

Tracing the Spatial Evolution of Young Massive Clusters Using

INDICATE

Index to **D**efine **I**nherent **C**lustering **A**nd **T**endencies



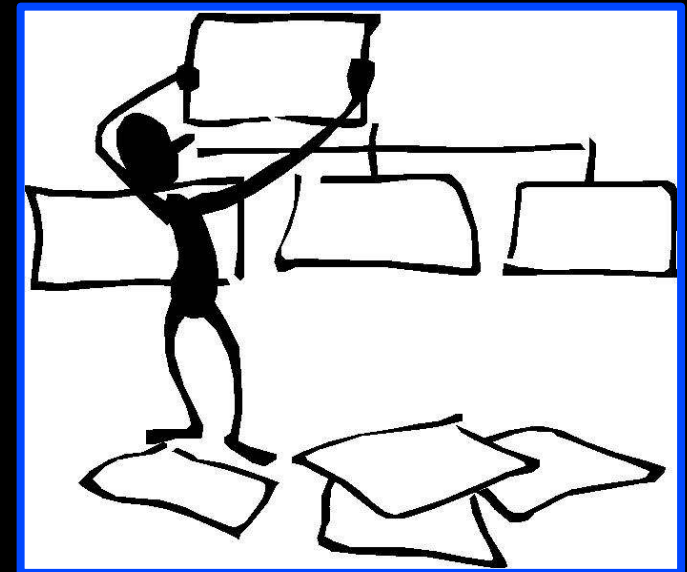
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Talk Structure

- Motivation
- What is INDICATE?
- How does it work?
- Why use INDICATE?
- Application: Mass segregation
- Future development
- Summary



Motivation

We want to constrain the mechanisms that underlie massive star and star cluster formation



Motivation - INDICATE

Traditional clustering algorithms

Assume: There are clusters in the dataset

Goal: Identify cluster centroids and members

Problem: Do not give enough quantitative information for individual objects

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Traditional clustering algorithms

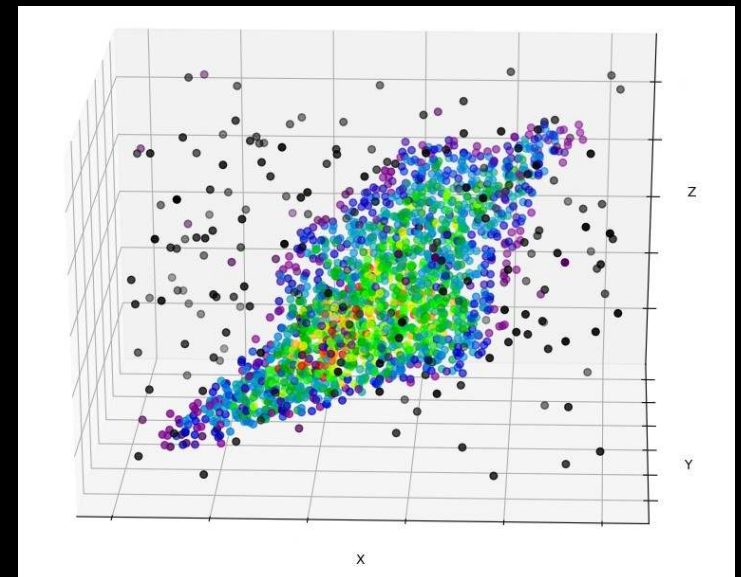
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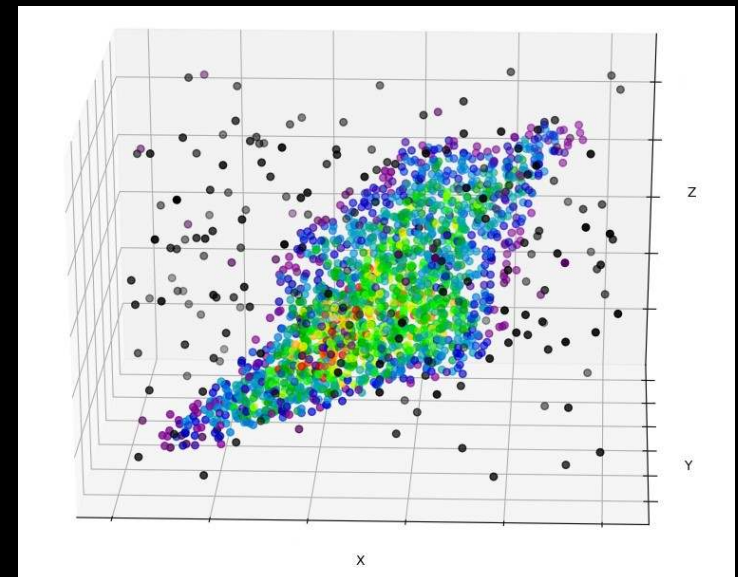
Need to quantitatively trace how “clustered” individual objects are in distribution & how this changes as the system evolves

What is INDICATE?



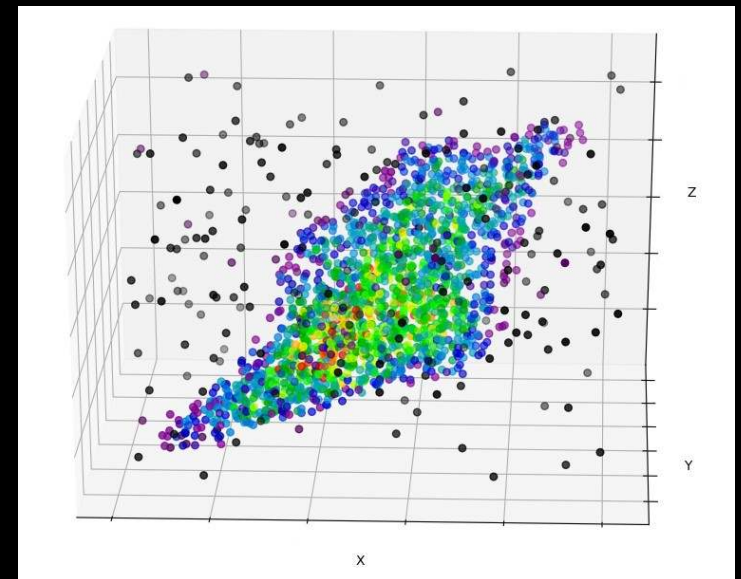
What is INDICATE?

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- Novel automated statistical clustering tool
- Quantifies the degree of clustering of each object in a discrete distribution



How does INDICATE work?

Calculates a Clustering Index for every vector in an 'observed' discrete distribution

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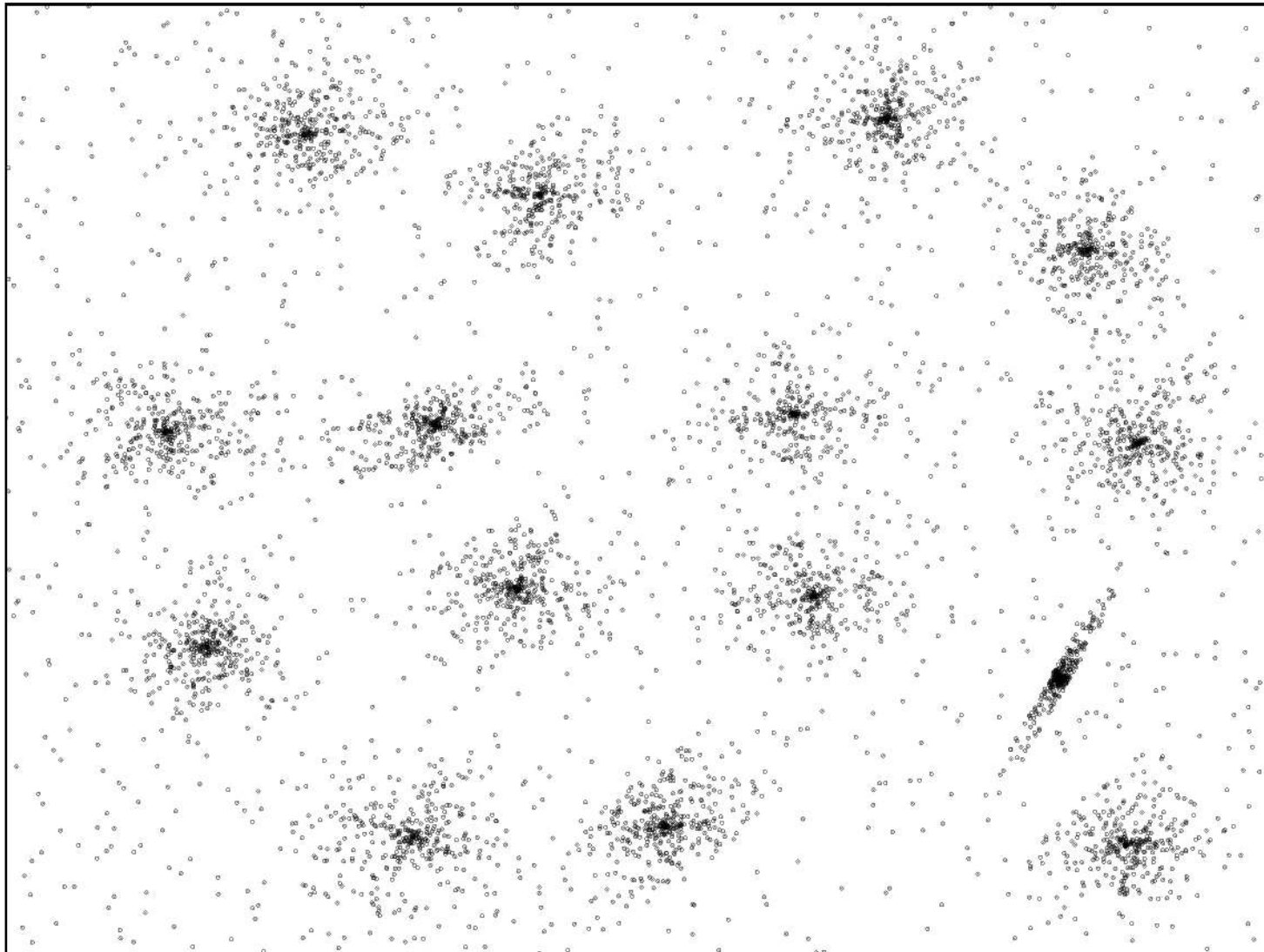
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- derived by comparing the number density of the vector's local neighbourhood with a generated evenly spaced uniform distribution

How does INDICATE work?

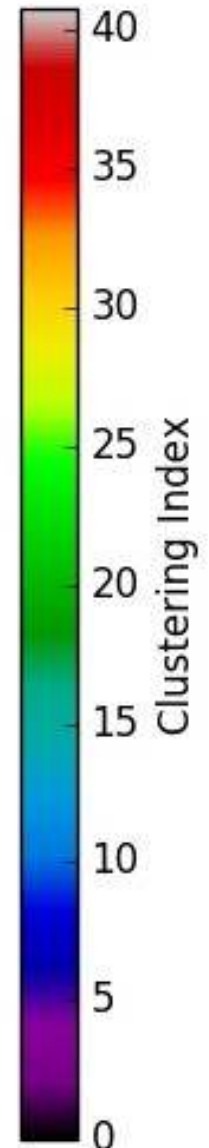
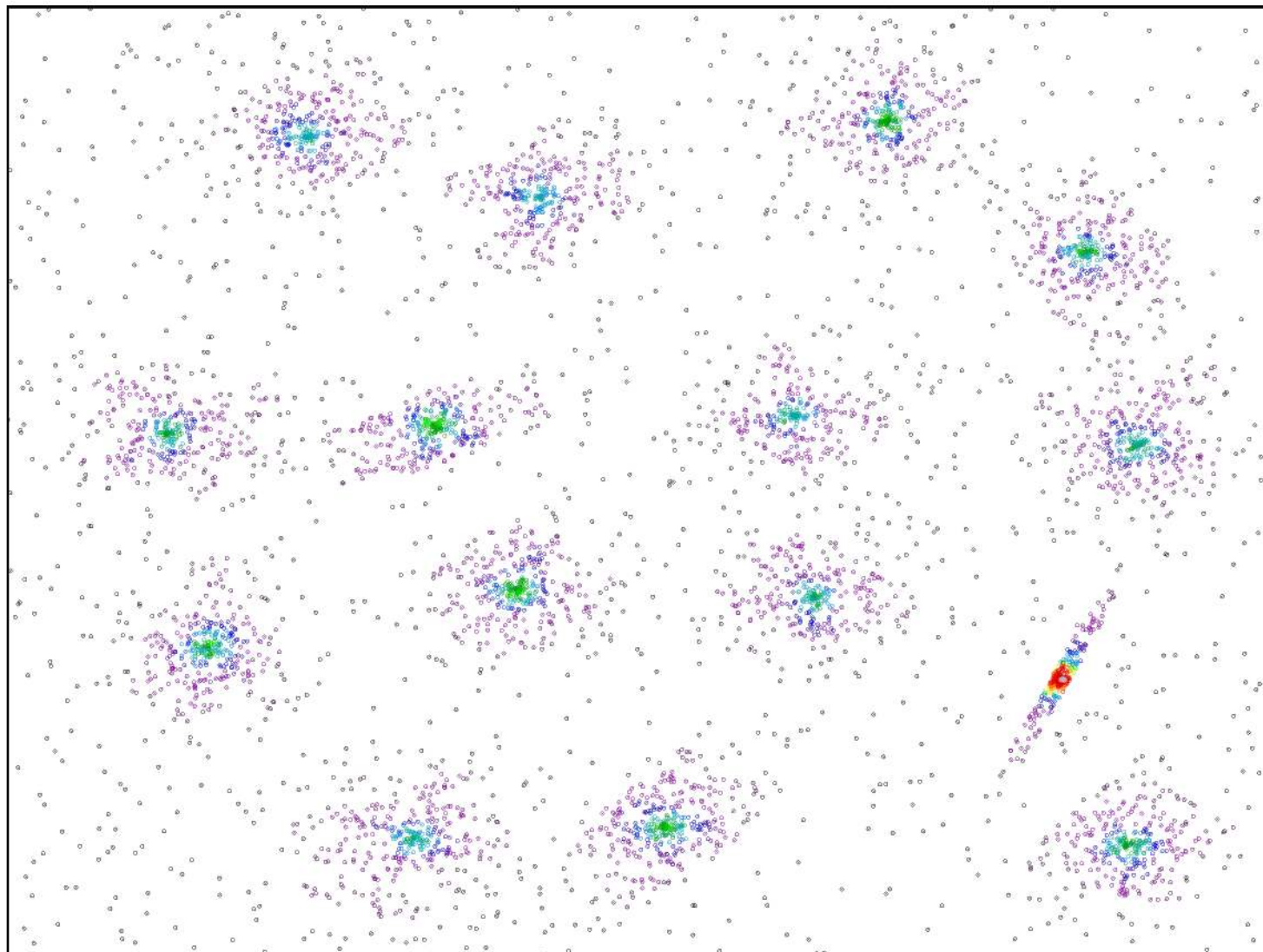
Calculates a Clustering Index for every vector in an 'observed' discrete distribution

- quantitatively describes the degree (or lack) of spatial clustering in the local neighbourhood of vector
- derived by comparing the number density of the vector's local neighbourhood with a generated evenly spaced uniform distribution
- The uniform distribution has the same overall number density as the 'observed' distribution

INDICATE: A 2D example



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How does INDICATE work?

Calibration

Index is calibrated with random distributions for effects of

- Sample size
- Number Density

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Preliminary: typically Index ranges 0-4 (mode 0.8)

Why use INDICATE?

- Can be applied in any desired parameter space
- Robust. No preference for data set
 - size
 - shape
 - number of dimensions (2D, 3D, 6D)
- Directly compare Index value for objects in different distributions
- Full automated

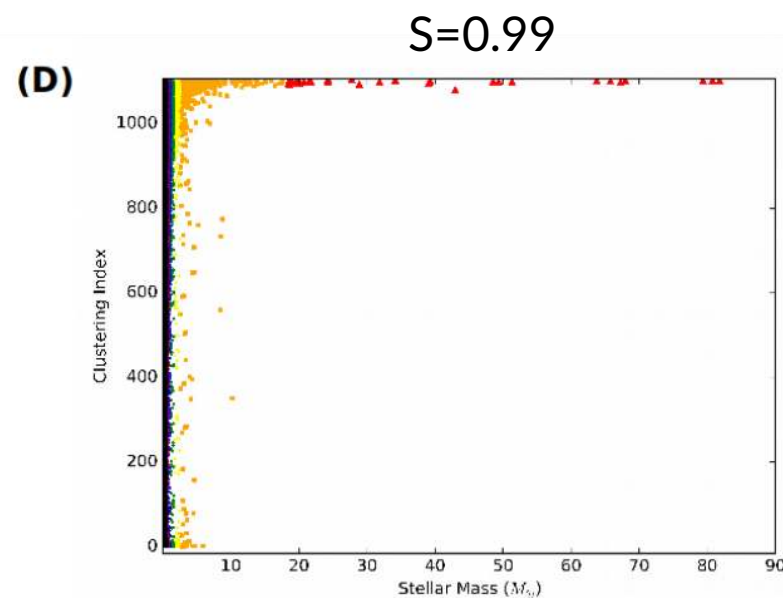
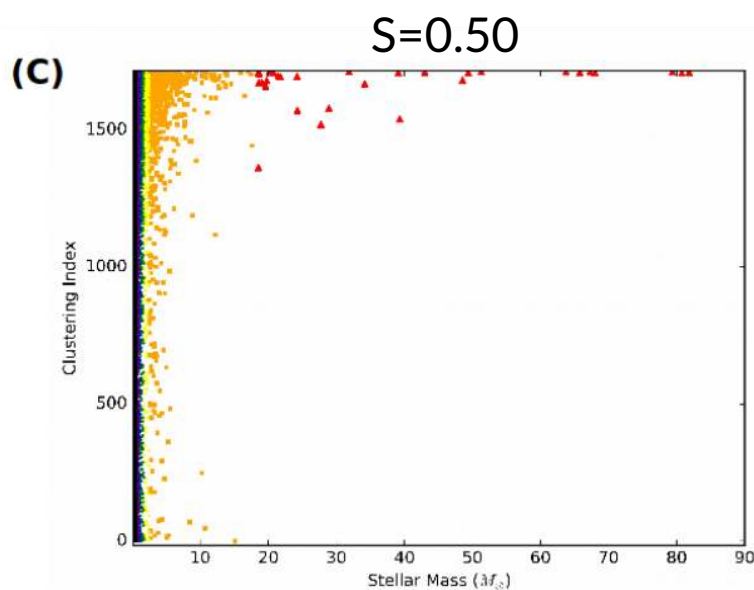
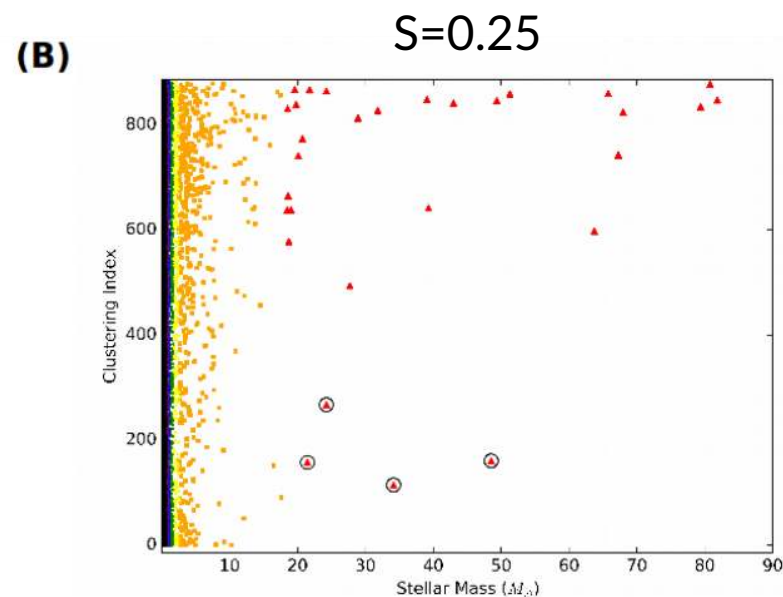
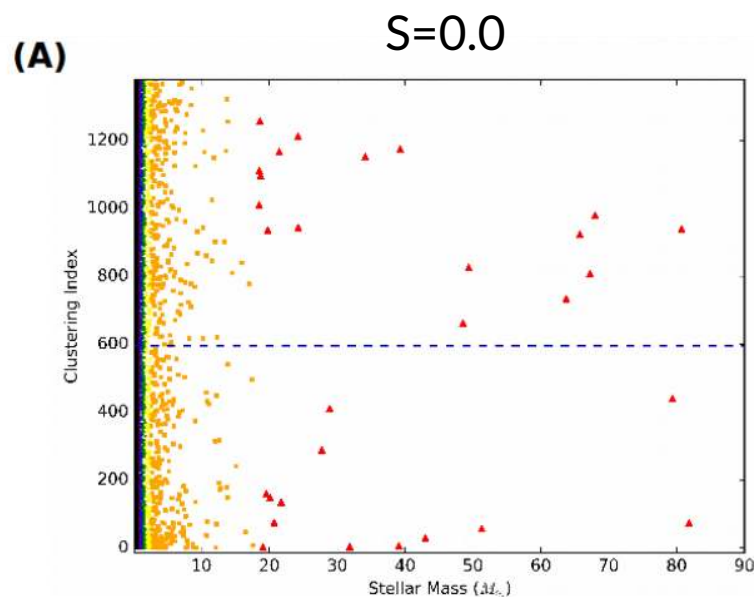
Applications

Young Massive Star Cluster / Formation

Quantitatively trace:

- **Mass Segregation**
- **Stellar Substructure**
- **Dynamical Evolution of Cluster System**
- **Spatial Evolution of Individual Stars in Cluster Mergers**

Example: Mass Segregation



Future Development of INDICATE

- 2D version to be published in upcoming paper (Buckner et al., in prep)
- Calibration & testing of 3D version
- Calibration & testing of 6D version

Summary

- INDICATE

- A novel statistical clustering tool
- Quantifies the degree of clustering of each object in a discrete distribution

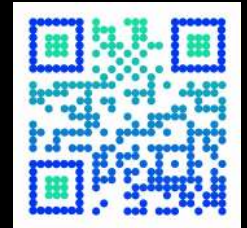
Advantages:

- Quantitatively trace the spatial evolution of each object in a distribution
- Full automated
- Robust
- Not dependent on distribution size, shape, of number of dimensions

- Applications:

- Mass segregation
- Tracing Dynamical Evolution
- Substructure
- Cluster Mergers

Scan me to learn about
our SFM project!



Questions?

