**Schedule for Computational Symmetry Tutorial (T3 of ECCV 2010)**
**Sunday September 5, 2010**
**Location: ECCV 2010 conference site, room ATHENA**
**Organizer: Dr. Yanxi Liu**

**9:00 - 10:40am Introduction, Lecture**

**A. Essence of Regularity and Symmetry -- rising from real world problems**

(1)What is regularity and symmetry? Why do they matter? Why do we care about symmetry?

(2) What is symmetry? Mathematical definitions and real world examples.

(3) The spectrum of symmetry from regular to stochastic

(4) What is computational symmetry?

(5) Why computational symmetry is a double-sided sward computationally?

(6) Computational challenges in computational symmetry

**B. Symmetry Groups: categorization and organization of symmetries – a formal definition**
Introduction to some basic concepts in group theory: definition of a group, group action an d orbits, subgroup, different types of (sub)groups, discrete, continuous, finite, infinitely countable, all types of symmetries and symmetry groups, symmetry group hierarchies

**10:40 – 11:00am COFEE BREAK**

**11:00am Invited Speaker**

**Dr. Zygmunt Pizlo** http://www1.psych.purdue.edu/~zpizlo/

**Talk Title: Perception of Symmetry by Human Beings**

**Abstract**
Perception of symmetry has been studied scientifically for the last 100 years, beginning with the seminal book by Mach. Mach pointed out that mirror symmetry is perceptually more salient than translational or rotational symmetry. Aesthetics and art provided the main motivation for the early studies, which concentrated on perception of symmetrical retinal images. The first use of symmetry as an a priori constraint in visual perception was described by the Gestalt Psychologists in the 1920s and 30s. They treated symmetry as representing a simplicity principle (Prägnanz), defined, informally, as economy of perceptual representation. Simplicity principle was responsible in Gestalt theory for

perceptual organization, in which spatially global features took precedence over spatially local ones. During the Cognitive Revolution in the 1950s and 60s, symmetry was extended to the case of 3D stimuli and shown to be responsible for the topological and metric properties of the 3D shape percept produced by a single 2D retinal image. In the 1970s, symmetry perception was again studied separately from shape. The effect of retinal position, orientation, skew, as well as the effect of the amount of noise was tested in a set of parametric studies. The adoption of an inverse problem approach to vision, in conjunction with the progress in regularization and Bayesian methods for solving ill-posed inverse problems, brought, for the second time in history, symmetry and shape studies together. This research included the role of parts (geons) in perception of 3D objects, the application of Curie principle to shape perception, the relation between symmetry and binocular vision, and the dependence of symmetry constraint on other constraints, namely compactness, planarity and the non-degenerate view assumption. The tutorial will be concluded with a new definition of shape based on the concept of symmetry.

**12 noon Lecture**

**C. Discrete versus Quantified, continuous symmetries and their Applications**
What has been done on computational symmetry in computer vision/graphics in the past several decades?
What is the state of the art?
Distortions of symmetries in real world: are the ideal Symmetry groups still useful?

1. Static and dynamic near-regular textures in computer graphics/vision
2. Skewed Symmetry Groups and automatic Geo-tagging
3. Symmetries in motion, and Symmetry Groups in Gait/Dance Analysis
4. Translation Symmetry detection
    i. as a higher order correspondence problem
    ii. as a mean-shift belief-propagation problem
5. Symmetry-based segmentation:
    i. Urban scene analysis
    ii. image de-fencing
6. Symmetry and Saliency
7. Symmetry as a Continuous Feature (revisit and a closer look)
    i. Facial Asymmetry as a biometric, facial asymmetry for expression and gender classification
    ii. Statistical brain asymmetry for image indexing, age/gender estimation and computer aided diagnosis
8. Symmetry as a (neural) code
9. Symmetry in 3D reconstruction in computer vision
10. Symmetries in visual arts

**1-2pm Lunch**

**2pm Lecture**

**D. State of the art Symmetry detection algorithms and Quantitative Evaluations of their performances**

1. Why symmetry detection is relevant for computer vision/human?
2. Where we started and where we are?
3. How to evaluate the quality of symmetry detection algorithms: test images, ground truth, evaluation function

**2:45 pm Invited Speaker**

**Dr. Luc Van Gool**
https://securewww.esat.kuleuven.be/psi/visics/people/?uid=1 and
http://www.vision.ee.ethz.ch/members/get_member.cgi?lang=en&id=1

**Talk Title: Symmetry Groups and their Invariants**

**Abstract**
Symmetric shapes, even when looked at obliquely, have invariants that irregular shapes do not have. So-called fixed structures play a key role in this. These are structures such as points or lines that remain fixed under the transformation expressing the symmetry. Under general perspective projection and for planar shapes, the fixed structures yield subgroups of the plane projectivities. We analyse some of the more interesting cases and derive example invariants for each.

**3:45 – 4pm  COFEE BREAK**

**4pm Invited Speaker**

**Dr. Sven Dickinson**
http://www.cs.toronto.edu/~sven/

**Talk Title: Symmetric Parts and their Role in Object Recognition**

**Abstract**
Perceptual grouping played a prominent role in support of early object recognition systems, which typically took an input image and a database of shape models and identified which of the models was visible in the image. When the database was large, local features were not sufficiently distinctive to prune down the space of models to a manageable number that could be verified. However, when causally related shape features were grouped, using intermediate-level shape priors, e.g., cotermination, symmetry, and compactness, they formed effective shape indices and allowed databases to grow in size. In recent years, the recognition (categorization) community has focused on the object detection problem, in which the input image is searched for a specific target object. Since indexing is not required to select the target model, perceptual grouping is

not required to construct a discriminative shape index; the existence of a much stronger object-level shape prior precludes the need for a weaker intermediate-level shape prior. As a result, perceptual grouping activity at our major conferences has diminished. However, there are clear signs that the recognition community is moving from appearance back to shape, and from detection back to unexpected object recognition. Shape-based perceptual grouping will play a critical role in facilitating this transition. But while causally related features must be grouped, they also need to be abstracted before they can be matched to categorical models. In this talk, I will focus on symmetry as a powerful regularity for decomposing a shape into parts. I will review a number of symmetric parts-based shape representations, including shock graphs, bone graphs, blobs/ridges, top-points, and medial surfaces, and show how they can support effective object indexing and recognition. I will also discuss the extent to which these representations provide shape abstraction, which is critical in order to handle the within-class shape variation that's required for object categorization.

**5pm Summary and Discussion (Questions and Answers)**

**E. Summary and Conclusion**

There is a LONG history of computational symmetry in computer vision, why there is a recent surge of interests in computational symmetry in computer vision/graphics (see the number of published papers in recent top-rate computer vision/graphics conferences), and where will this subfield go from here?

- Theoretical directions
- A uniform taxonomy
- A list of un-answered questions
- Image test sets
- Ground truth labeling
- Sharing (and shared) code
- A competition!