MultiLink: Multi-class Structure Recovery via Agglomerative Clustering and Model Selection

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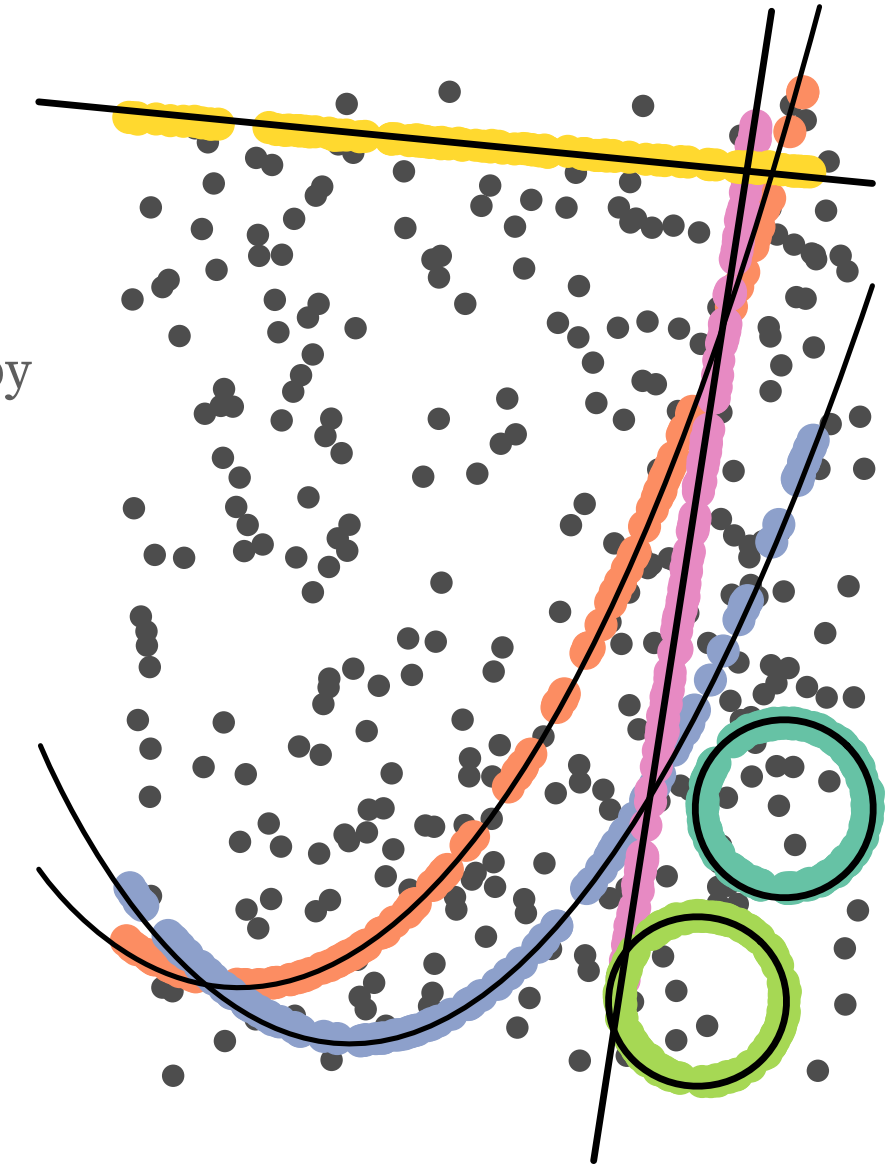
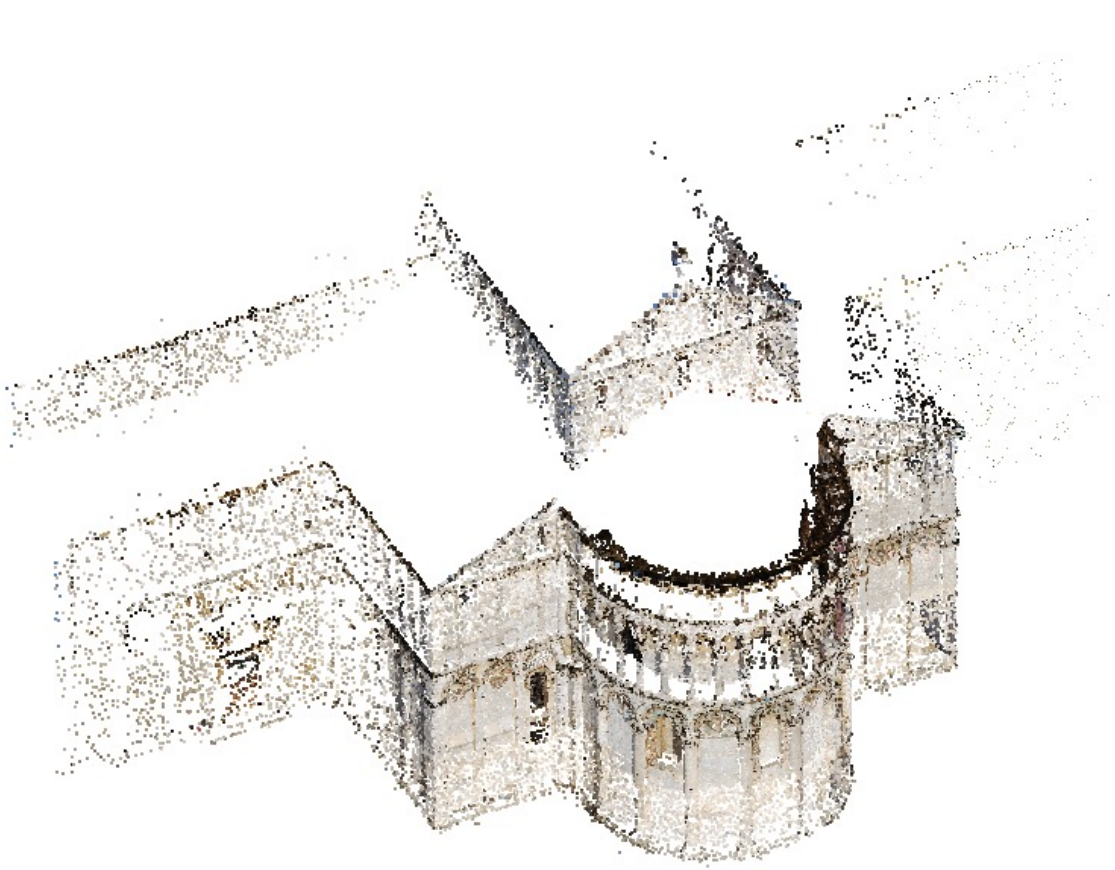
Multi-class multi-model fitting

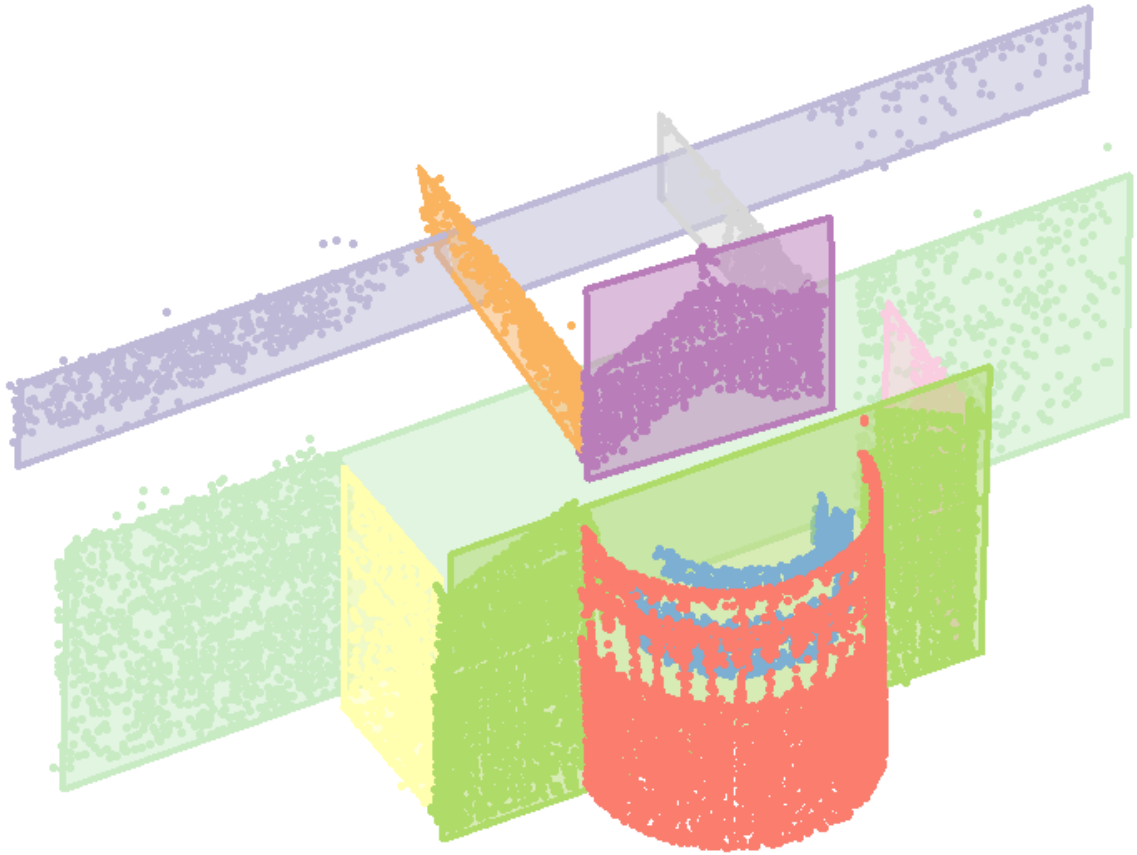
Recover structures described by a **mixture** of parametric models belonging to **multiple** classes (*e.g.*, lines, circles and parabolas) from data contaminated by noise and outliers.

Task	Classes of models
Stereo geometry	Homography, fundamental and affine fundamental matrices
Motion segmentation	Subspaces of varying dimensions
3D Point cloud segmentation	Geometric primitives



Multi-class model fitting





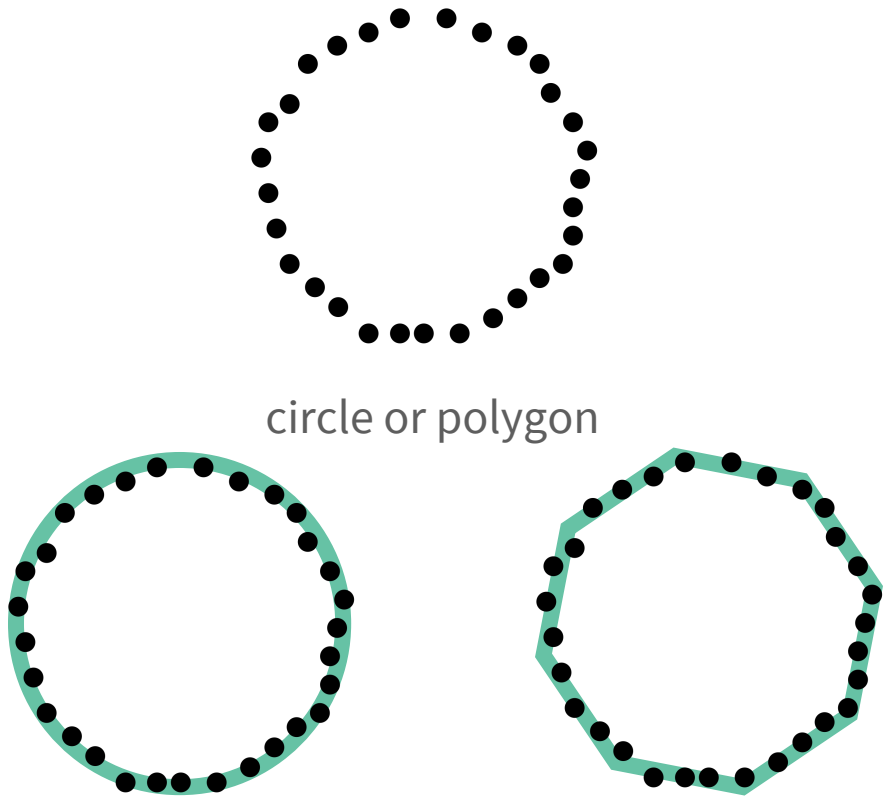
Organize a 3D point cloud in either planes or cylinders

Challenges

- Ill-posed problem
- Automatically estimate the number of structures and the proper class of models

Motivations

- Deal with nearly-degenerate configurations
- Higher level of abstraction



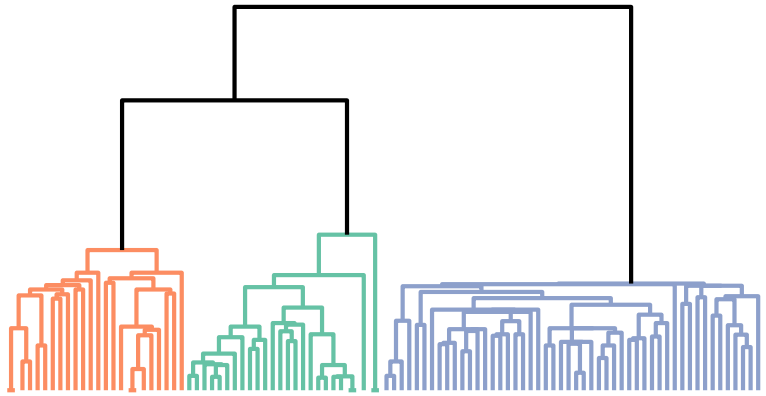
MultiLink

Existing techniques can be categorized in two main approaches:

Optimization-based

Model selection

Preference-based



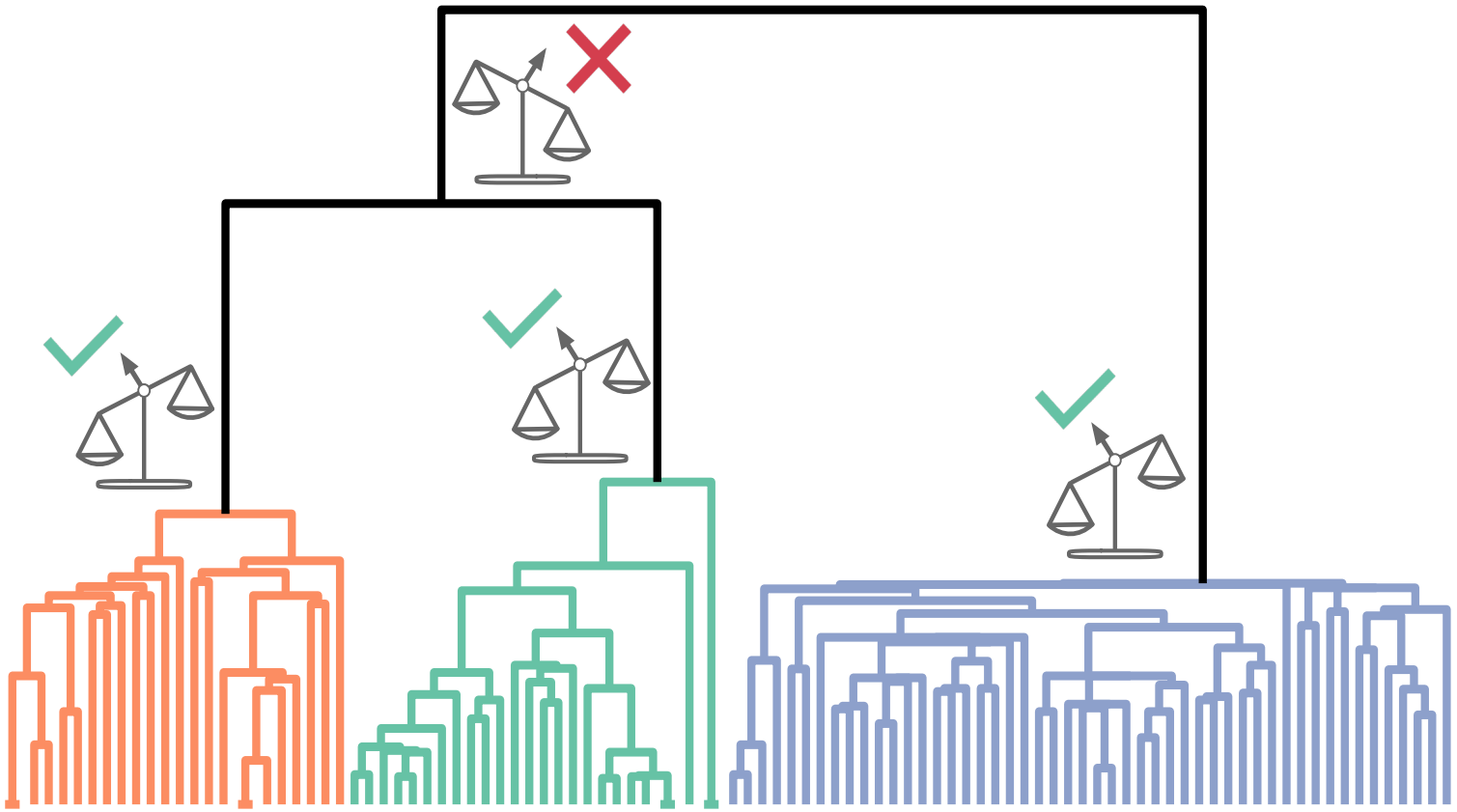
Agglomerative clustering

MultiLink

implements a novel clustering based on:

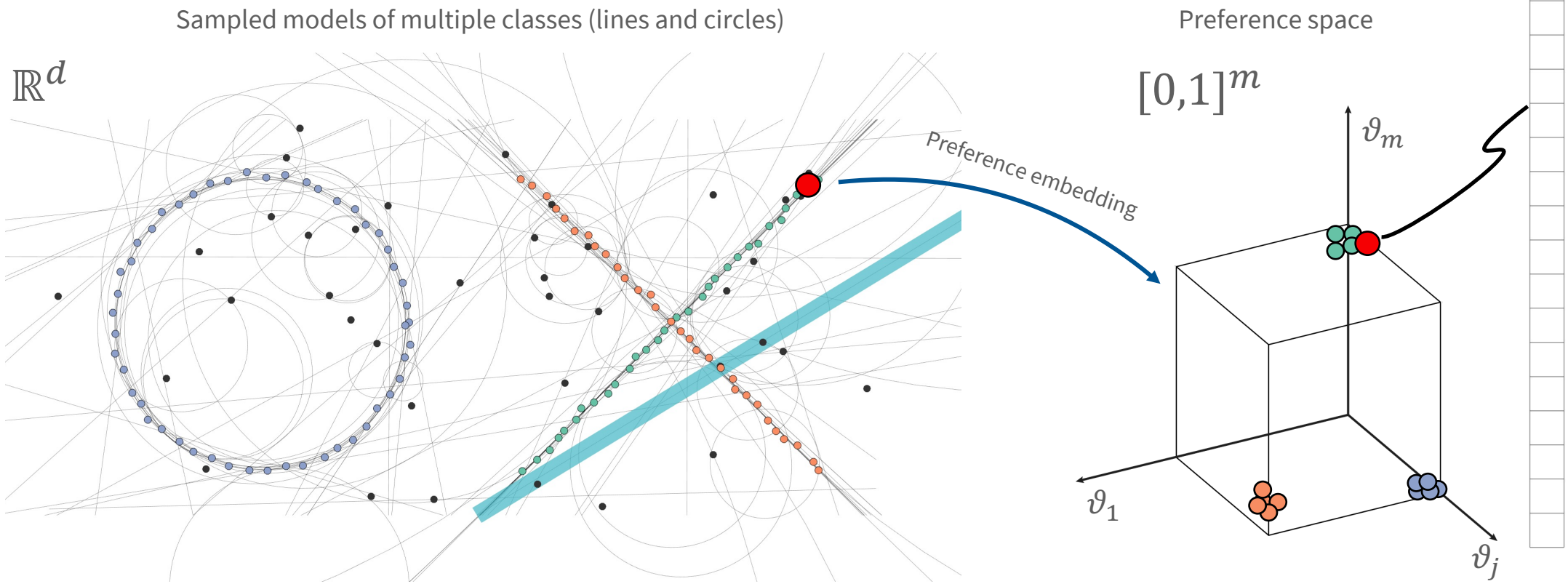
- simple model selection criterion
- on-the-fly model fitting

to decide whether two clusters must be merged and which is the best model class



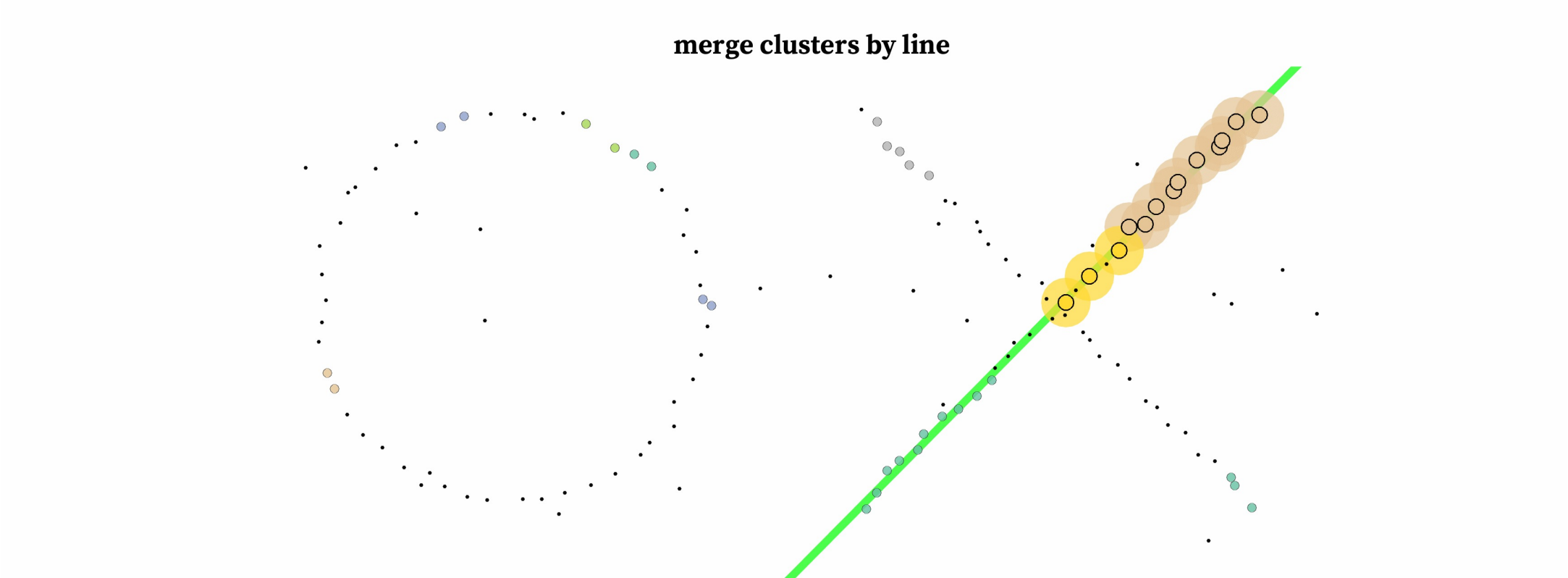
Preference embedding

Every points is represented as a vector of preferences that measure its adherence to sampled models of different classes.
Points belonging to the same structure are close in the preference space.



Multilink clustering

- Single-linkage using Tanimoto distances between preferences determine the pair of clusters that must be merged.
- Models of different classes are fitted on-the-fly during clustering
- Model selection to validate merging and decide the class of model



Geometric Robust Information Criterion (GRIC)

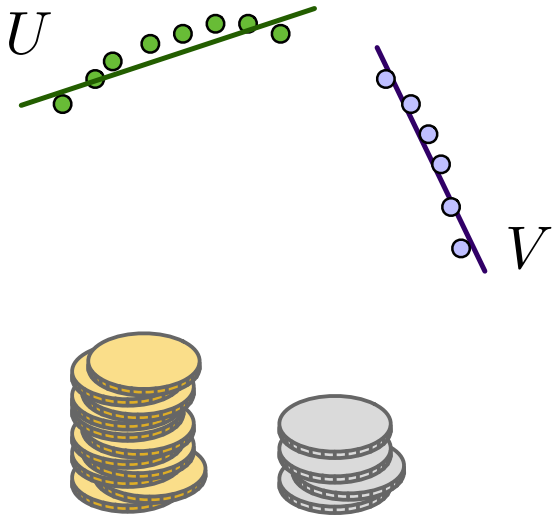
GRIC cost:

$$\underbrace{-\frac{1}{2}\sum\left(\frac{r_i}{\sigma}\right)^2}_{\text{Geometric residuals}} + \underbrace{\lambda_1 dn + \lambda_2 k}_{\text{Model complexity}}$$

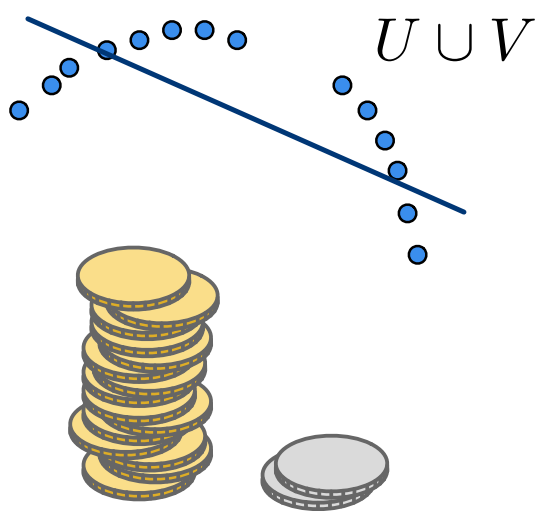
r_i residuals
σ noise estimate

d dim. of model manifold
n # points
k # model parameters

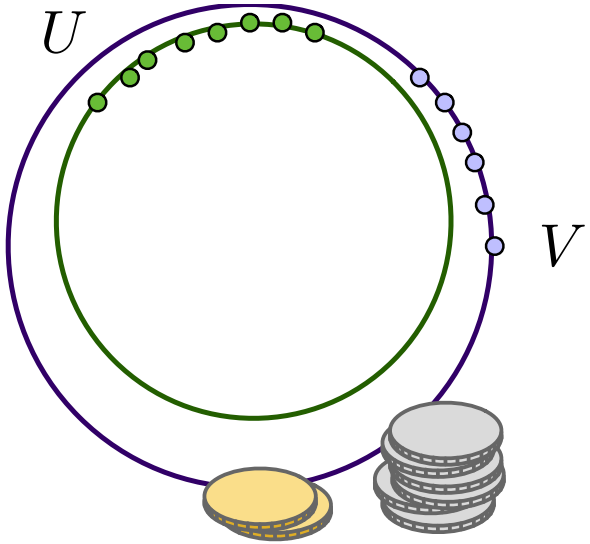
MultiLink model selection



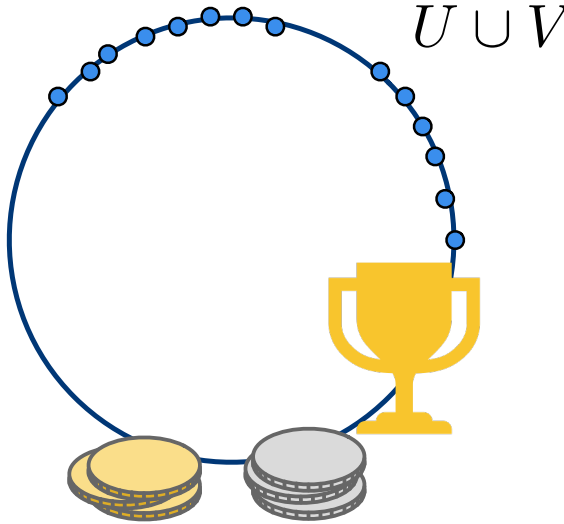
high residuals and
high complexity



high residuals



high complexity



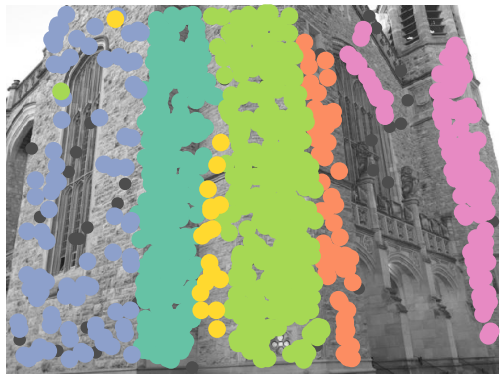
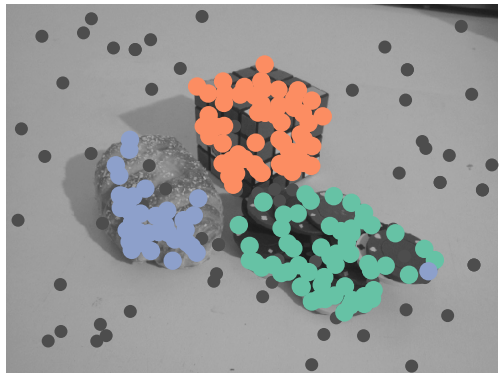
lowest GRIC

Merging the two clusters by fitting a single circle
is the cheaper explanation

Conclusions

Experiments demonstrated that MultiLink is

- **General**: can cope with different class of models
- **Faster and stabler**: w.r.t. preference-based solution. It alleviates dependencies from the sampling and from the choice of the inlier thresholds.
- **Accurate**: improves or performs on par with state-of-the-art alternatives on synthetic and real word dataset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