Each lecture consists of several recorded parts. Below we list for each lecture the parts recorded as mp4 files, a brief description of each, given in the order they should be viewed for the lecture. We are separately including four PDF files for the powerpoint presentations of the lectures. However, these four PDFs represent the four topic areas of the lectures:

1) CIMPA.21.intro.imag.pdf
   Introduction to problems in computer and medical imaging and an outline of methods of singularity theory to be employed;
2) CIMPA.21.Med.Imag.Skel.Reps.pdf
   Medial and skeletal structures capturing shape and geometry of individual regions in $\mathbb{R}^n$;
3) CIMPA.21.Med.Imag.Lnk.Strs.pdf
   Medial/skeletal linking structures capturing combined shape and position geometry of a configuration of regions in $\mathbb{R}^n$; and
4) CIMPA.21.Nat.Imag.pdf
   Determination of the generic local properties of objects in natural images using their geometric features, shade/shadows from a fixed generic light source together with viewer direction, including generic transitions under viewer movement.

We also include for the lectures a partial bibliography separated into parts for each portion of the lectures.

Lecture 1: Introduction to Problems in Computer and Medical Imaging

1) Lect1.intro.imaging.pt1.mp4
   Introduction to different types of computer imaging questions beginning with special interest in problems involving 2D and 3D medical images;
2) Lect1.intro.imaging.pt2.mp4
   Introduction to questions involving identifying objects in Natural Images by making use of their local features, resulting from their geometric features, shade/shadow, and viewing direction. Also, we give a brief outline of methods of singularity theory which will be used for both classes of images: Thom-Mather theory and stratification theory.
3) Lect1.Skel.Str.pt1.mp4
   Introduction to methods for capturing shape information of regions. We specialize to the Blum medial axis, and the use of singularity theory to describe its generic structure, and its generalization to skeletal structures.

Skeletal structures consist of stratified sets and a multi-valued vector fields on them. These relax conditions of Blum medial axis and provide "deformable templates" which are more amenable to statistical methods for medical images. These can also be adapted to obtain specialized structures such as generalized tubular structures with uses in videos and time series.

Lecture 2: Medial Geometry of Single Regions from Skeletal Structures and Medial/Skeletal Linking Structures for Multi-Region Configurations

1) Lect2.skel.str.props.pt2.mp4
   Introduction to the mathematical structures defined from skeletal structures and their applications. This includes giving a representation of the regions via a "radial flow", deducing the local differential geometry of the boundary, and defining medial and skeletal integrals on the skeletal sets which can be used for computing global geometric invariants on the region or boundary.
2) Lect2.lnk.strs.pt1.mp4
   Introduction to modeling a configuration of regions in $\mathbb{R}^n$, allowing them to share portions of boundaries, motivated by consideration of multiple objects in medical images. This includes general questions about positional geometry for a configuration of objects, and introducing medal/skeletal structures to capture this information.
3) Lect2.lnk.strs.pt2.mp4
   We determine the generic properties of Blum linking structure using transversality theorems for "multi-distance" and "height-distance" functions in "partial multi-jet spaces". We also indicate how external structure is captured via a "linking flow"and how it can be used to obtain global geometric invariants, including volumetric measures for positional geometry.

Lecture 3: Applications of Singularity Theory for Describing the Local Features of Objects in Natural Images

1) Lect3.nat.imag.pt1.1.mp4
   This gives a more detailed introduction to problems for natural images and specific questions to be answered.
2) Lect3.nat.imag.pt1.2.mp4
   This explains how classical results from singularity theory yield answers in the case of images of smooth objects without shade or cast shadows. Then the additional visual features are introduced and a method involving the consideration of two projections in the light and view direction will be separately considered.
3) Lect3.nat.imag.pt2.mp4
   To apply Thom-Mather theory, the strategy for allowing all of the visual features involves two steps, both using a modified form of $\mathcal{A}$ equivalence which preserves a stratification in the source. These stratifications are shown to have a special property so the full local Thom-Mather theory can be applied. Stable mappings in the light directions gives rise to stratifications involving local geometric features and shade/shadow curves. Then,

projections in the viewer direction are classified to obtain abstract classifications yielding both (topologically) stable mappings and low codimension mappings.

4) Lect3.nat.imag.pt3.mp4

The resulting abstract classifications are realized as projections (with a few higher codimension examples), taking into account multiple cases arising from visibility restrictions. The presence of moduli require in a number of cases the use of the corresponding topological equivalence. Generic transitions under viewer movement are obtained from the (topologically) versal unfoldings via realizations of the germs of (topological) codimension one germs. Several visual examples are illustrated.