Symmetry Detection from Real World Images

A *First-of-a-Kind* US NSF funded Competition

Gratitude

- Students involved in the extensive work

Ingmar Rauschert

Jingchen Liu

yle Brocklehurst

Somesh Kashyap

- NSF
- Advisory Board
- CVPR 2011
- Contestants!
- YOU

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Why “symmetry”?

Because

- they exist everywhere …

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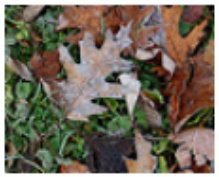
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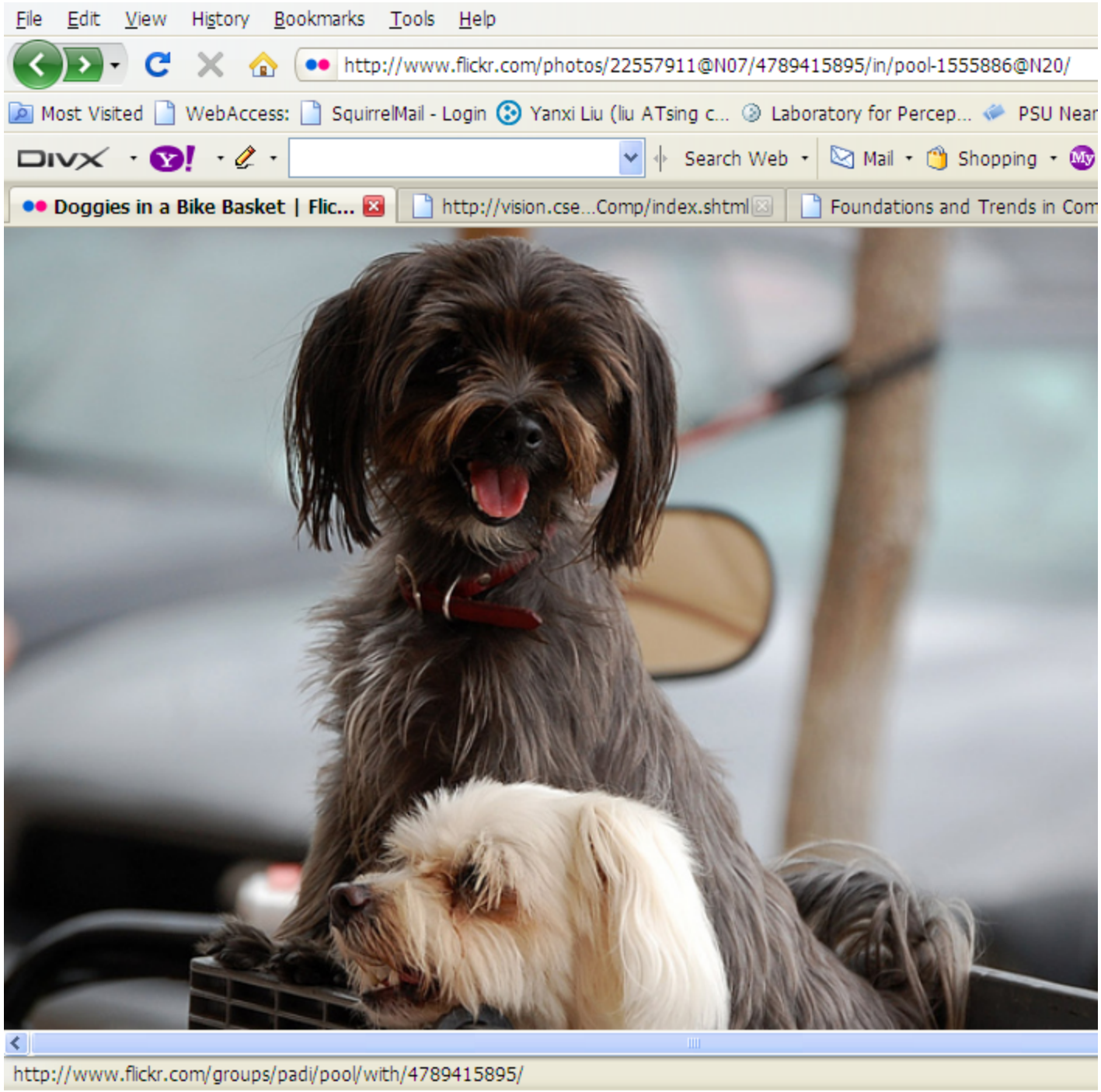
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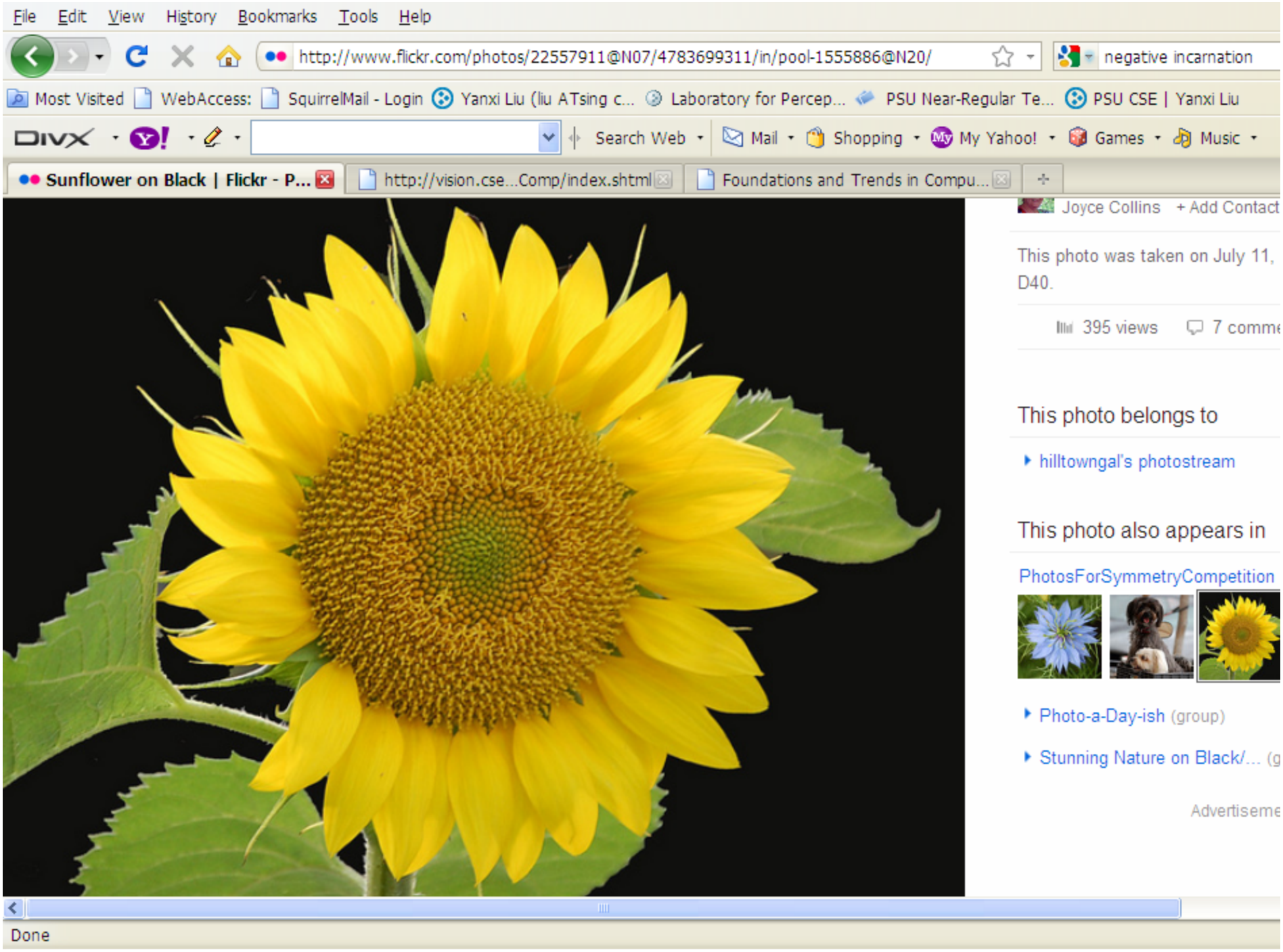
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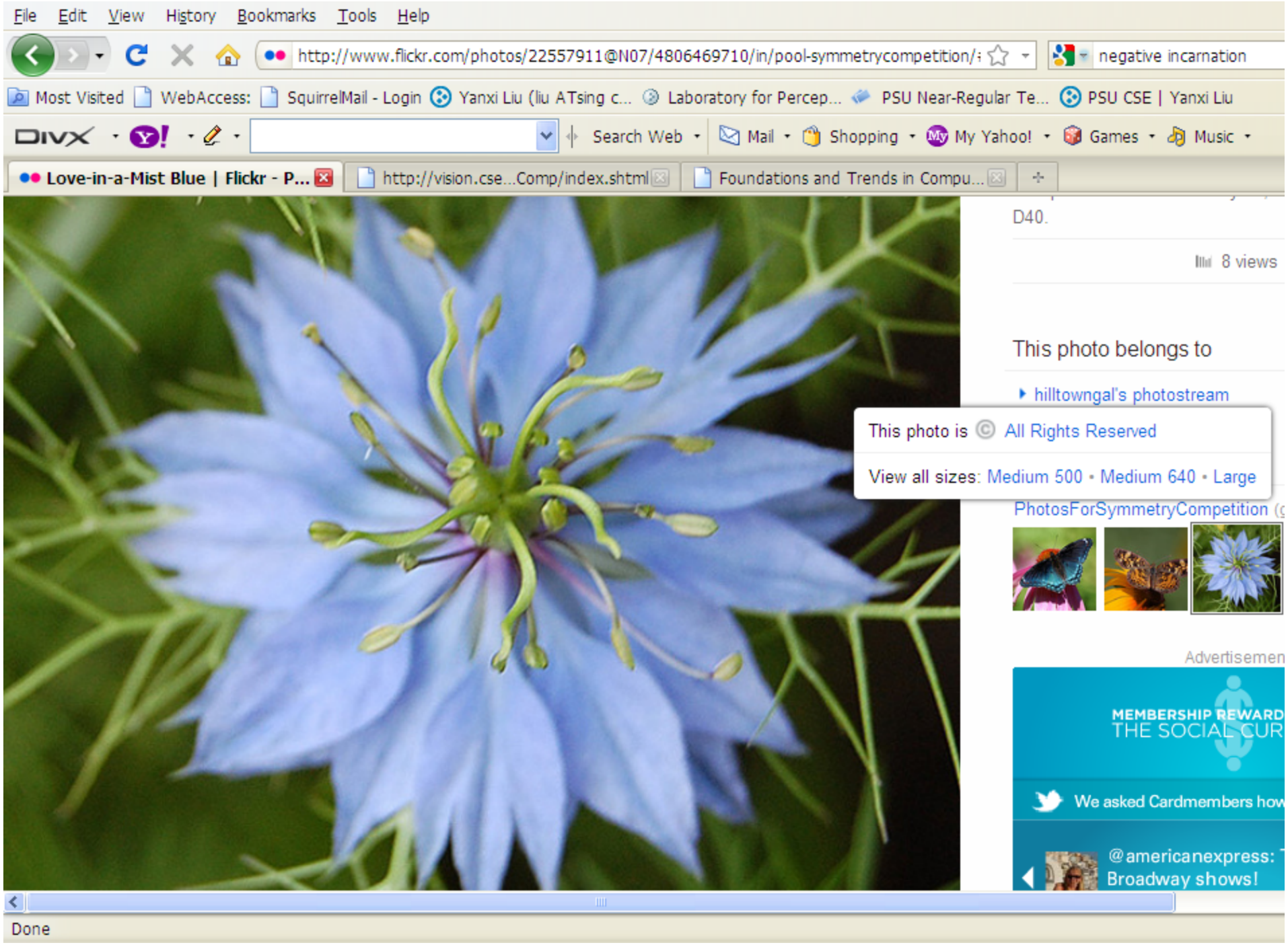
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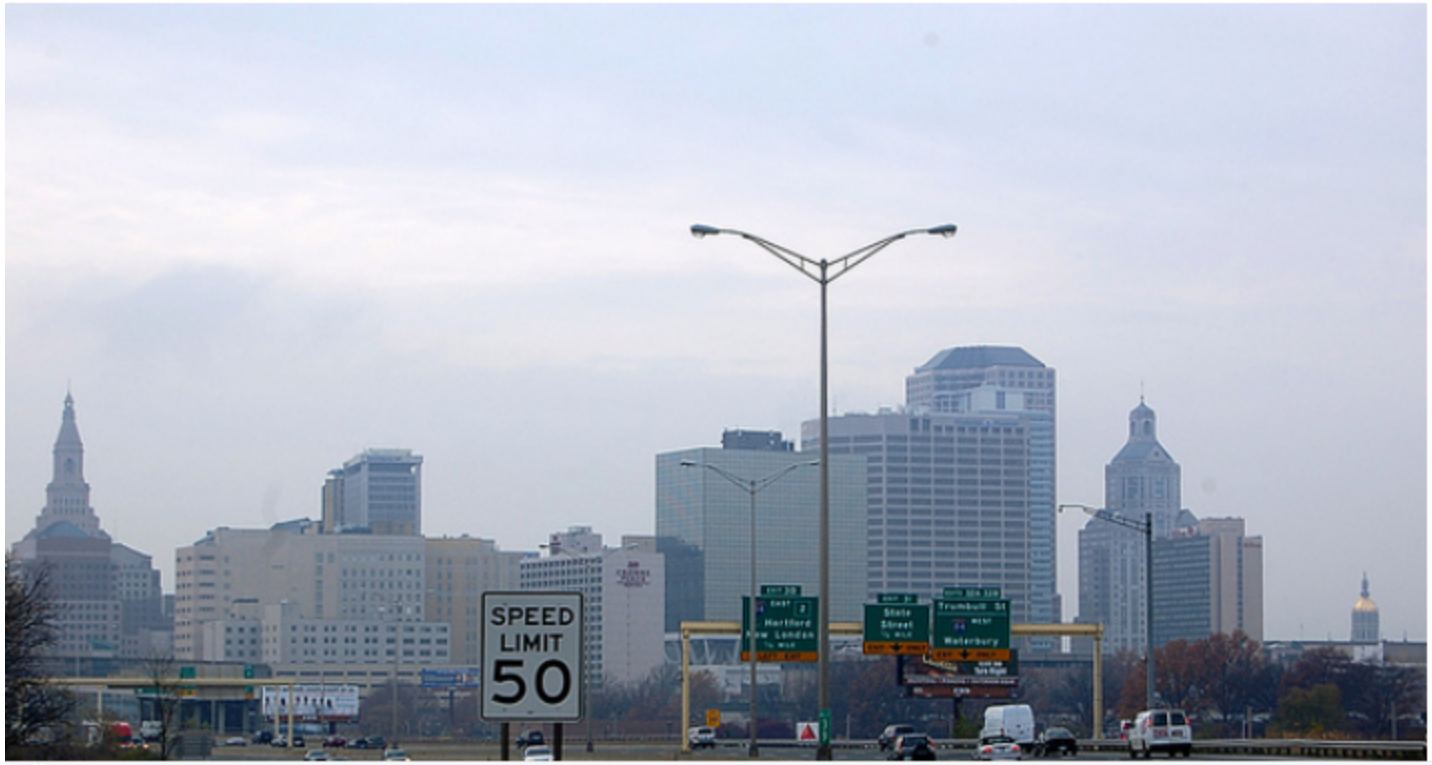

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Why “symmetry”?

Because

- they exist everywhere …
- they are well-defined mathematically, while almost **never** appear in reality the way they are defined in a textbook
- there is a diverse set of types of symmetries
- They play an important role in intermediate-level vision – across object class, modality, and scale

A Formal Definition of **Symmetry**

If **g** is a **distance preserving** (isometry) transformation in n-dimensional Euclidean space R^n, and S is a subset of R^n , then **g** is a **symmetry** of S iff

$$g(S) = \{g(s) | \text{ for all } s \text{ in } S\} = S.$$

Note:

A symmetry is a **transformation** !

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Symmetry ≠ Mirror Reflection Alone

TYPES of
PRIMITIVE SYMMETRIES
in 2D Euclidean Space

Foundations and Trends® in
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Vol. 5, Nos. 1–2 (2009) 1–195

DOI: 10.1561/0600000008

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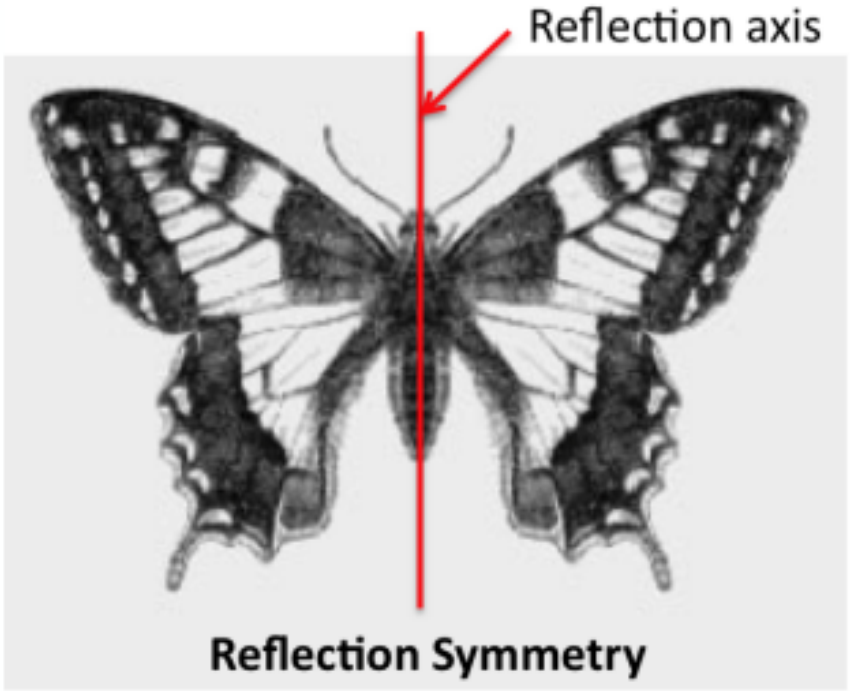
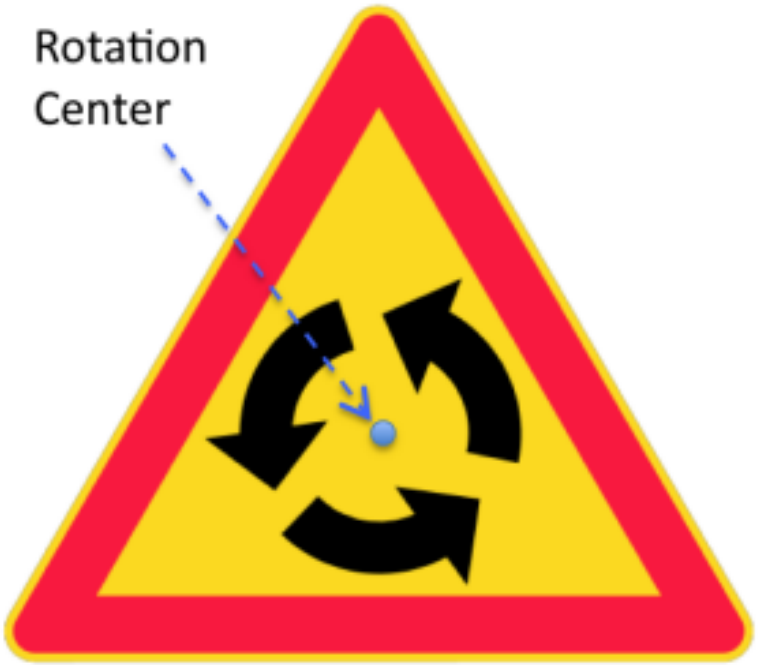
Computational Symmetry in Computer Vision and Computer Graphics

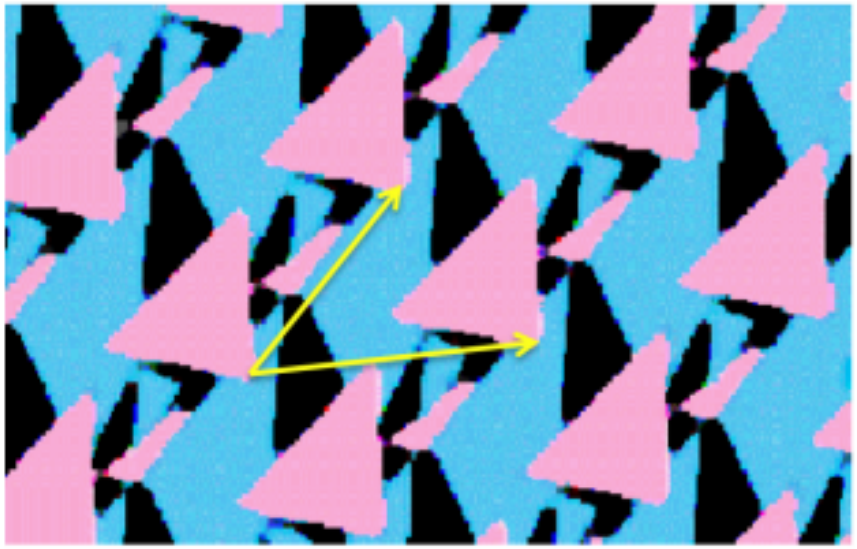
By Yanxi Liu, Hagit Hel-Or,
Craig S. Kaplan and Luc Van Gool



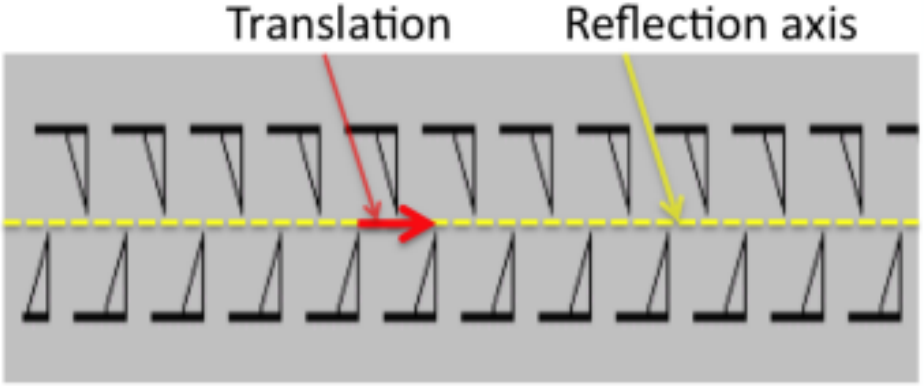
Reflection Symmetry



Rotation Symmetry

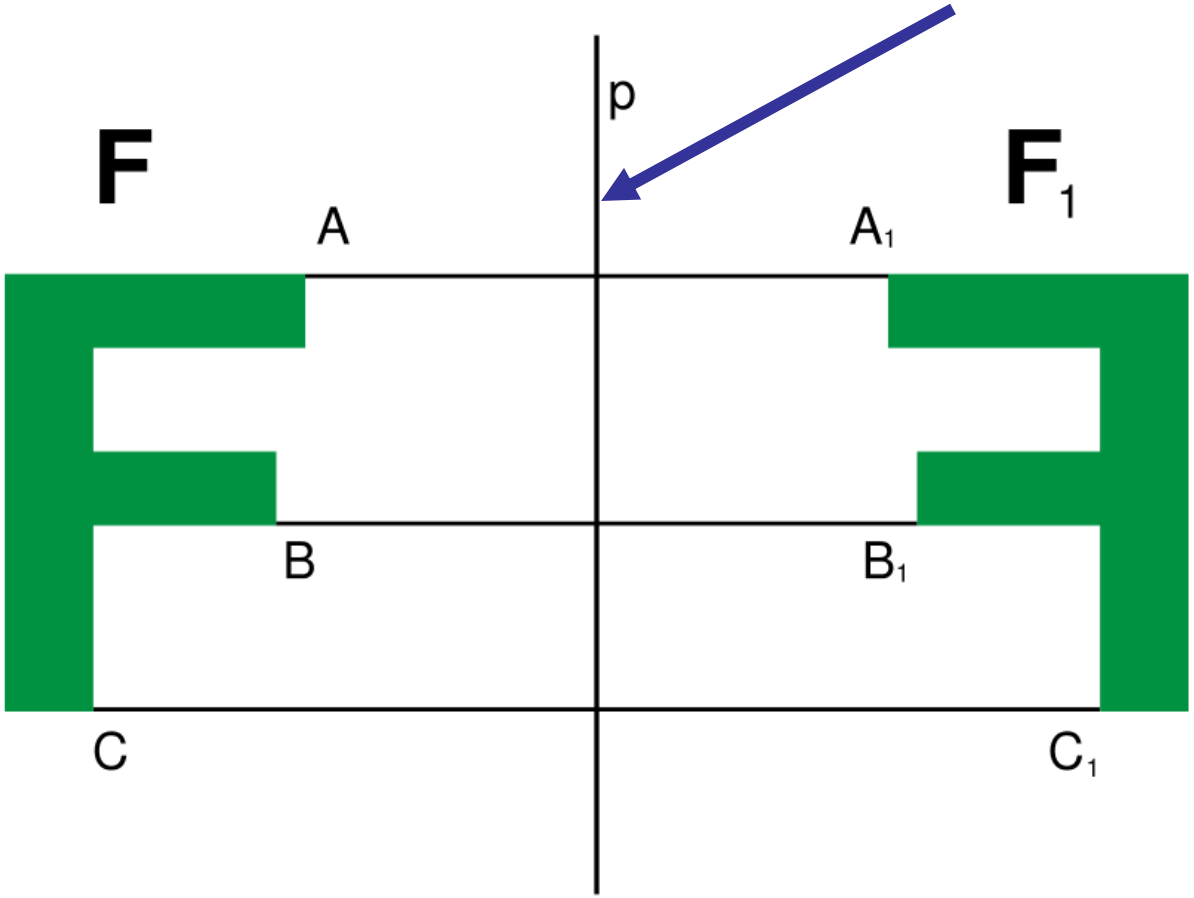


Translation Symmetry



Glide-Reflection Symmetry

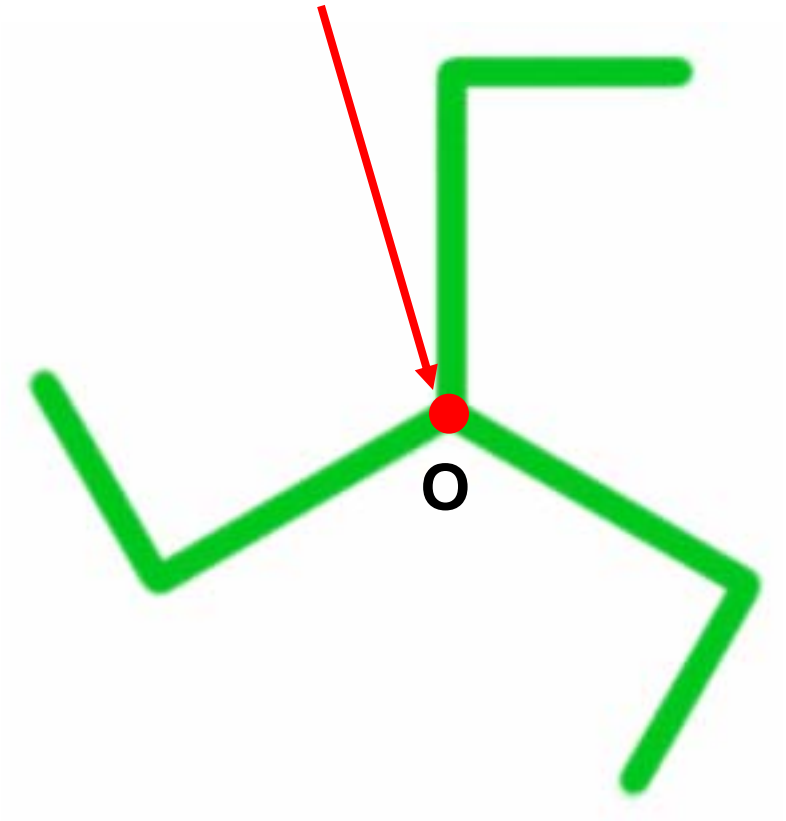
Reflection
invariance = the reflection axis p



With respect to an axis of reflection symmetry

Rotation

invariance: the center of rotation O

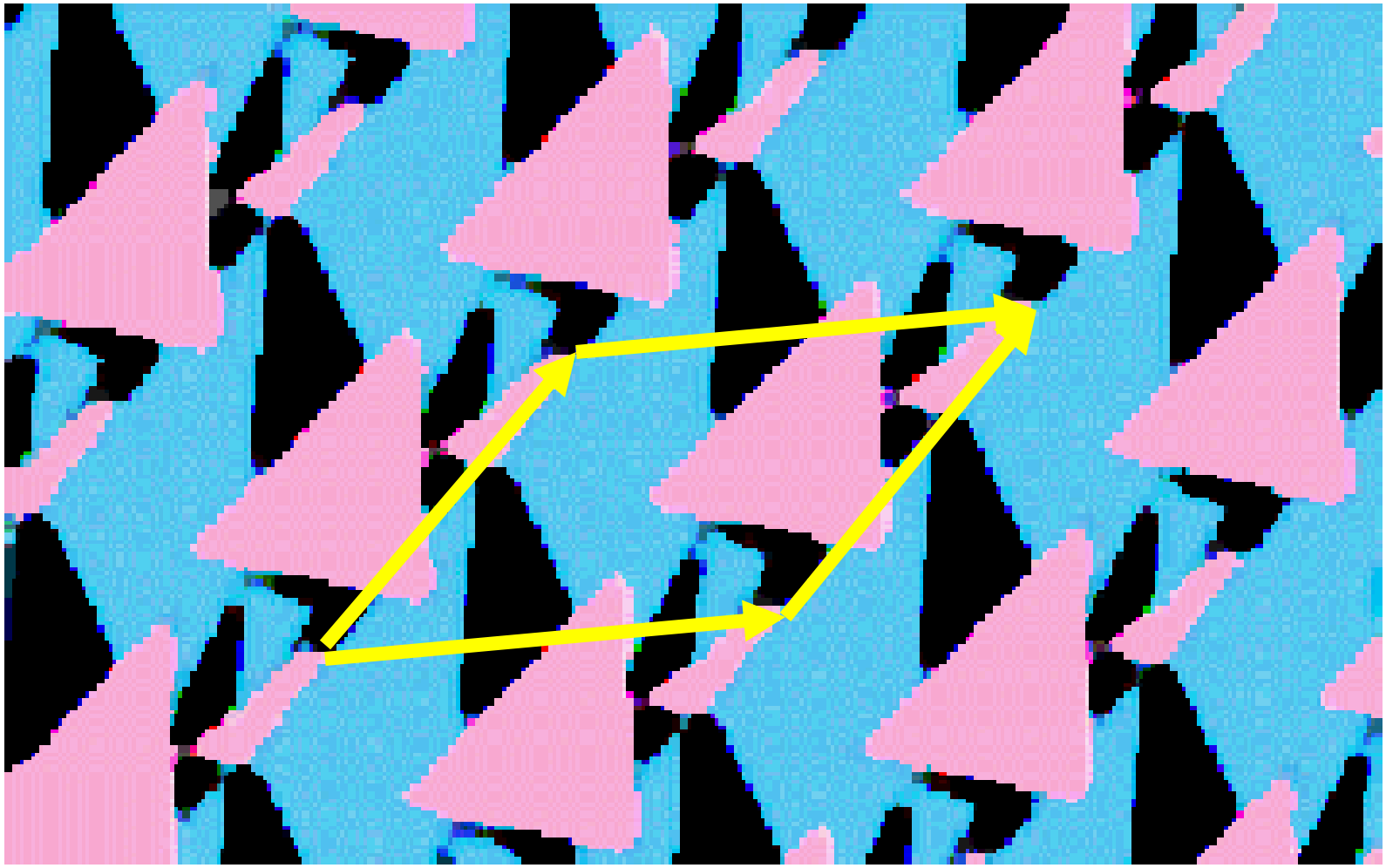


N-fold rotational symmetry:

Rotational symmetry of order *n*, also called *n*-fold rotational symmetry, or discrete rotational symmetry of the nth order, with respect to a particular point (in 2D) or axis (in 3D) means that rotation by an angle of 360° /n does not change the object as a whole.

Translation

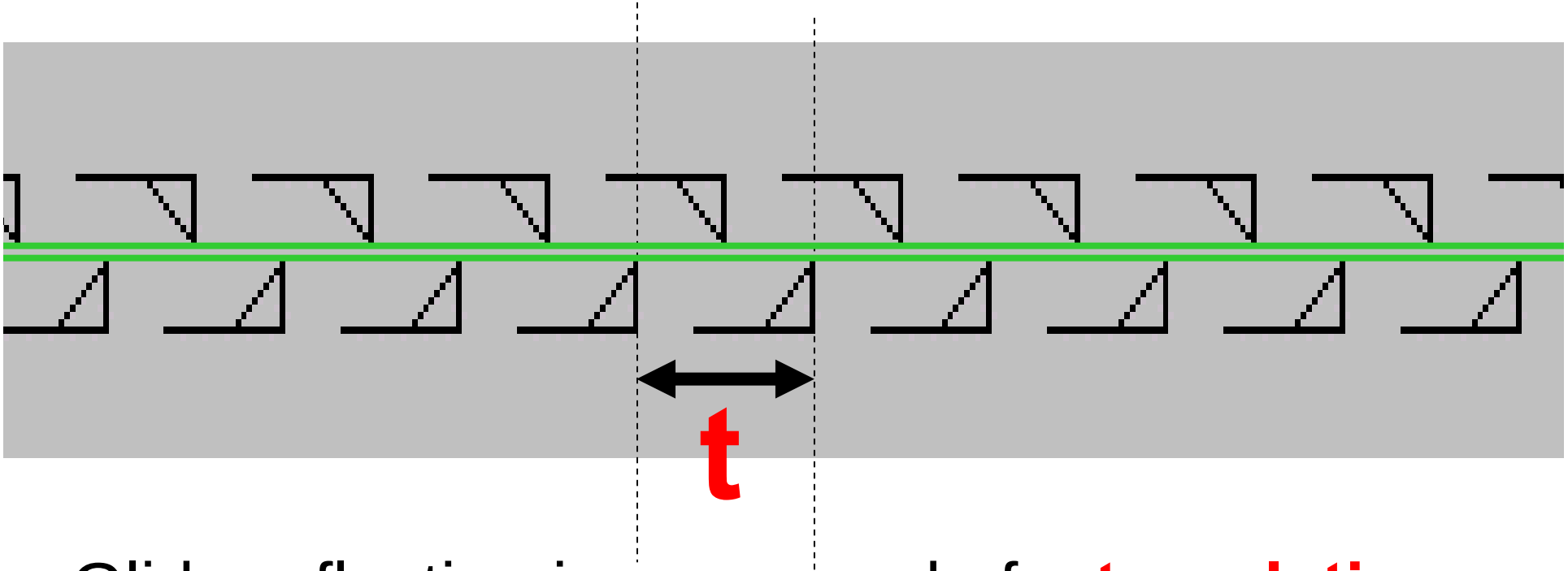
Invariance = invariant points = **none**



(**where g(S) = S, S expands the 2D plane**)

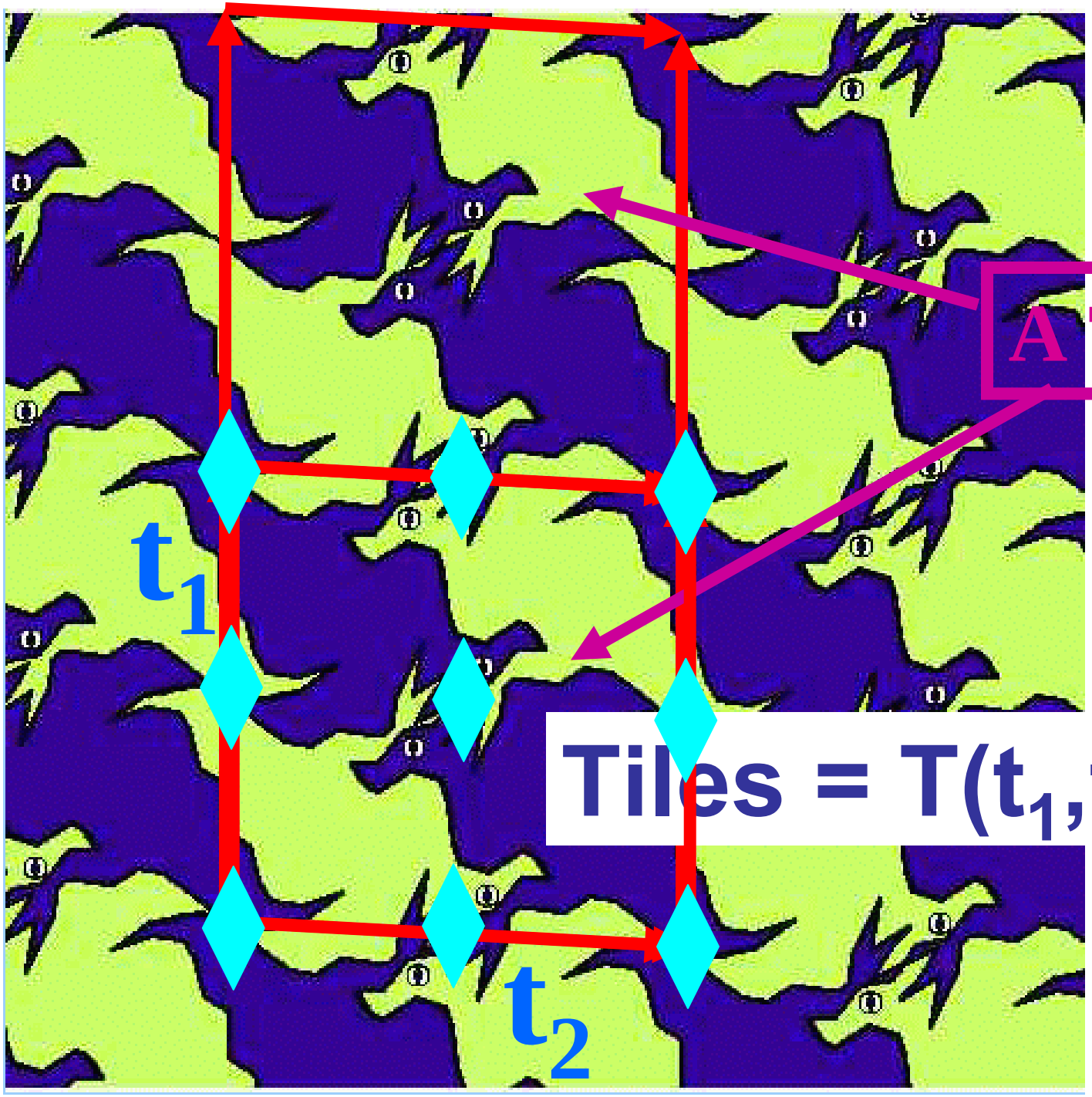
Glide-reflection

Invariance = invariant points = **none**



Glide reflection is composed of **a translation** that is ½ of the smallest translation symmetry **t** and **a reflection r** w.r.t. a reflection axis along the direction of the translation

Wallpaper Pattern



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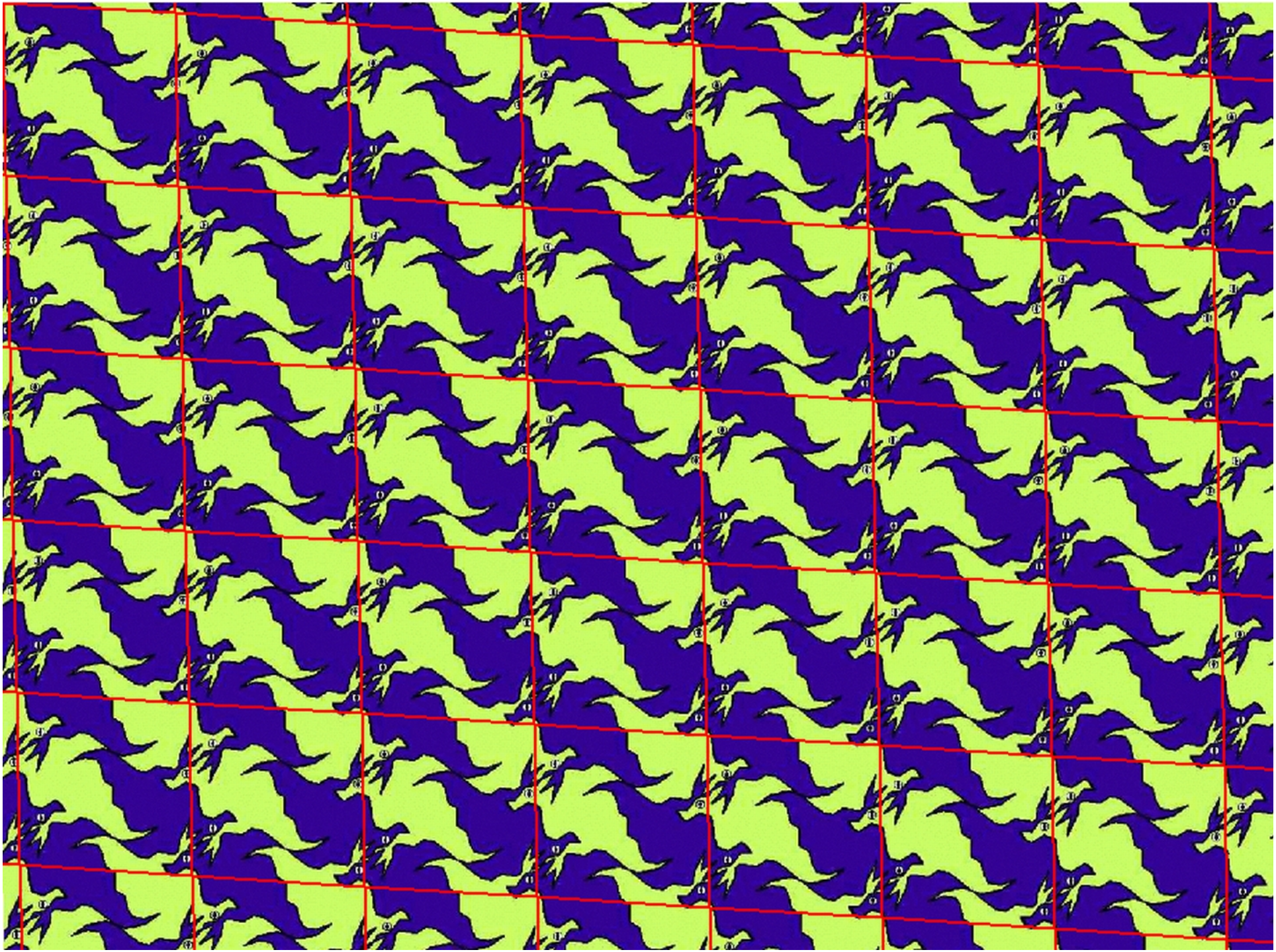
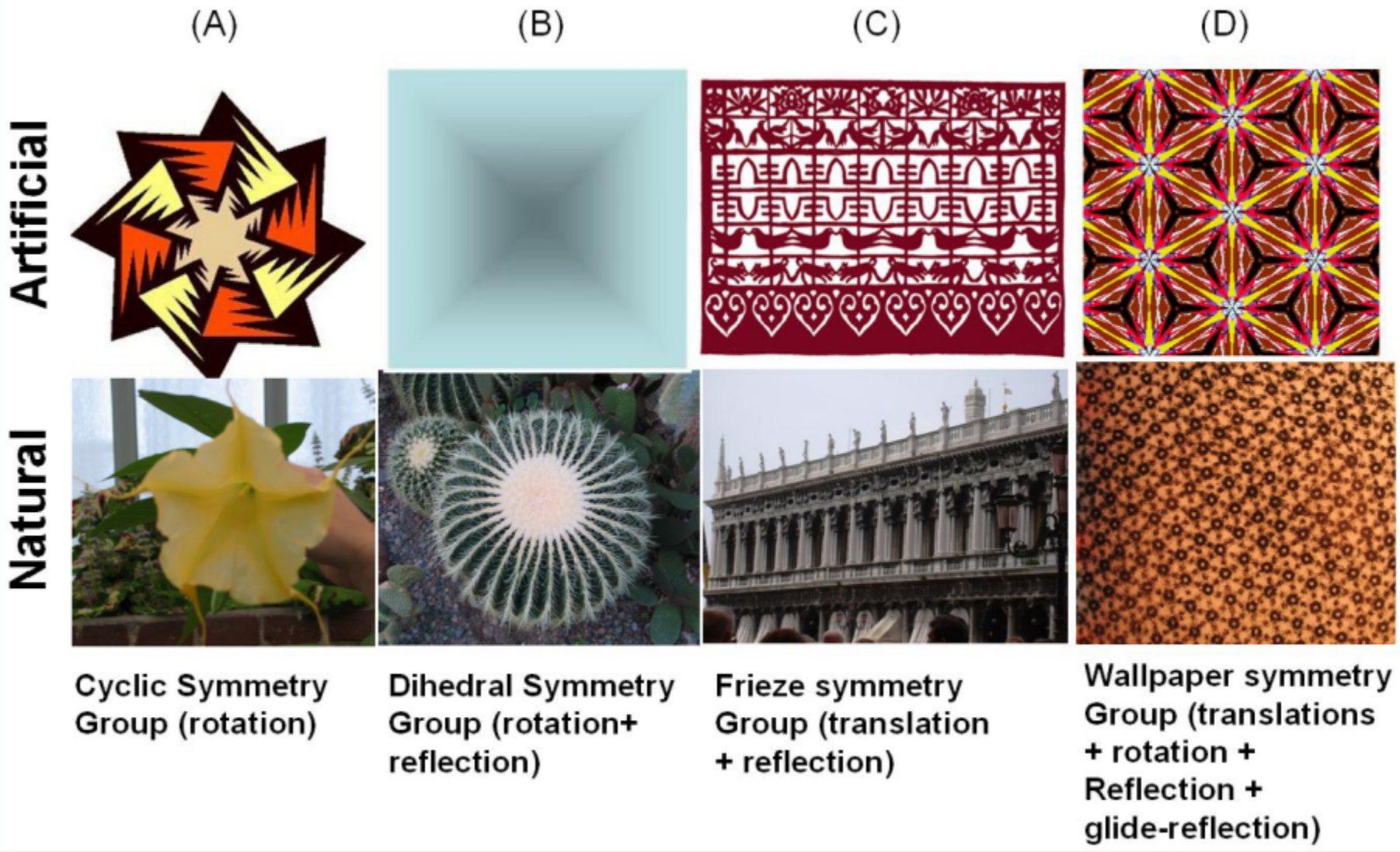


Four Types of Symmetry Groups in 2D Euclidean Space



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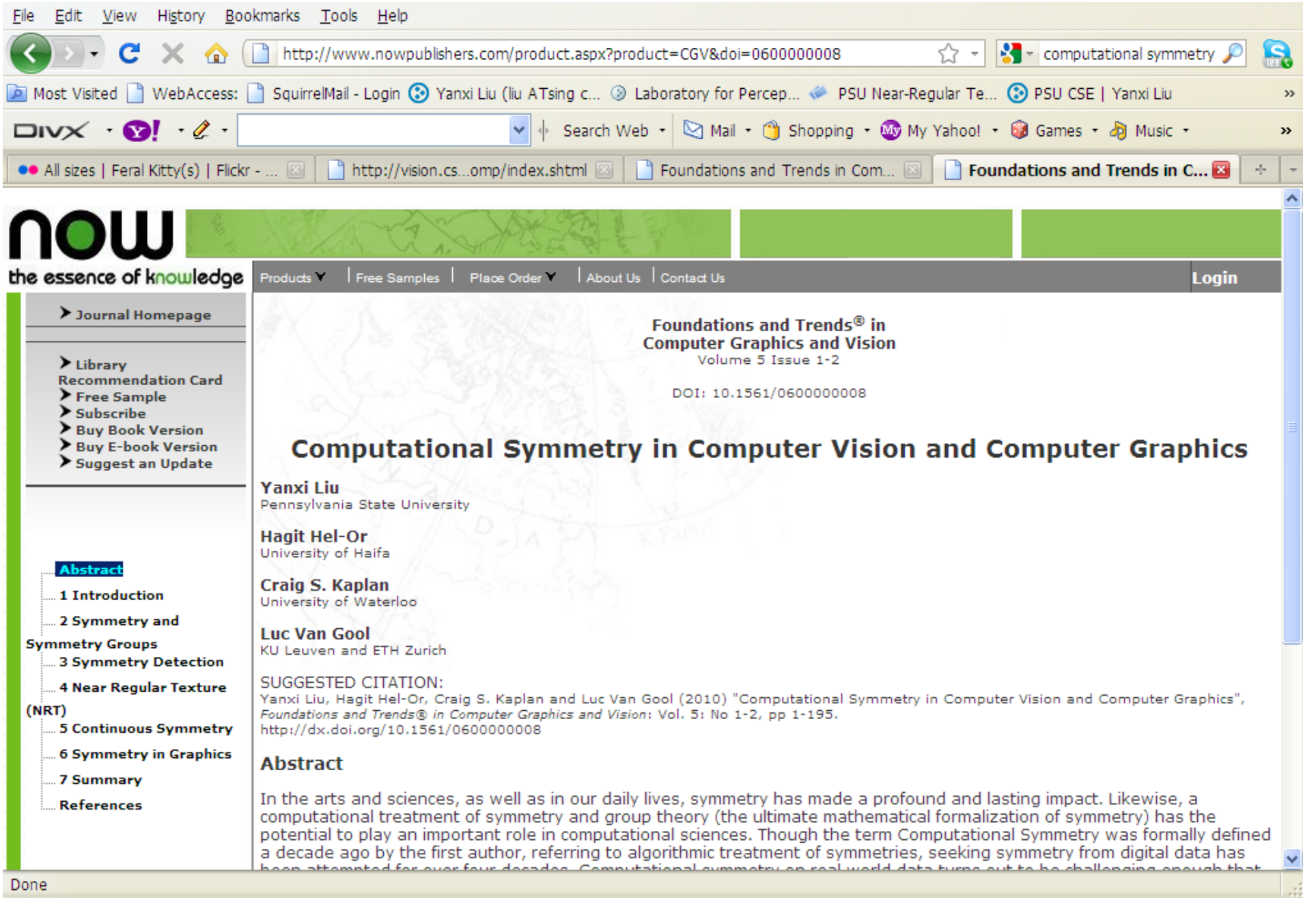
- there is a diverse set of types of symmetries
- It plays a crucial role in **intermediate-level vision** – across object class, modality, and scale …

Why “Symmetry detection”?

- A historical perspective …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1 Introduction
2 Symmetry and Symmetry Groups
3 Symmetry Detection
4 Near Regular Texture (NRT)
5 Continuous Symmetry
6 Symmetry in Graphics
7 Summary
References
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Volume 5 Issue 1-2
DOI: 10.1561/0600000008
Computational Symmetry in Computer Vision and Computer Graphics
Yanxi Liu
Pennsylvania State University
Hagit Hel-Or
University of Haifa
Craig S. Kaplan
University of Waterloo
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http://dx.doi.org/10.1561/0600000008
Abstract
In the arts and sciences, as well as in our daily lives, symmetry has made a profound and lasting impact. Likewise, a computational treatment of symmetry and group theory (the ultimate mathematical formalization of symmetry) has the potential to play an important role in computational sciences. Though the term Computational Symmetry was formally defined a decade ago by the first author, referring to algorithmic treatment of symmetries, seeking symmetry from digital data has
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Computational Symmetry in Computer Vision and Computer Graphics

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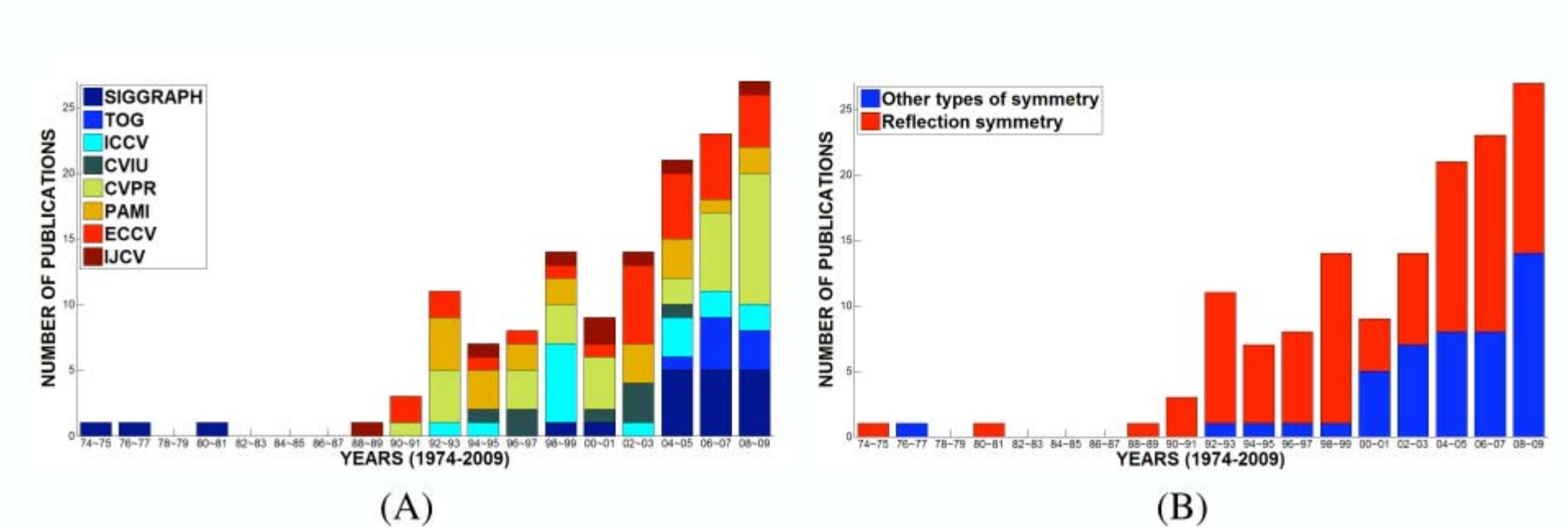
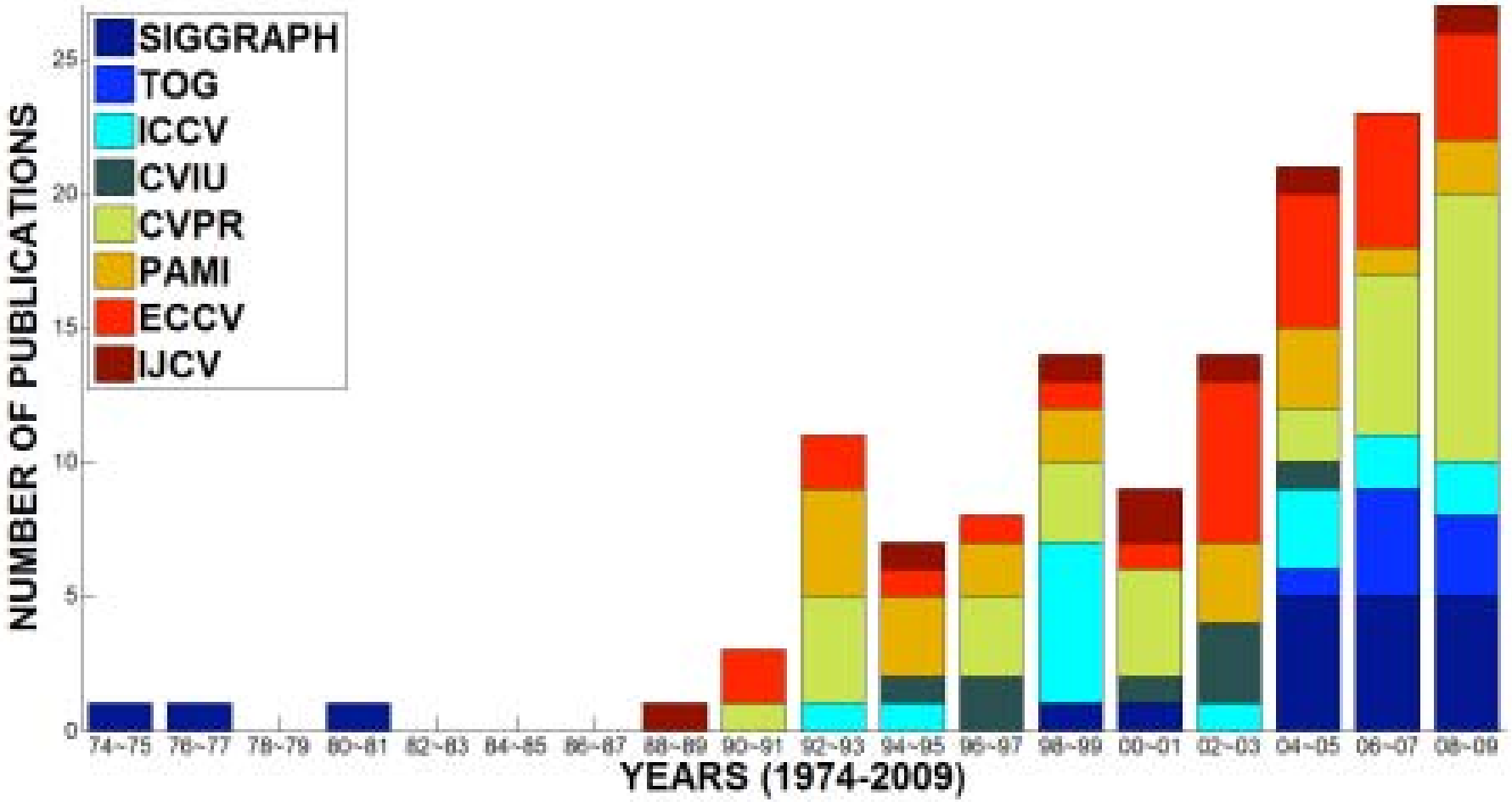
Statistics of Symmetry Detection Papers in Computer Vision and Computer Graphics (36 years)

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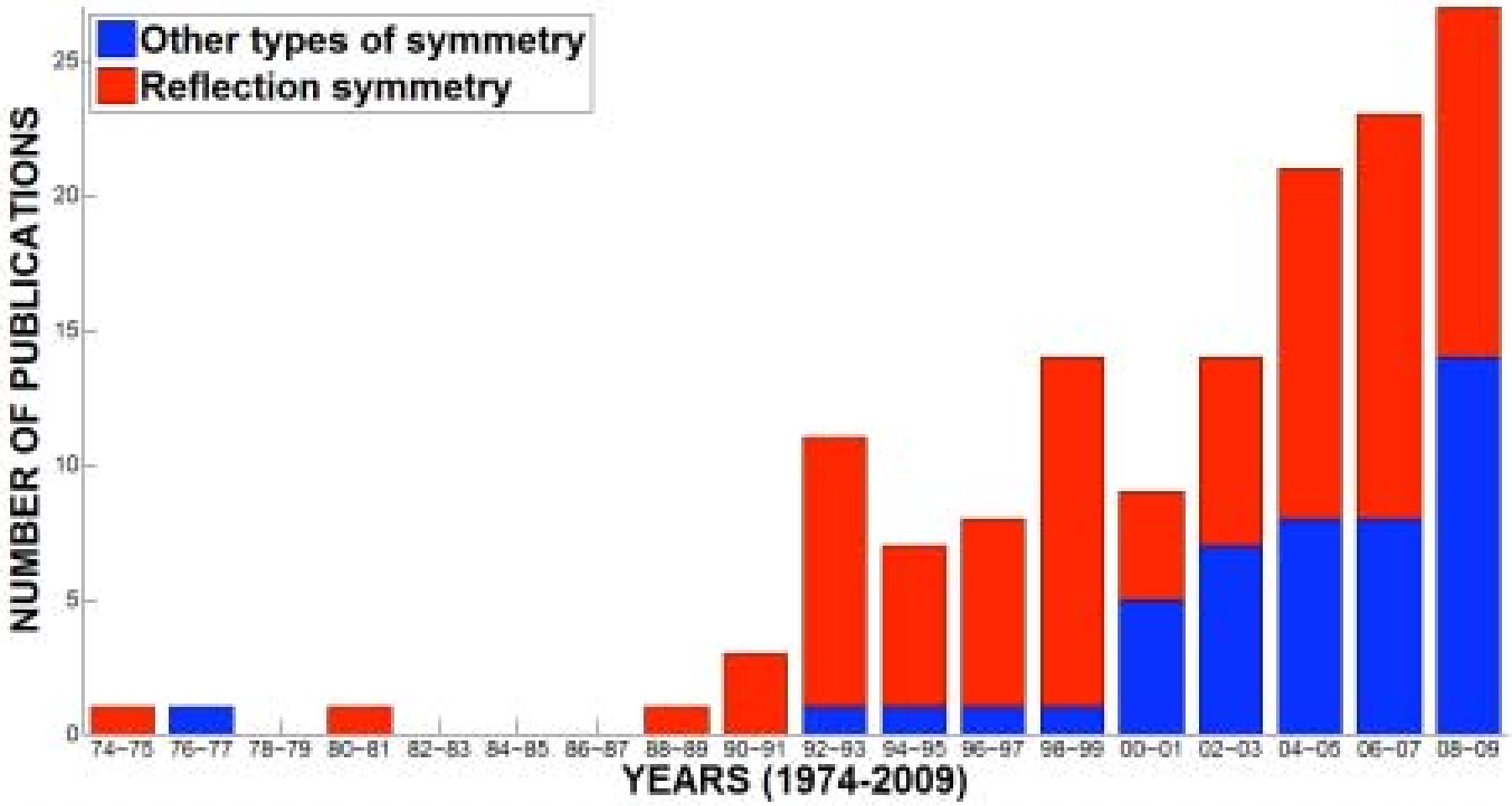
YEARS (1974-2009)

(A)


Other types of symmetry
Reflection symmetry
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06–07
08–09
YEARS (1974-2009)

(B)

Why “real world images”?

A turning point …

- G. Loy and J. Eklundh. Detecting symmetry and symmetridc constellations of features. In European Conference on Computer Vision (ECCV'04), Part II, LNCS 3952, pages 508,521, May 2006.
- V. Prasad and L. Davis. Detection rotational symmetries. In IEEE International
- Conference on Computer Vision (ICCV), pages 346–352, 2005.

SIGGRAPH 2005
Liu, Hays, Xu, Shum

(1) reflection symmetry group detection [17]: multiple symmetry axes of local regions are detected one-by-one.

ECCV06 Loy & Eklundh

(2) reflection (left) and rotation (right) symmetry detection [19] Top row: input images.

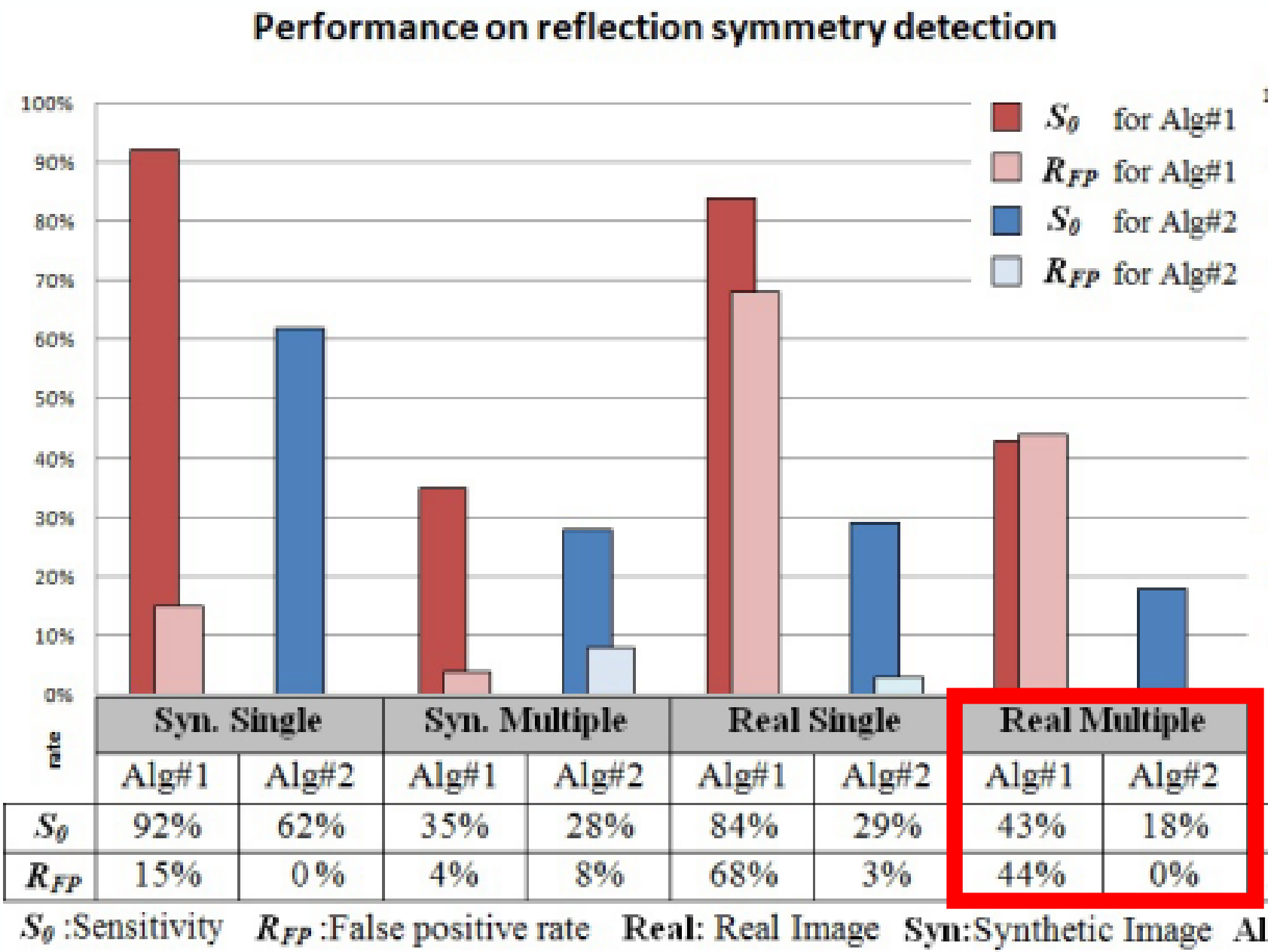
ICCV05 Prasad & Davis

(3) rotation symmetry detection [25].

Previous Evaluations

- **Performance Evaluation of State-of-the-Art Discrete Symmetry Detection Algorithms**
  Minwoo Park, Seungkyu Lee, Po-Chun Chen, Somesh Kashyap, Asad A. Butt and Yanxi Liu
  Computer Vision and Pattern Recognition Conference (CVPR '08)
- **A Quantitative Evaluation of Symmetry Detection Algorithms**
  P. Chen and J.H. Hays and Seungkyu Lee and Minwoo Park and Yanxi Liu
  CMU-RI-TR-07-36, Robotics Institute, CMU

  PSU-CSE-07-011, CSE, PSU 2007



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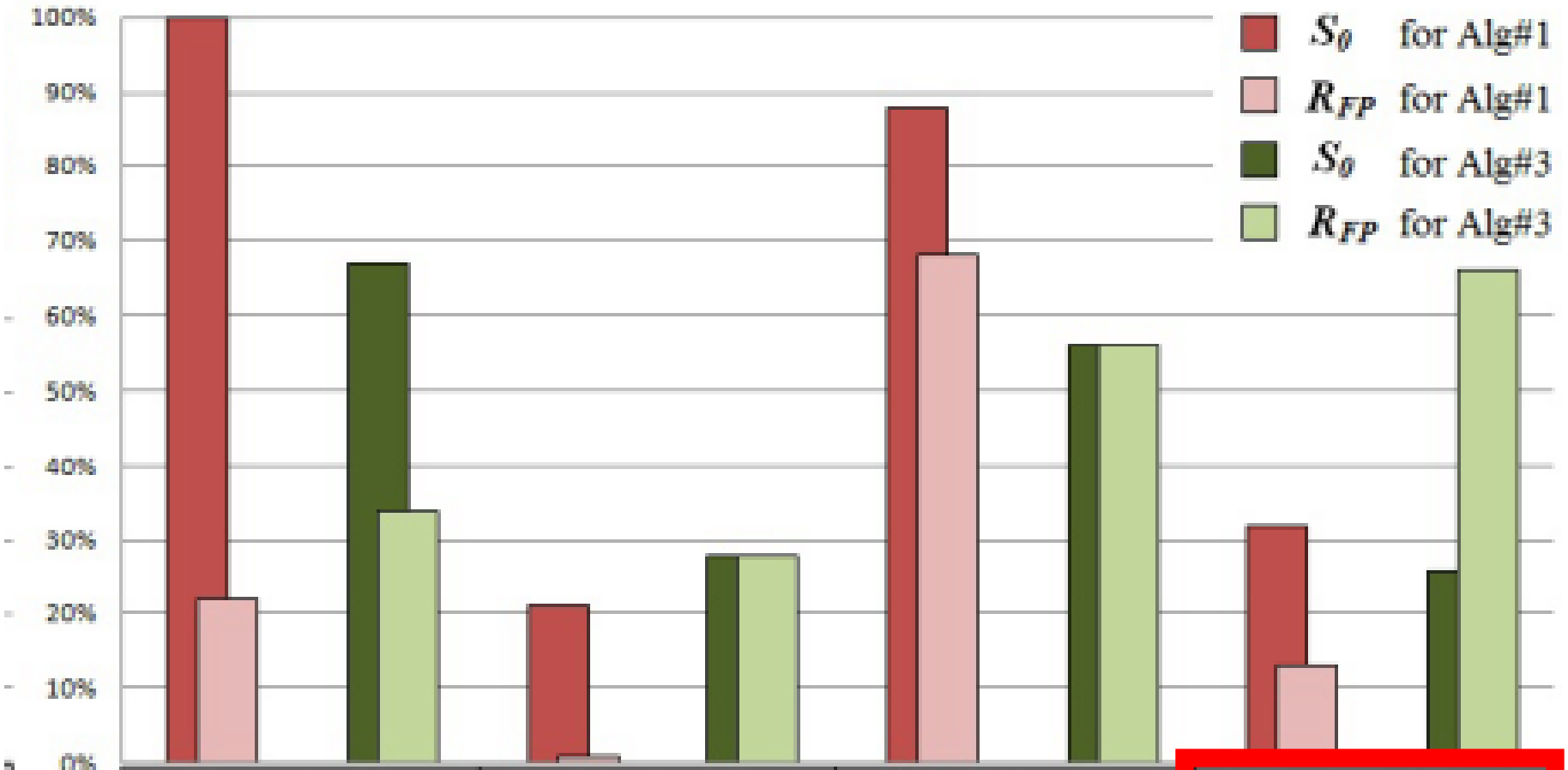
	Alg#1	Alg#2	Alg#1	Alg#2	Alg#1	Alg#2	Alg#1	Alg#2
S_θ	92%	62%	35%	28%	84%	29%	43%	18%
R_{FP}	15%	0%	4%	8%	68%	3%	44%	0%

S_θ :Sensitivity R_{FP} :False positive rate **Real**: Real Image **Syn**:Synthetic Image **Al**

Figure 4. The pairwise reflection and rotation symmetry detection algo

Performance on rotation symmetry detection



rate	Syn. Single		Syn. Multiple		Real Single		Real Multiple	
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S_θ	100%	67%	21%	28%	88%	56%	32%	26%
R_{FP}	22%	34%	1%	28%	68%	56%	13%	66%

Alg#1: Loy and Eklundh 2006 **Alg#2**:Liu.et al. 2005 **Alg#3**: Prasad and Davis 2005

A Fun and Exciting Program

AM

Competition Details (reflection/rotation) --- Ingmar Rauschert

Top winners presentations:

Detecting Bilateral Symmetry with Feature Mirror

Mo and Draper

Multi-Scale Kernel Operators for Reflection and Rotation Symmetry

Kondra and Petrosino

Symmetry-growing for skewed rotational symmetry detection

Kim, Cho and Lee

A Fun Full-day Program

AM

PANEL on **Symmetry-based Object Recognition, Segmentation and 3D Reconstruction**

Symmetric Parts and Their Role in Object Recognition

Sven Dickinson

Symmetry-integrated Image Segmentation

Bir Bhanu and **Yu Sun**

New Addition: Symmetric Piecewise Planar Object Reconstruction from a Single Image

Xue, Liu, Tang, The Chinese Univ. Of HK

PM starting at 1:30

Competition Details on Translation Symmetry Detection

Ingmar Rauschert

Panel on Urban Scene Analysis

Translational and reflection symmetry for detection of salient repeating regions in urban scenes

Changchang Wu, Jan-Michael Frahm and Marc Pollefeys

Image-based Facade Modeling and Symmetry Detection

Long Quan

Parsing Facade Images using Reinforcement Learning

Iasonas Kokkinos and Nikos Paragios

Discussion

4:00pm Summary and Conclusion Yanxi Liu