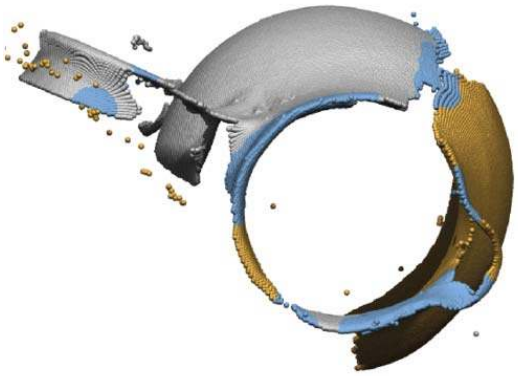
4-Points Congruent Sets for Robust Pairwise Surface Registration

SIGGRAPH2008

Dror Aiger Niloy J. Mitra Daniel Cohen-Or



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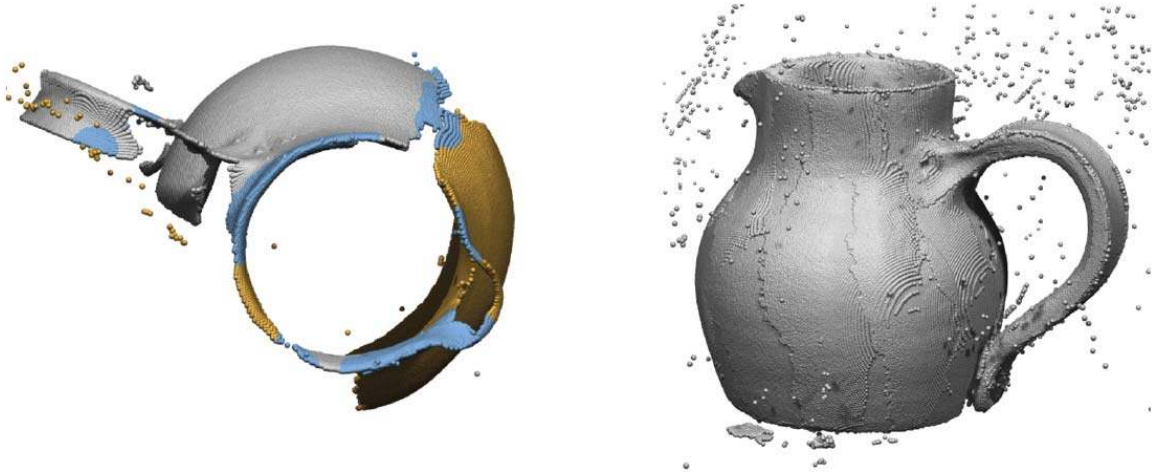

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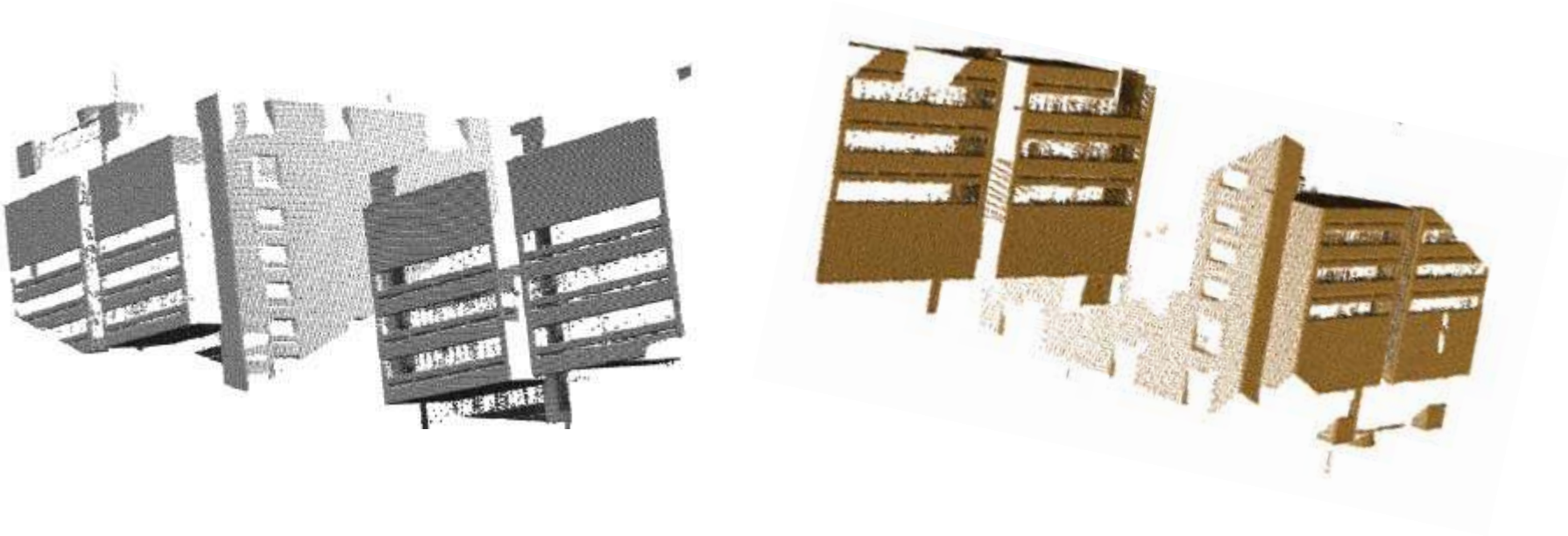
Problem Statement

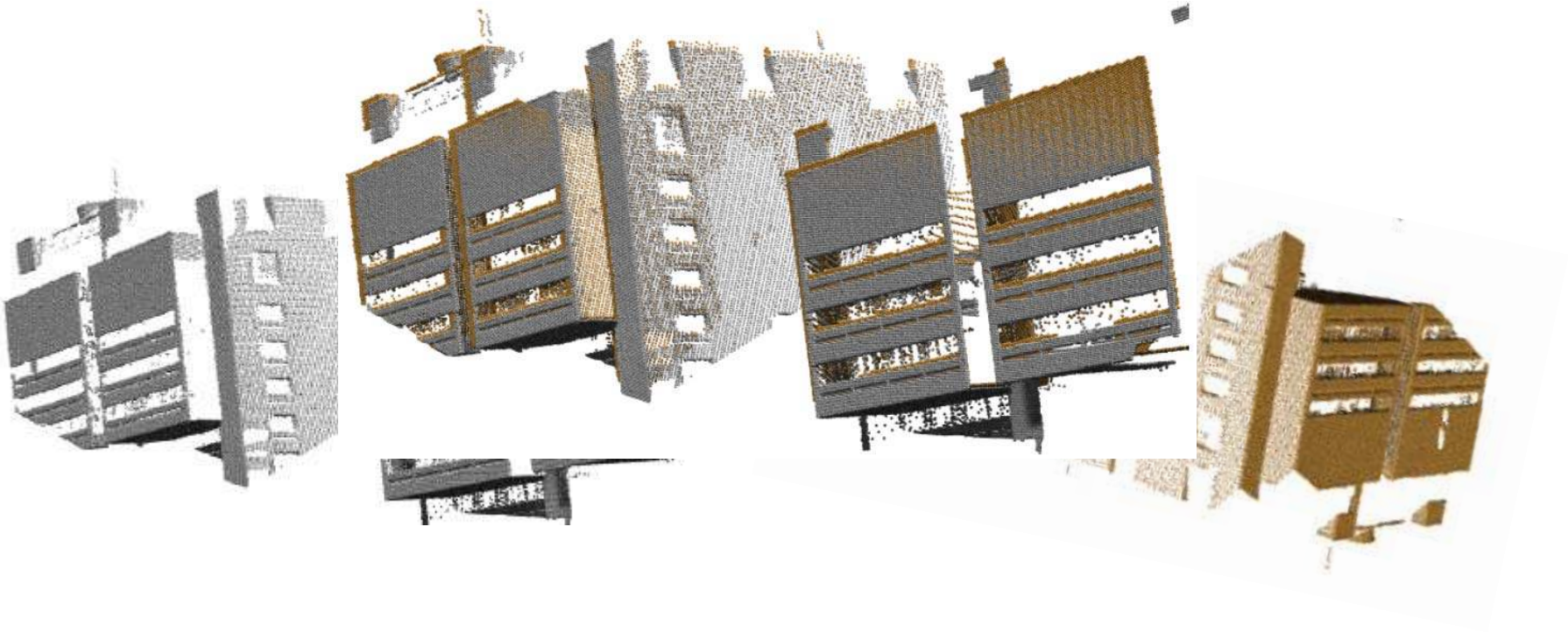
Given: Two models (P and Q)

- corrupted with noise and outliers
- in *arbitrary initial* poses



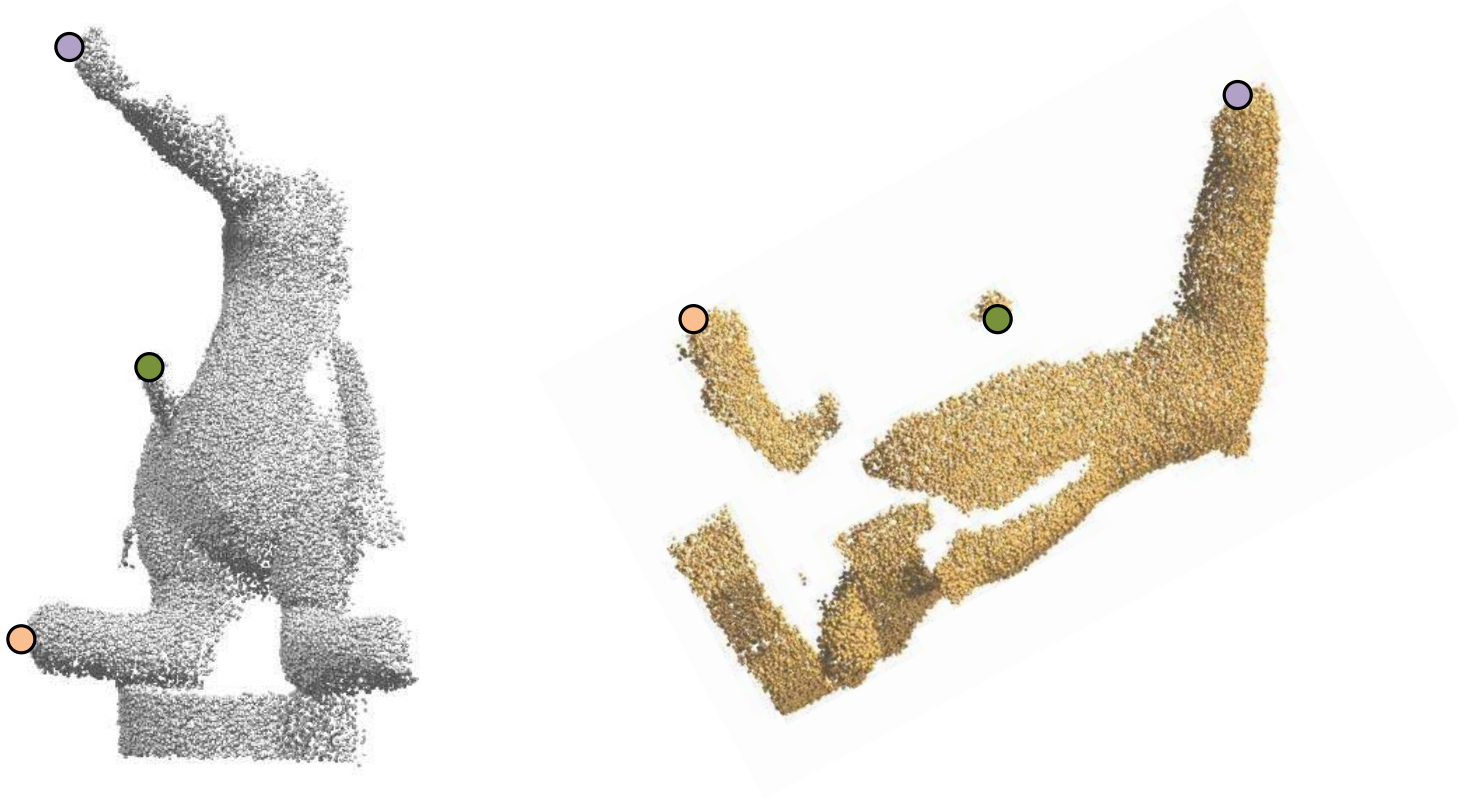
Problem Statement

Goal: *Automatically* align the models



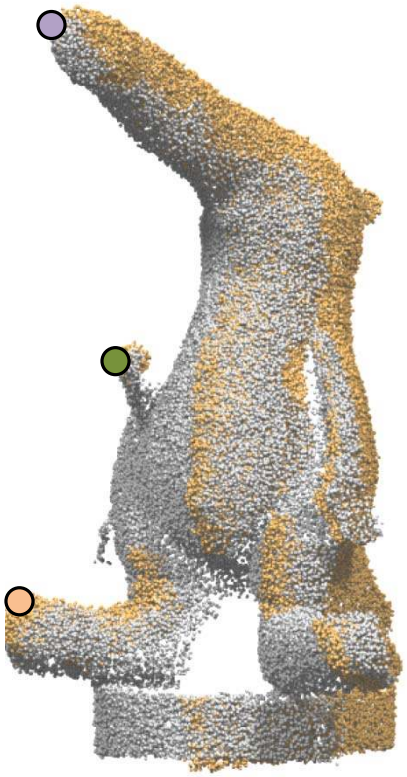
Aligning with Feature Points

Aligning with Feature Points



3 corresponding point-pairs ! solve for aligning rigid transform

Aligning with Feature Points



Data + *holes + outliers + noise* ! *unreliable* feature points (FP)

Why not De-noise Scans?

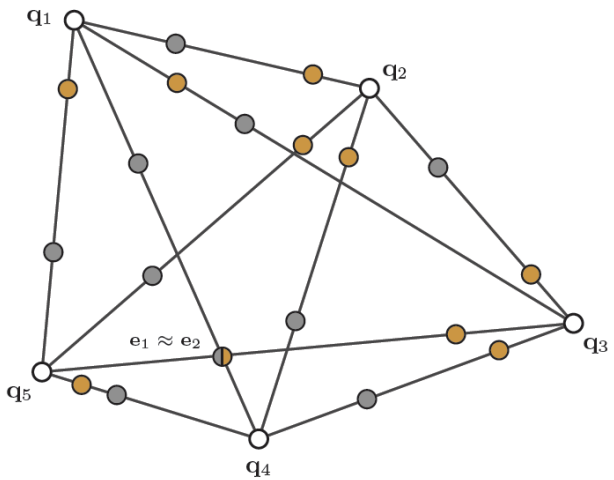
de-noise,
compute FP-s,
align

align with 4PCS,
de-noise

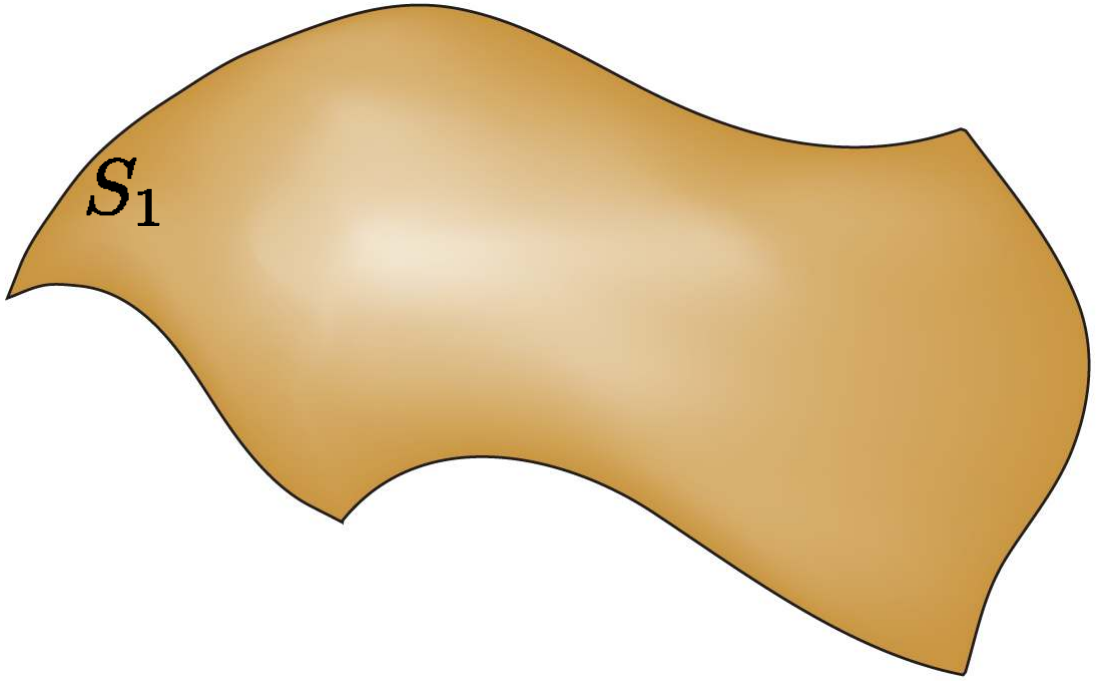
Insight #1

A pair of triples (from *P* and Q) is enough to uniquely define a ***rigid transform*** ! $O(n^3)$

Surprisingly, a *special* set of 4-points, ***congruent sets***, makes problem simpler ! $O(n^2)$



Affine Invariance



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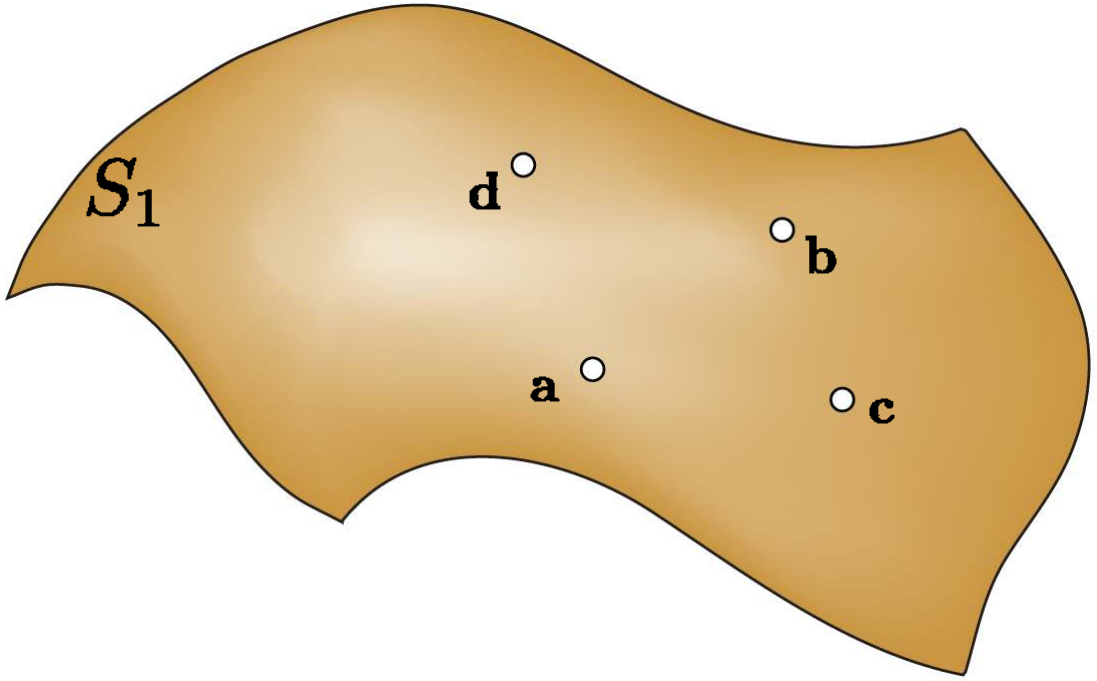

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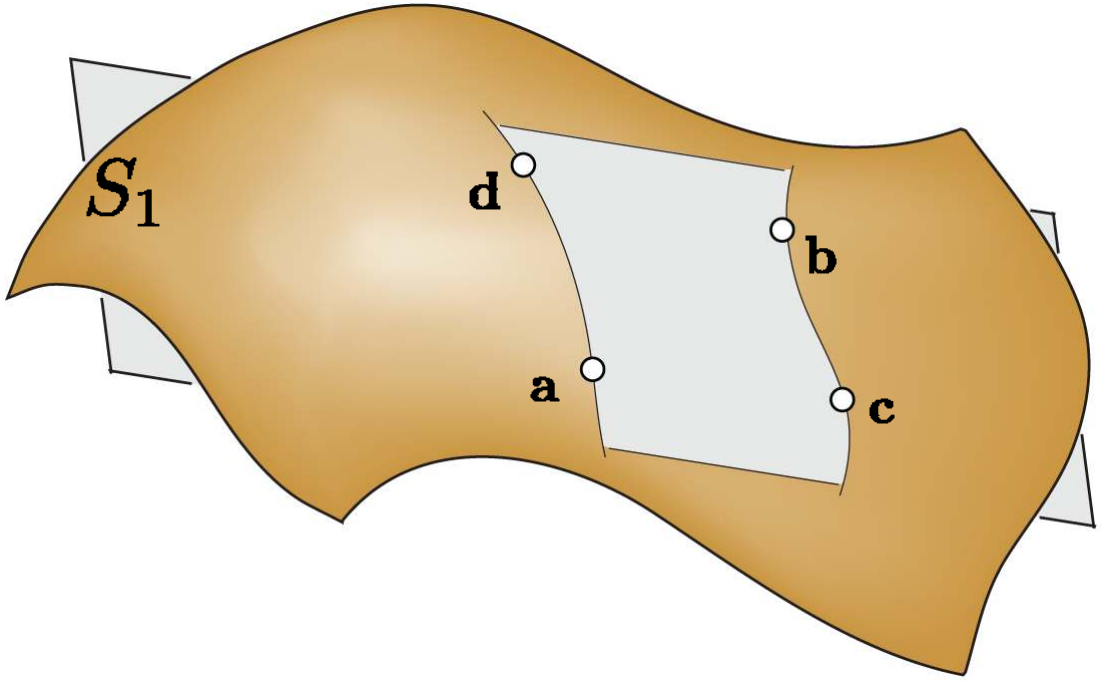
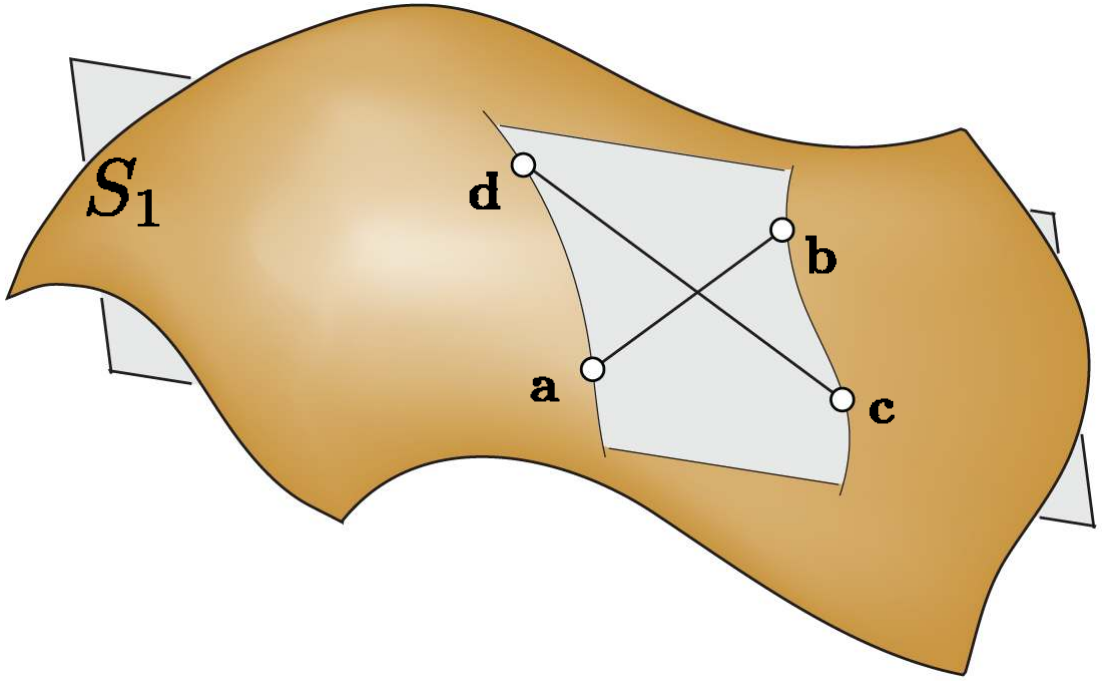
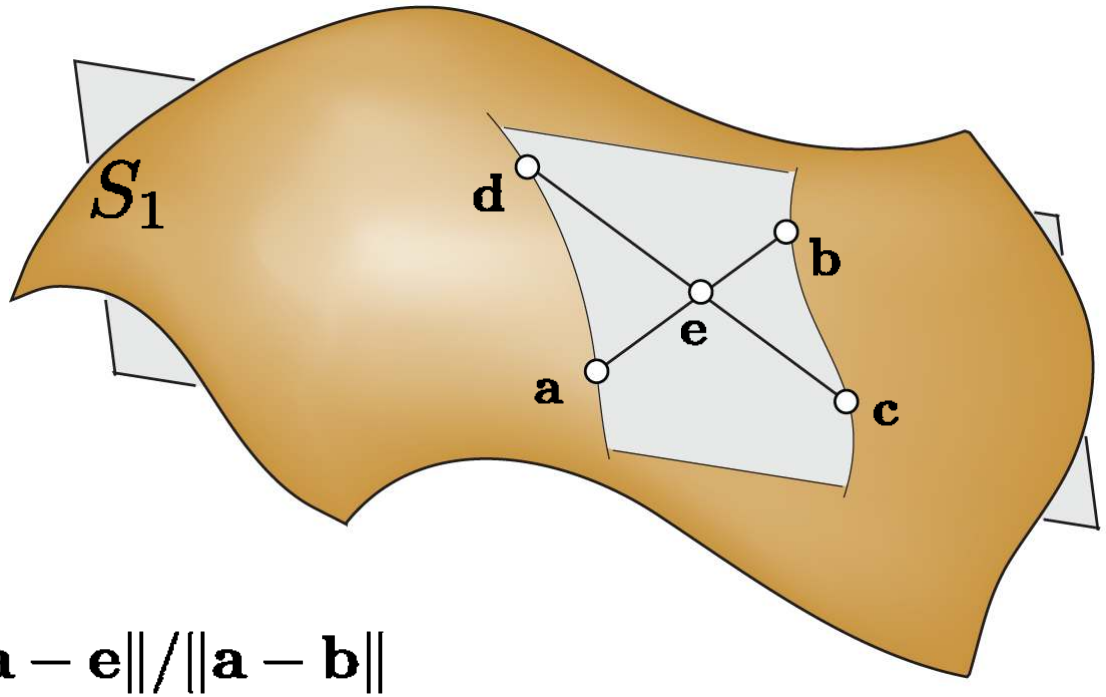


4 coplanar points

Affine Invariance



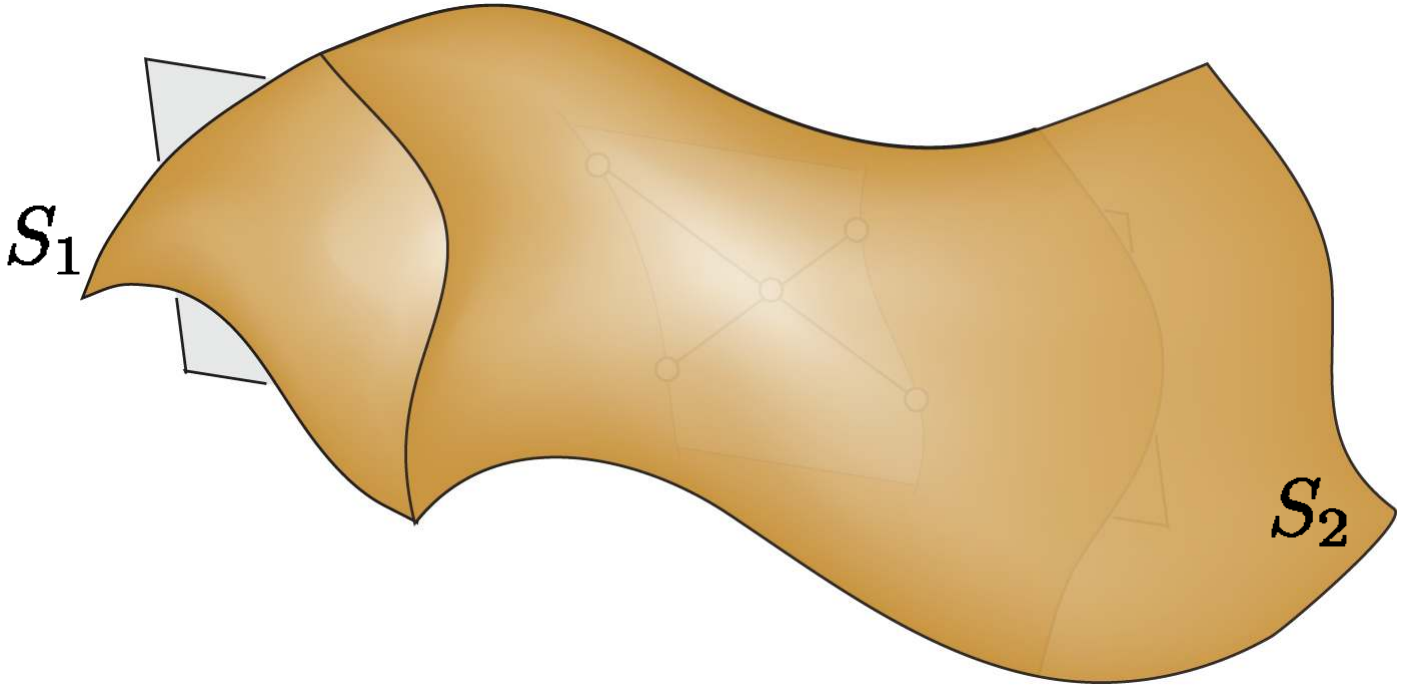
Affine Invariance



$$r_1 = \|\mathbf{a} - \mathbf{e}\| / \|\mathbf{a} - \mathbf{b}\|$$

$$r_2 = \|\mathbf{c} - \mathbf{e}\| / \|\mathbf{c} - \mathbf{d}\|$$

Affine Invariance



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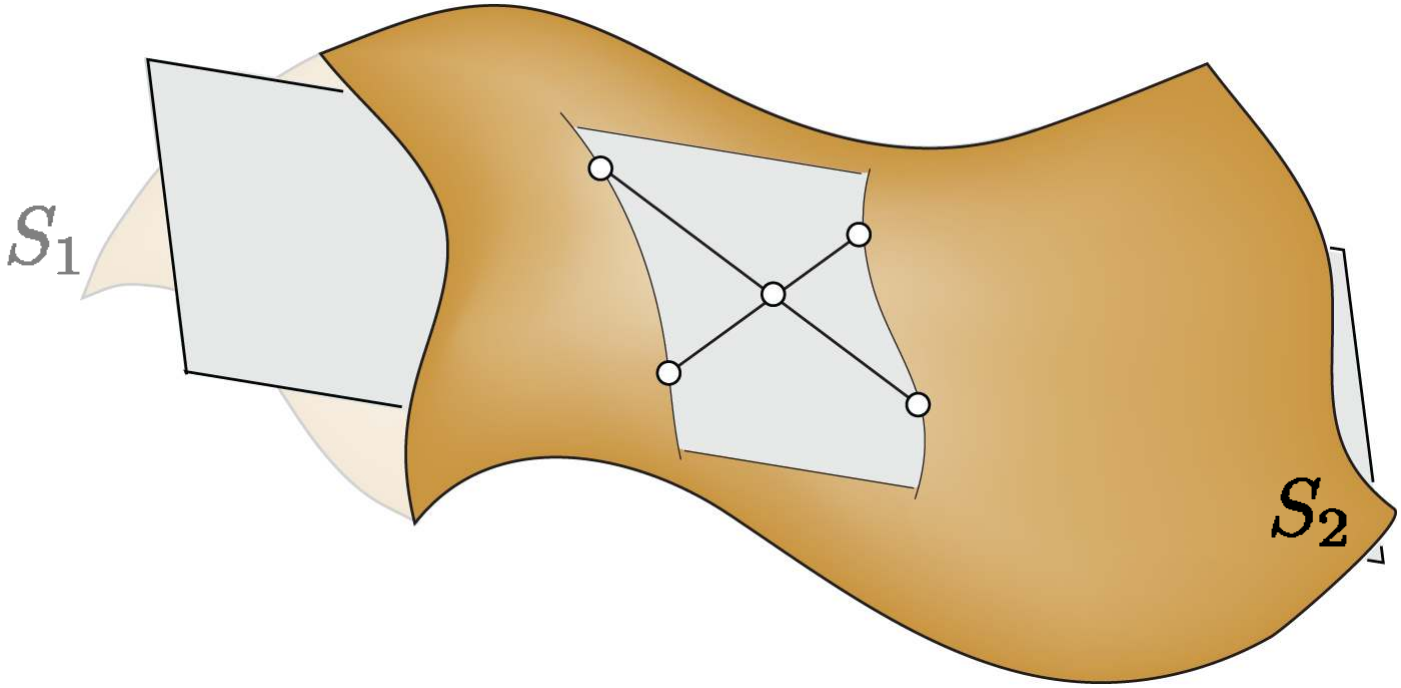

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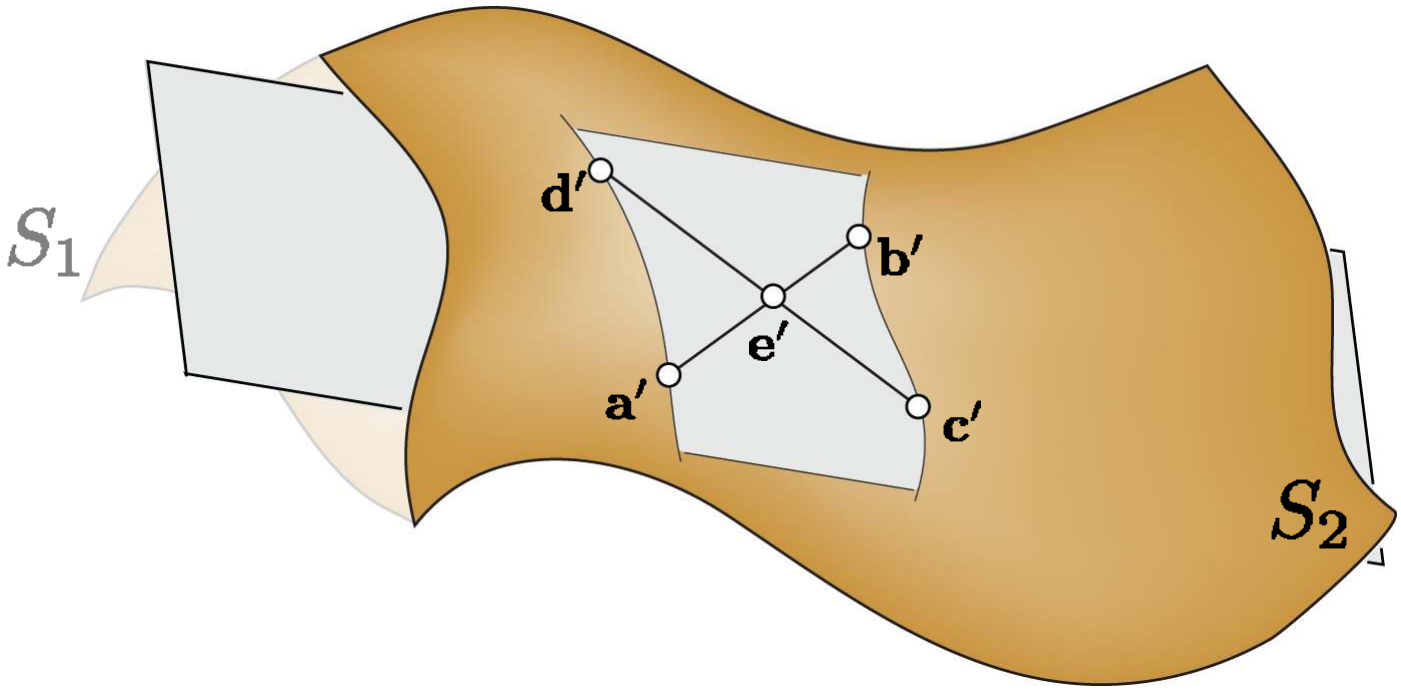
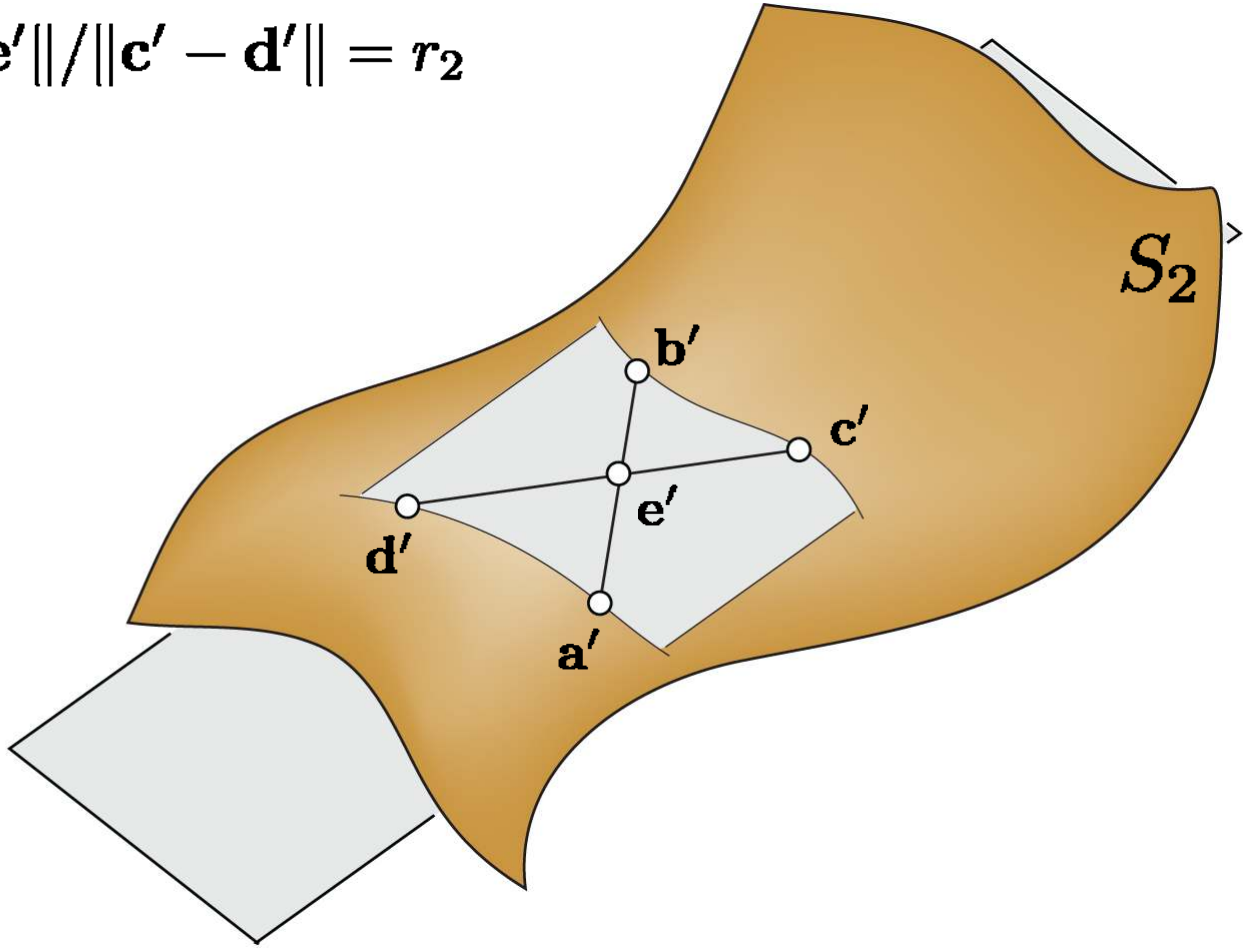


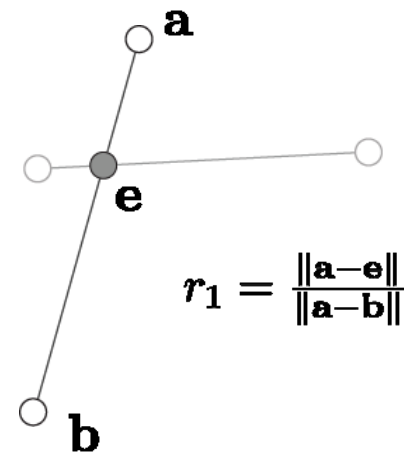
Affine Invariance

$$\|\mathbf{a}' - \mathbf{e}'\| / \|\mathbf{a}' - \mathbf{b}'\| = r_1$$

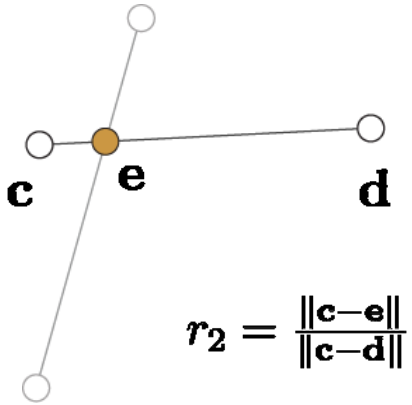
$$\|\mathbf{c}' - \mathbf{e}'\| / \|\mathbf{c}' - \mathbf{d}'\| = r_2$$



Extracting Congruent 4-points

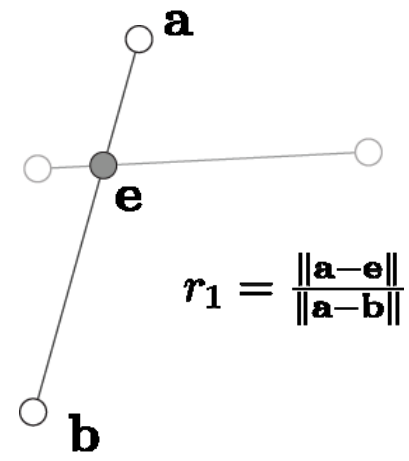


$$r_1 = \frac{\|\mathbf{a}-\mathbf{e}\|}{\|\mathbf{a}-\mathbf{b}\|}$$



$$r_2 = \frac{\|\mathbf{c}-\mathbf{e}\|}{\|\mathbf{c}-\mathbf{d}\|}$$

Extracting Congruent 4-points



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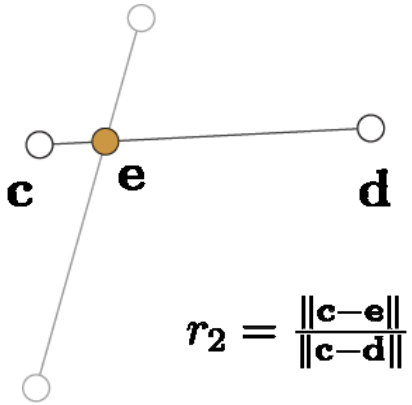

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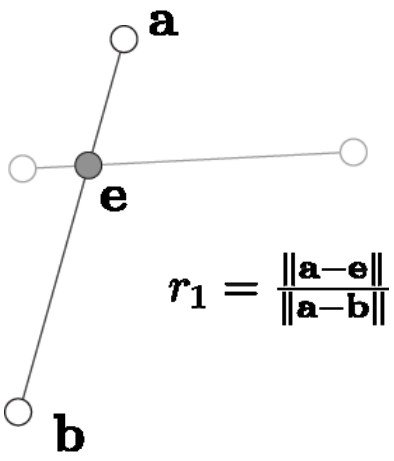

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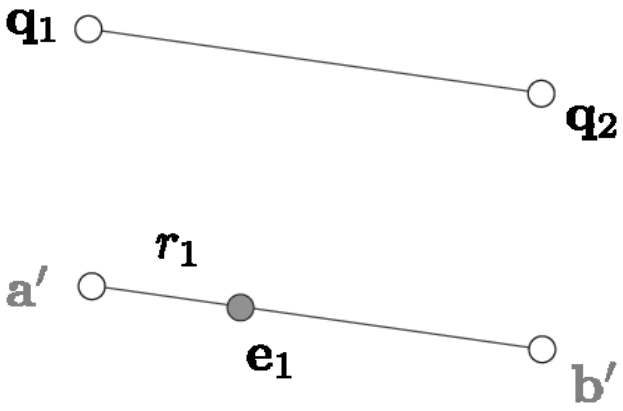

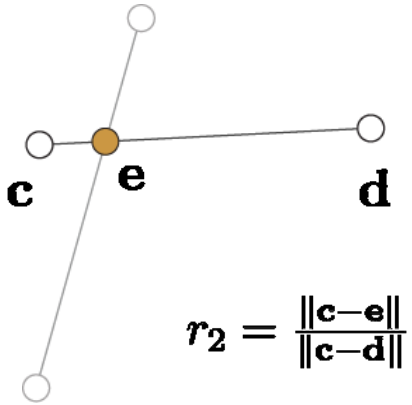

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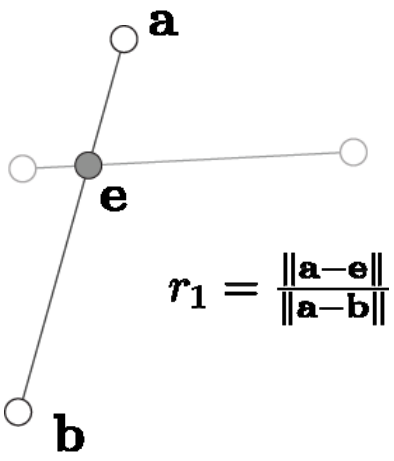

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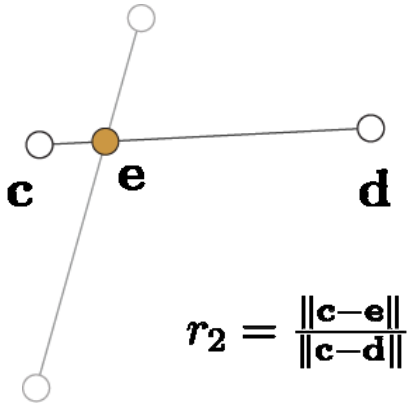

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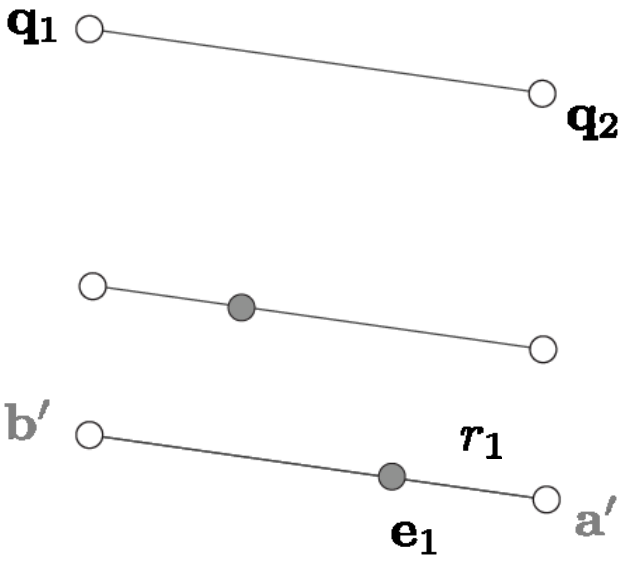

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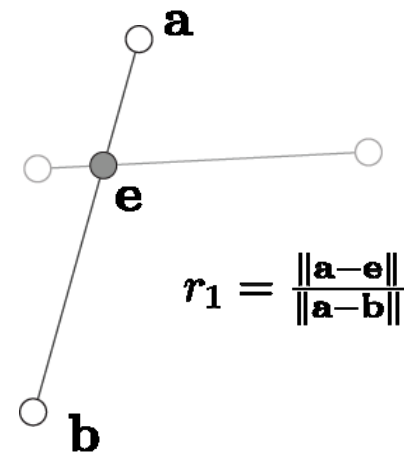
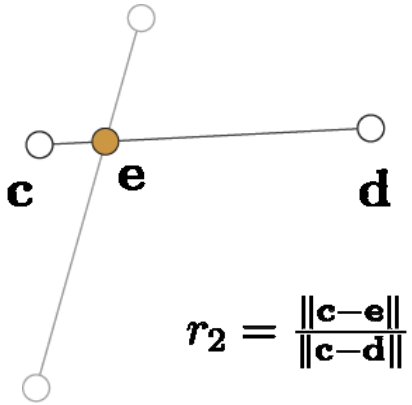
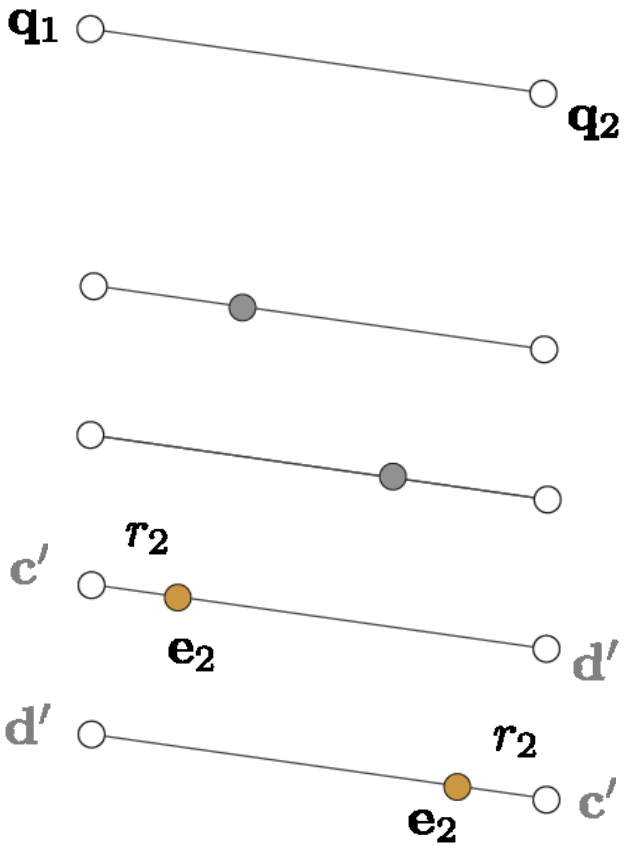
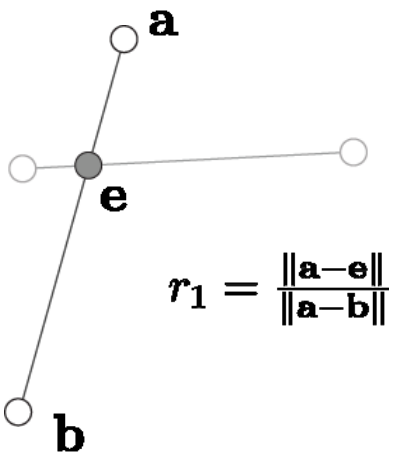






What if $\mathbf{e}_1 \neq \mathbf{e}_2$?



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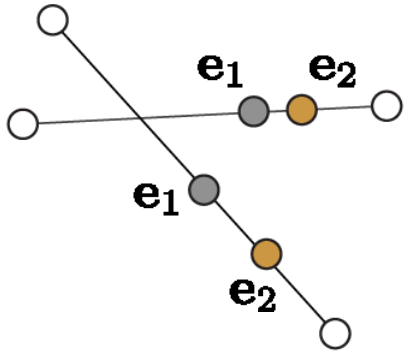
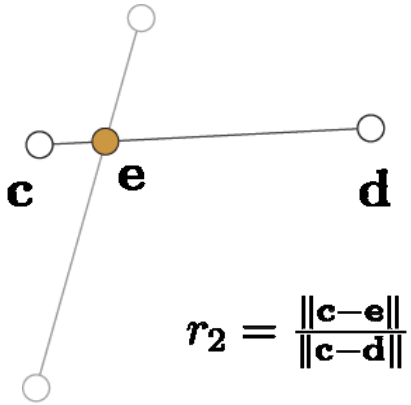
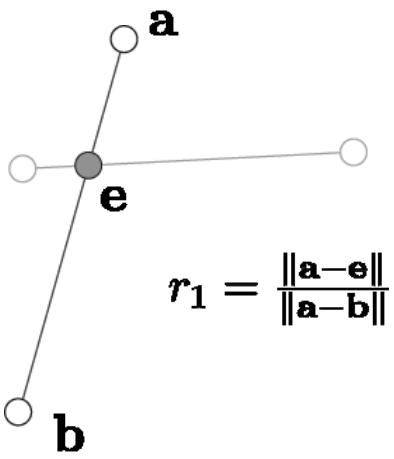


typical scenario



$$r_2 = \frac{\|\mathbf{c}-\mathbf{e}\|}{\|\mathbf{c}-\mathbf{d}\|}$$

What if $\mathbf{e}_1 = \mathbf{e}_2$?



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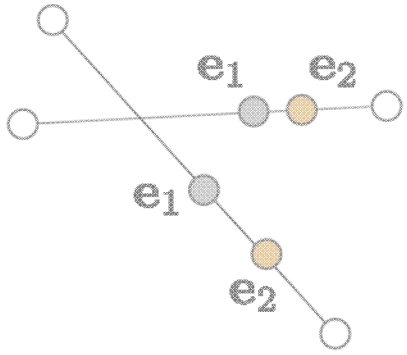

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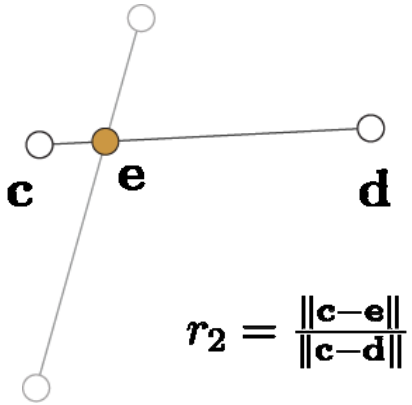

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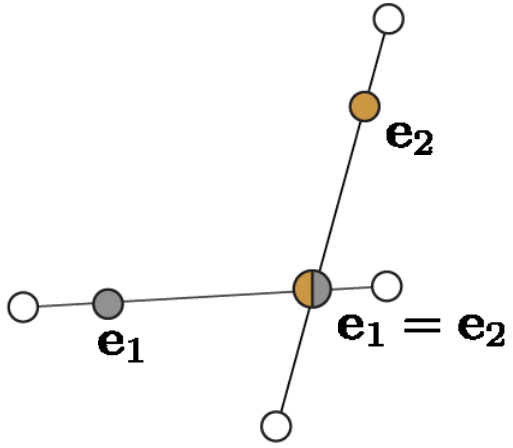
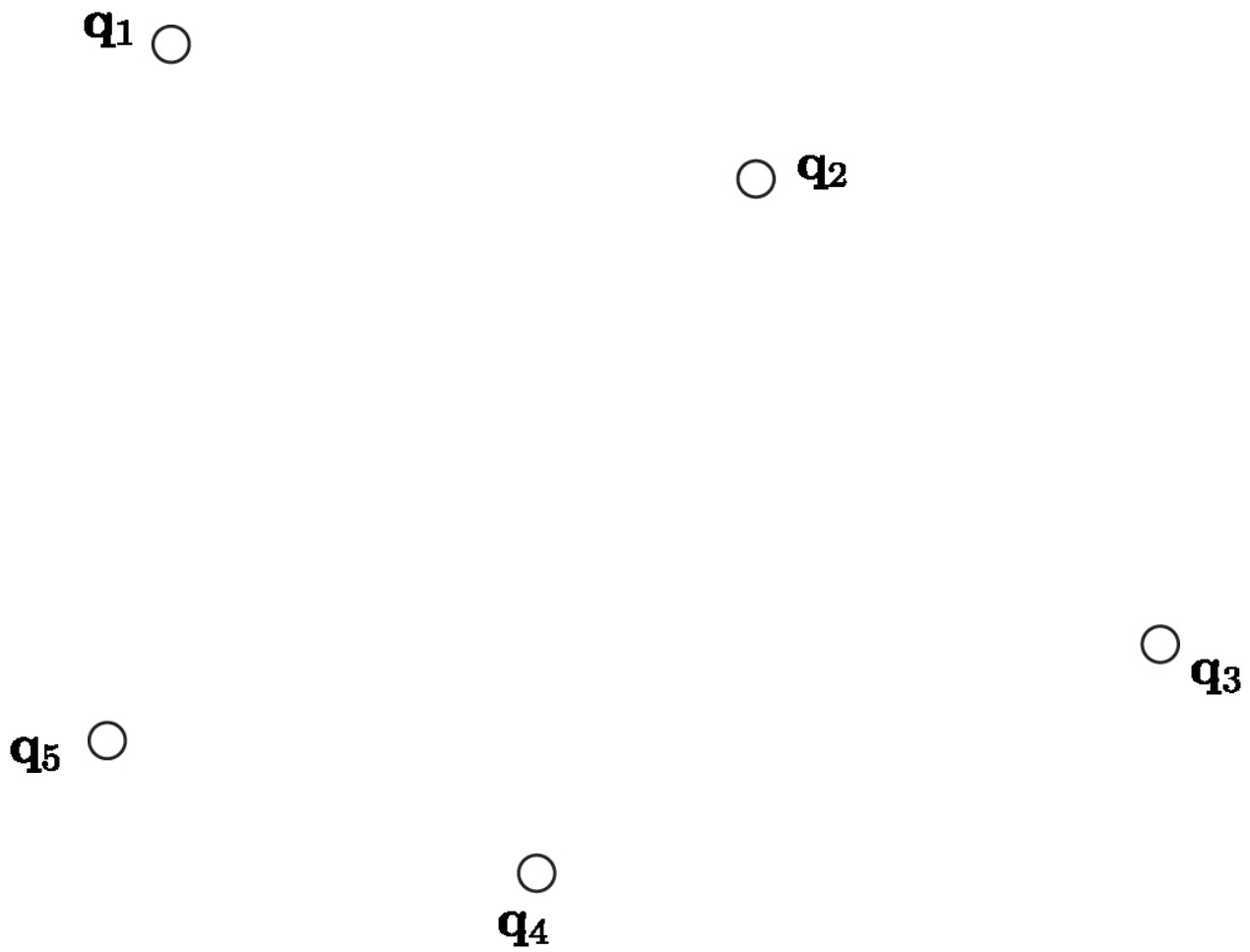


congruent 4-points!

Extracting Congruent 4-points



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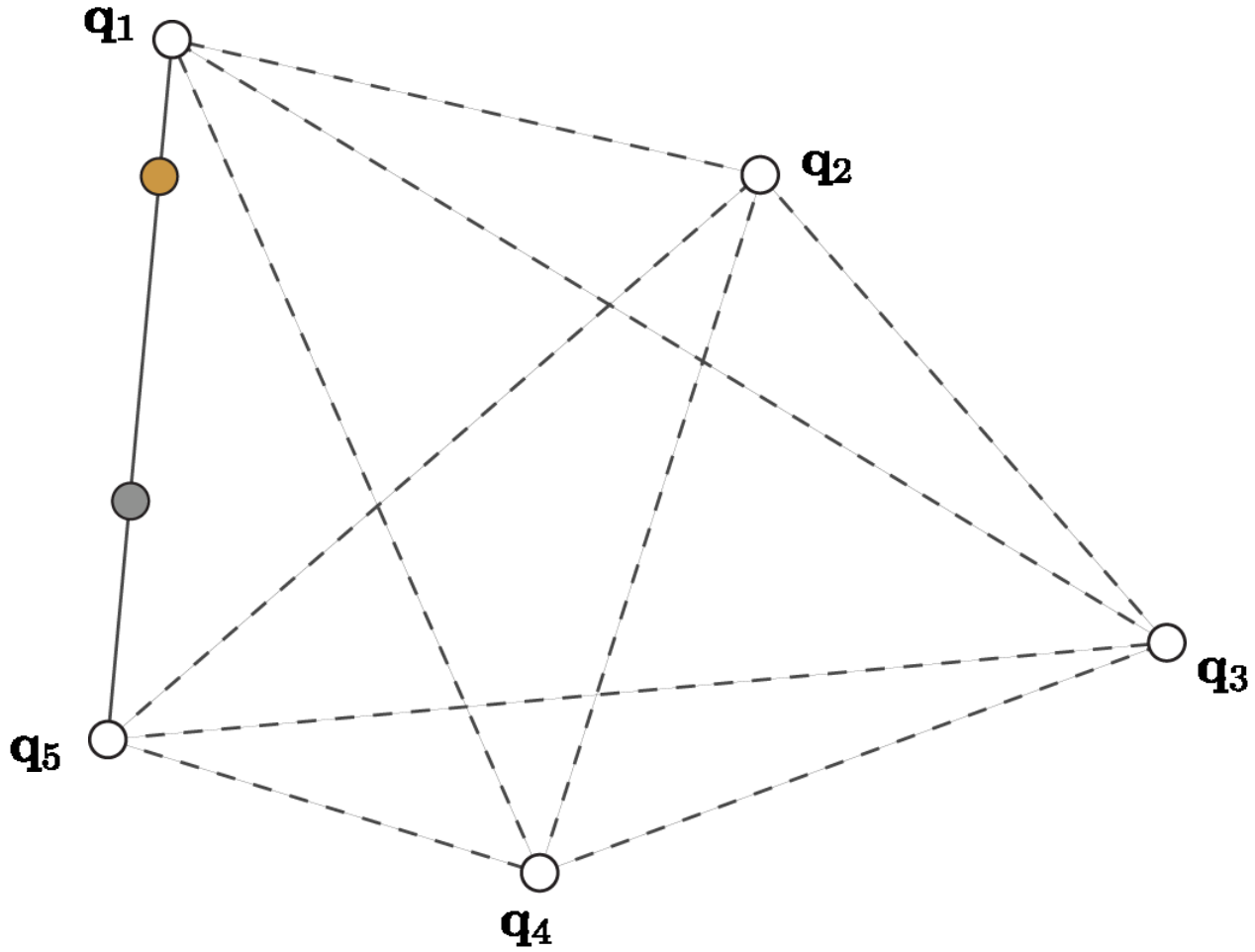

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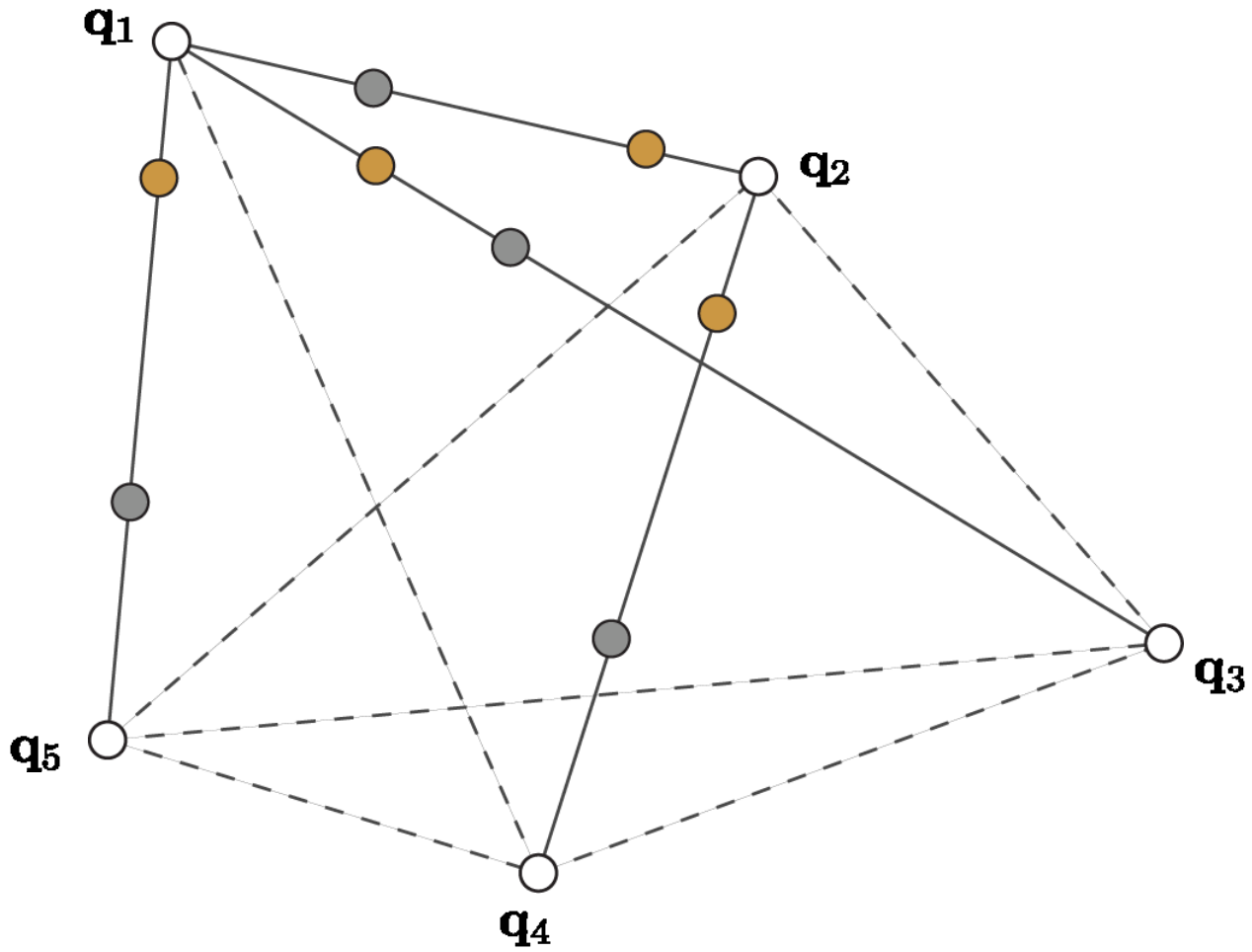

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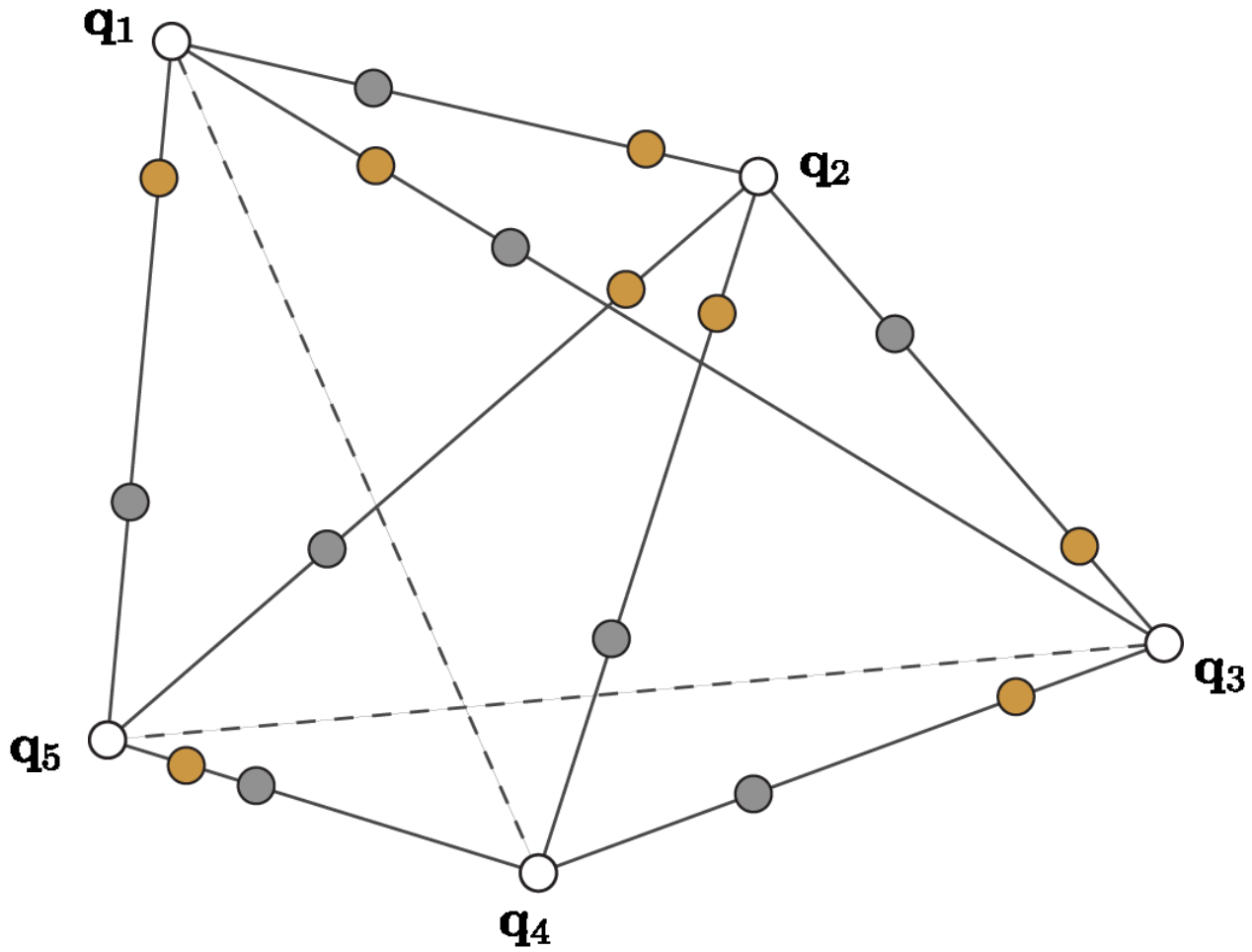

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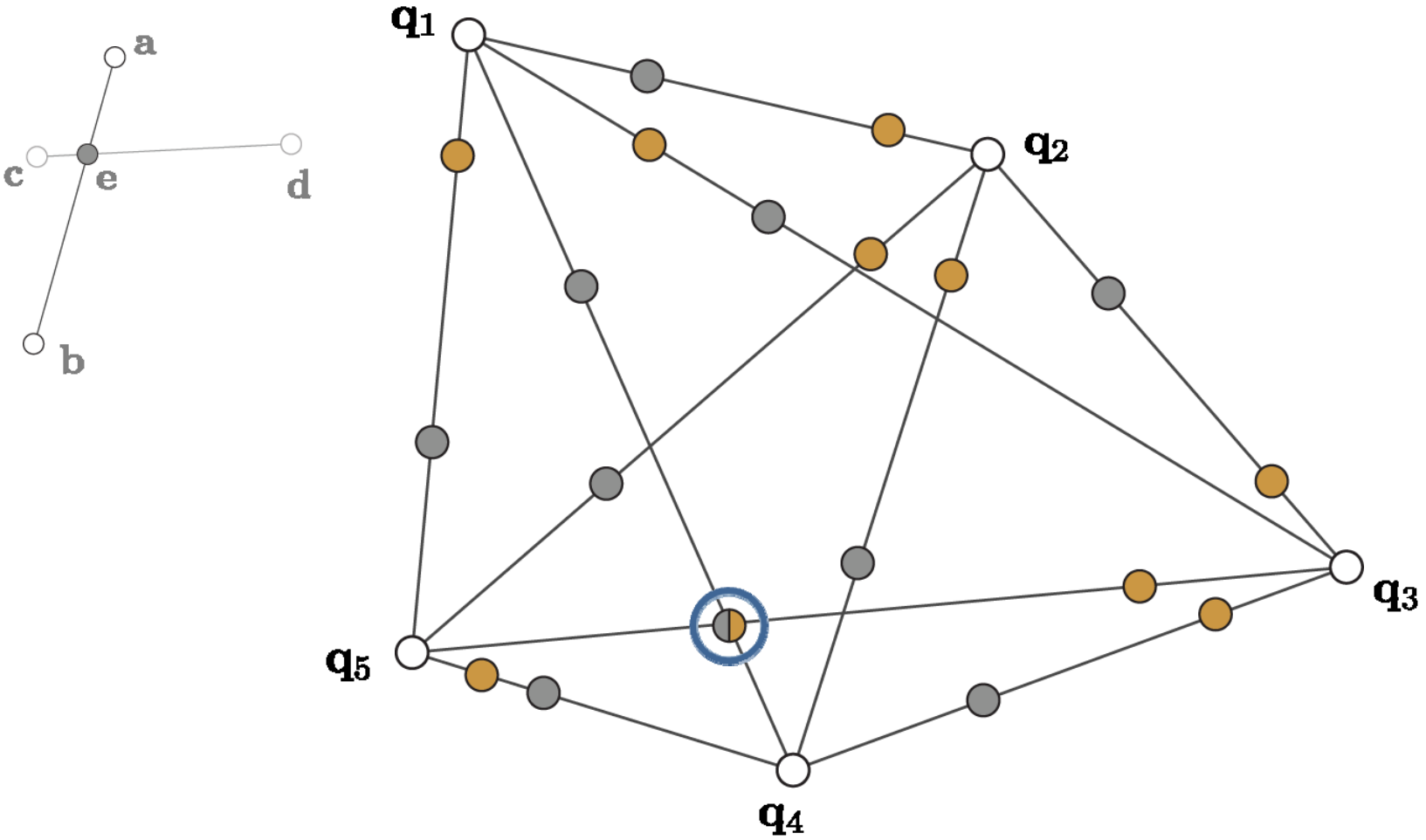
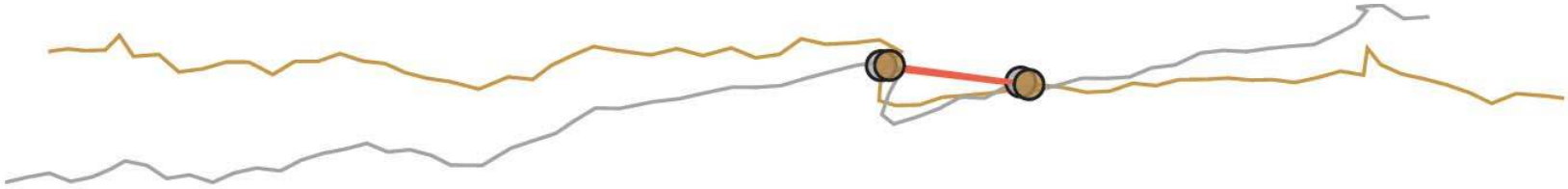


$$\{a, b, c, d\} \equiv \{q_1, q_2, q_3, q_4\}$$

Wide-base ! more stable

narrow base ! unstable



wide base (4-points set) ! increased stability

Result: Gallery