

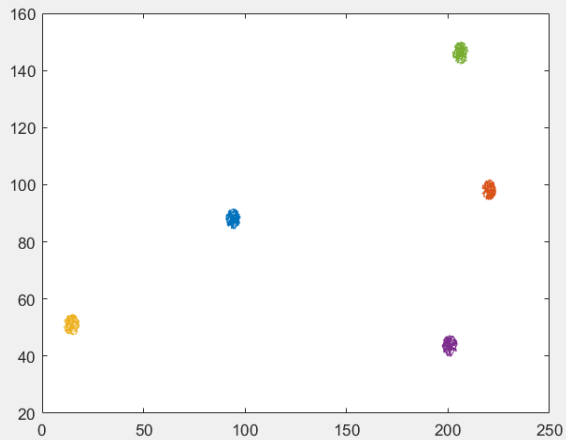


- Final Project - Motion Analysis

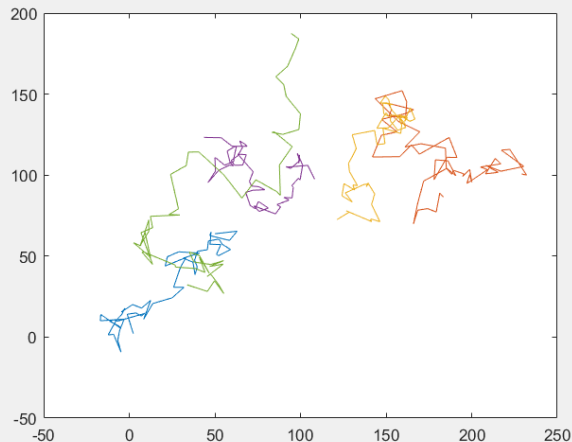
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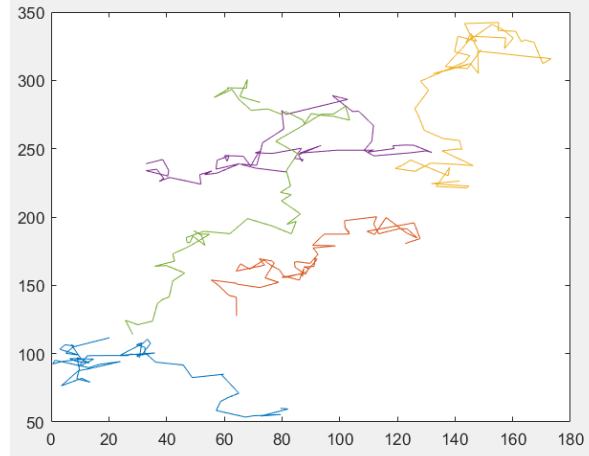
Background



A. Confined Motion



B. Free Motion



C. Drift Motion

Background

Goal:

- Write a software package which can determine the trajectory motion type of the particles
- Apply our motion classifier to supplied trajectory data set
 - Compare output against ground truth provided
- Apply motion classifier to real trajectories and find motion type

Background

Approaches:

Mean Square Displacement Analysis

Anisotropic/Isotropic Analysis

Moment Scaling Displacement

Mean Square Displacement

Features:

Calculate the MSD for different time lags:

Ensemble average:
$$\mu_p(\tau) = \frac{1}{N} \sum_{i=1}^N \left(\left| \vec{x}_i(\tau) - \vec{x}_i(0) \right| \right)^2$$

Assuming ergodicity ...

Time average:
$$\mu_p(\tau) = \frac{1}{T - \tau} \sum_{i=1}^{T-\tau} \left(\left| \vec{x}(i + \tau) - \vec{x}(i) \right| \right)^2$$

Used: simMultiMotionTypeTrajCVMI

Focus: durationRange

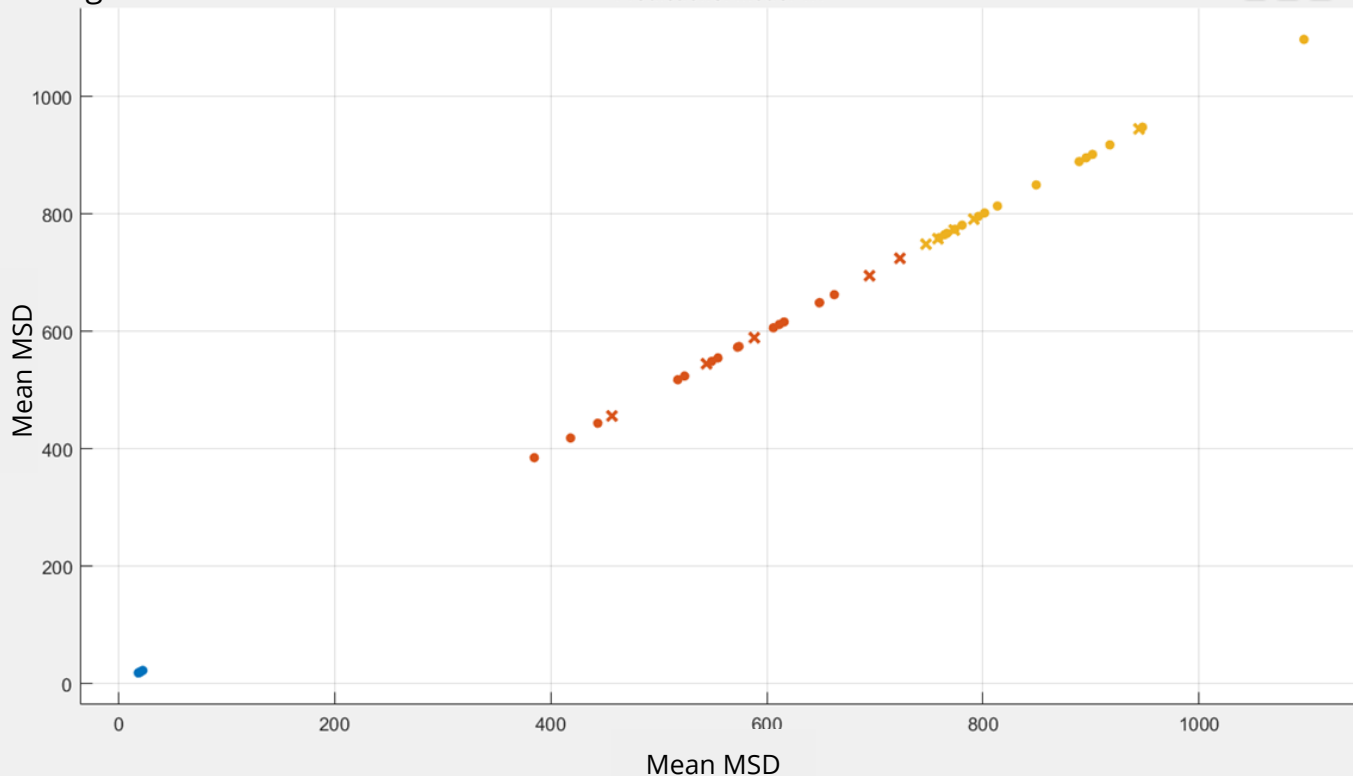
Calculating MSD: Mean displacement for particle at each time step ~ 20 of each

- Mean of MSD (input into ClassificationLearner)

Mean Square Displacement

Using: Linear Discriminant

Predictions: model 1.1



☐ Data

☒ Model predictions

☒ Correct

☒ Incorrect

Predictors

X: column_2

Y: column_2

Classes [Move to Front](#)

Show	Order
<input checked="" type="checkbox"/>	1
<input checked="" type="checkbox"/>	2
<input checked="" type="checkbox"/>	3

[How to investigate features](#)

Mean Square Displacement

Linear Discriminant: 85% accuracy

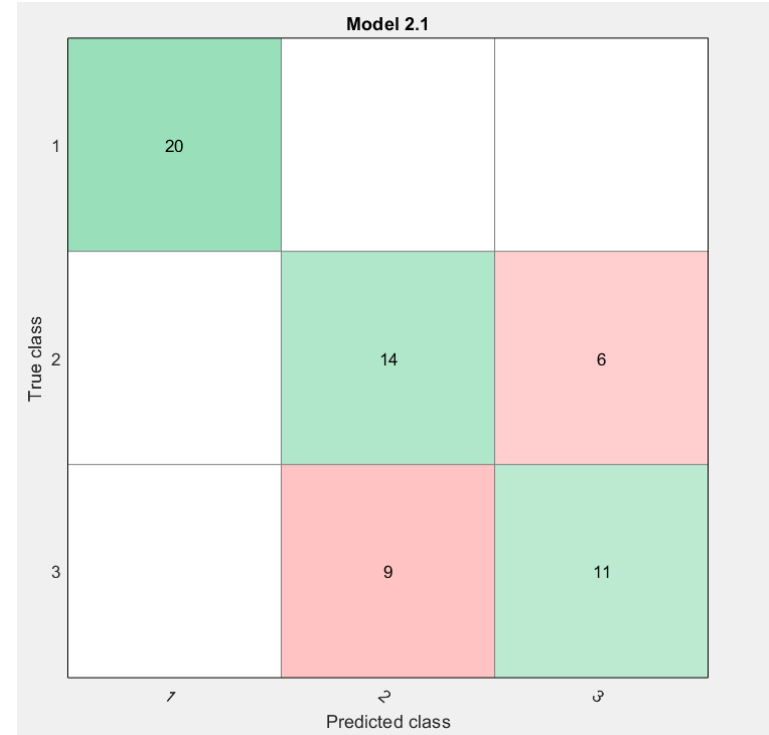
Quadratic Discriminant: 85% accuracy

True class Types Clarified:

1=confined

2=free

3=drift



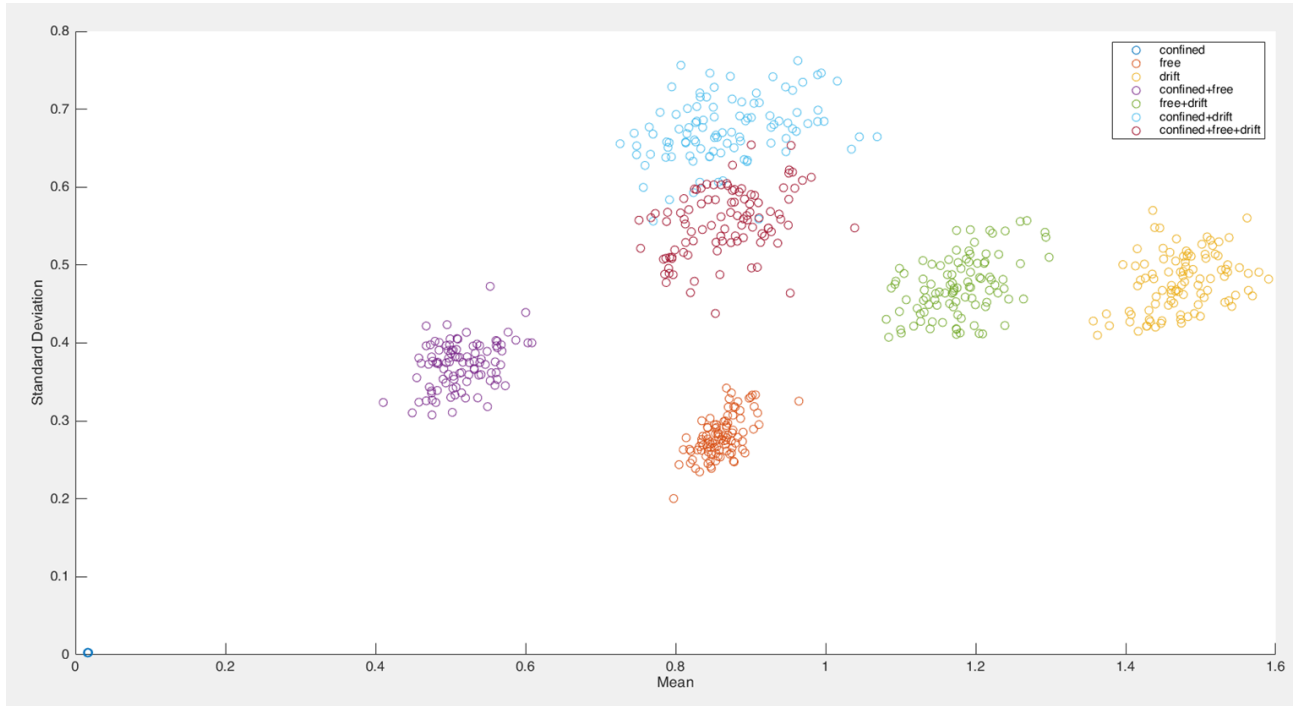
Isotropy Analysis

Features:

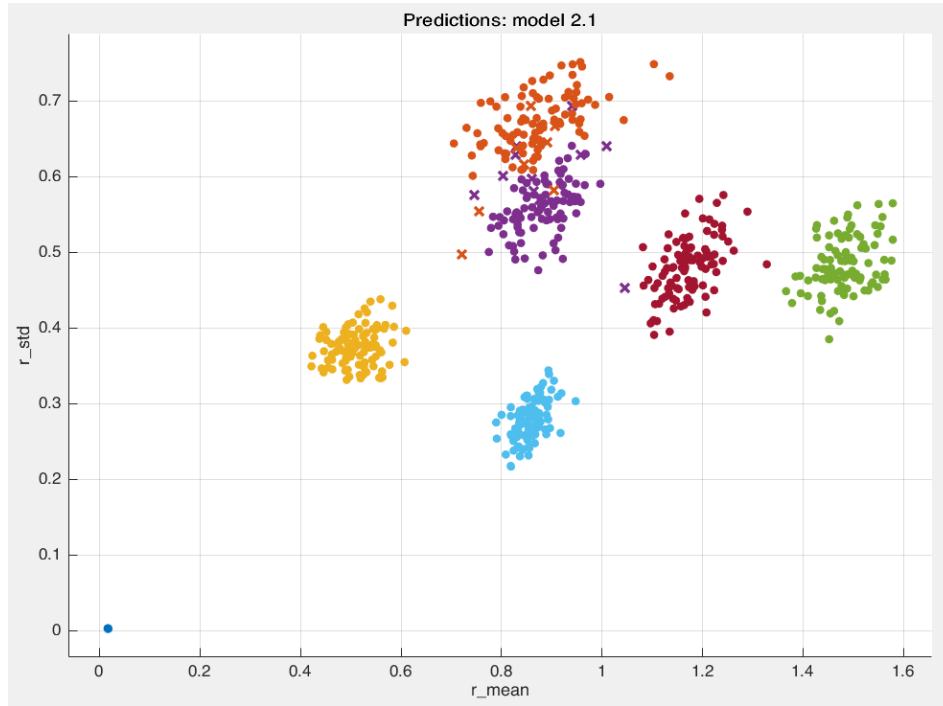
$$V_{pos} = (V_x + V_y + V_z) / N \quad R = \sqrt{V_{pos} \times (N + 2)}$$

- Mean of R
- Standard Deviation of R

Isotropy Analysis (Cont.)

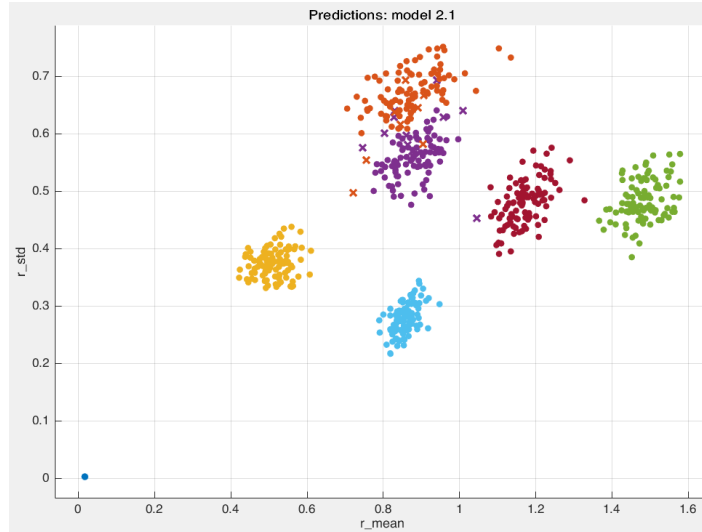


Isotropy Analysis (Clustering)



Isotropy Analysis (Confusion Matrix)

- SVM: **98.1%** Accuracy
- KNN: **98.1%** Accuracy



Model 2.1

True class \ Predicted class	"confined"	"confined+drift"	"confined+free"	"confined+free+drift"	"drift"	"free"	"free+drift"
"confined"	100						
"confined+drift"		90		10			
"confined+free"			100				
"confined+free+drift"		9		91			
"drift"					100		
"free"						100	
"free+drift"				1			99

MOMENT SCALING DISPLACEMENT

1.) Calculate the 0th to 6th moment for different time lags:

$$\mu_p(\tau) = \frac{1}{T-\tau} \sum_{i=1}^{T-\tau} \left(\left| \vec{x}(i+\tau) - \vec{x}(i) \right| \right)^p, \quad p = 0, \dots, 6$$

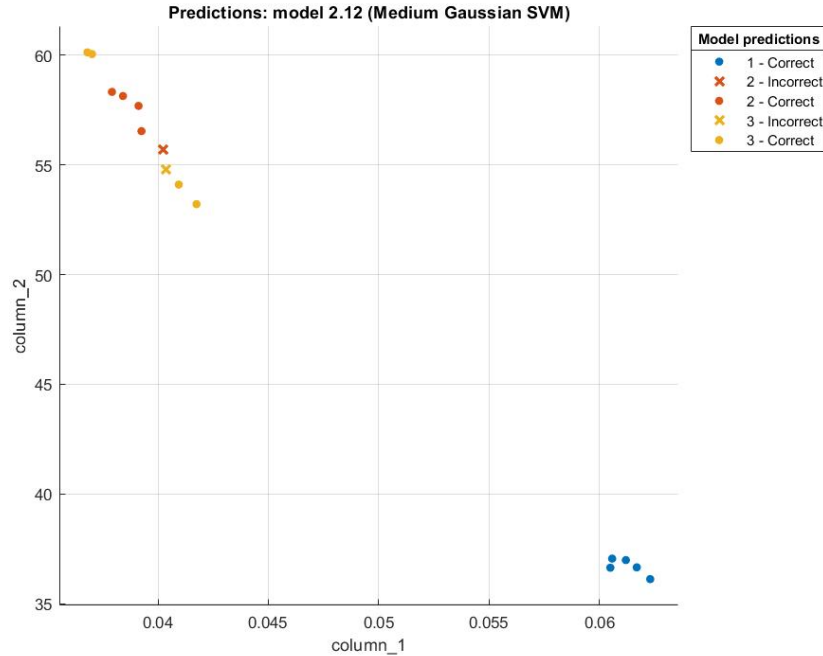
2.) Determine how each moment scales with time lag:

$$\mu_p(\tau) = 2ND_p \tau^{\gamma_p}, \quad p = 0, \dots, 6$$

Diagram illustrating the scaling of the moment with time lag:

- Dimension
- Generalized diffusion coefficient
- Exponent

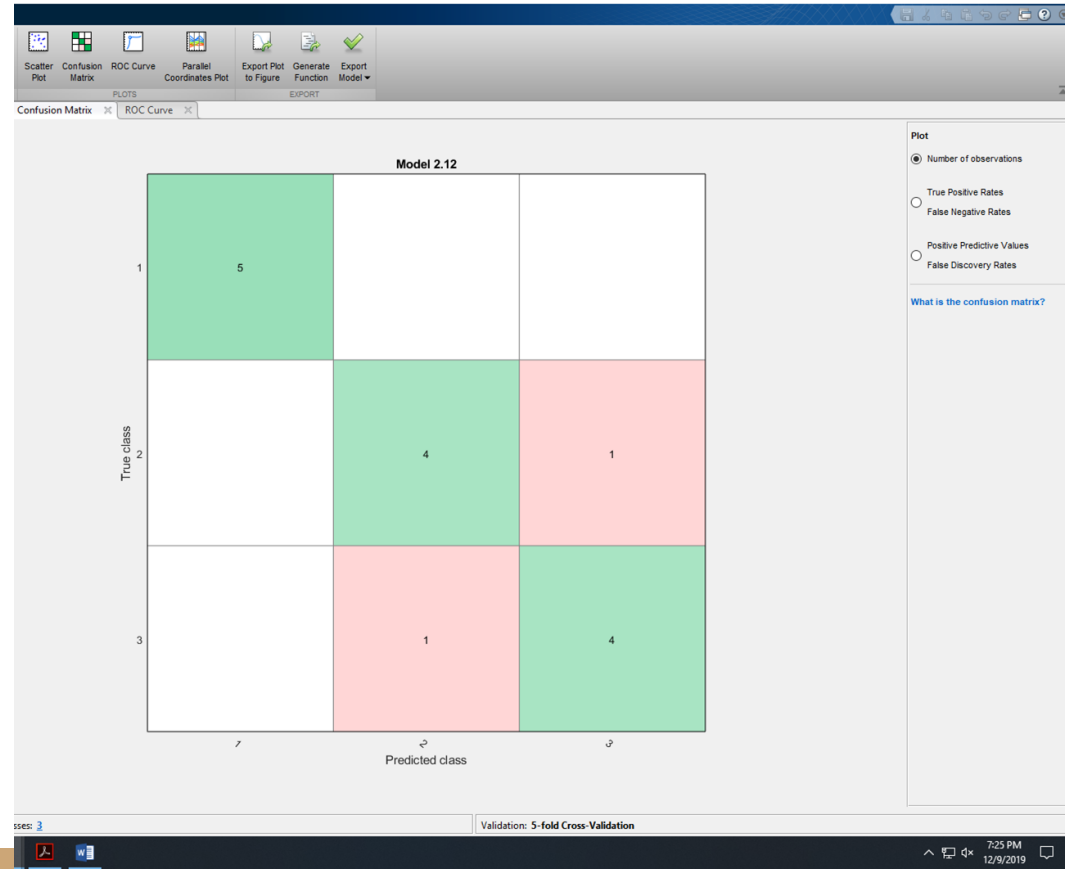
MOMENT SCALING DISPLACEMENT (SVM)



MOMENT SCALING DISPLACEMENT (SVM)

SVM- 86.7% ACCURACY

Quadratic Discriminant:
86.7% ACCURACY



Cross Validation Motion Classifier

Mean Square Displacement: 36% accurate using challenge data

Ideally use isotropy analysis due to high training accuracy and ability to detect switching motion

Classifying Real Trajectories

Cells Undergoing Sheet Migration

Using Mean Squared Displacement

Motion Classified as DRIFT

Limitation:

MSD cannot find switching motions

Drift vs free motion are difficult to distinguish against

