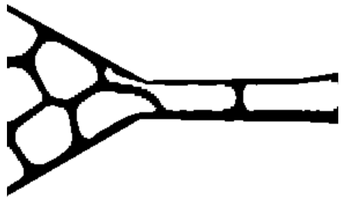


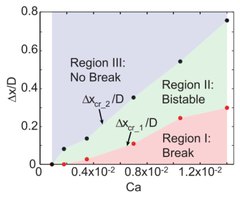
Prediction of microscale droplet instability in concentrated emulsion

Davis Hoffman[1]
Department of Mechanical Engineering

Stanford University

MOTIVATION

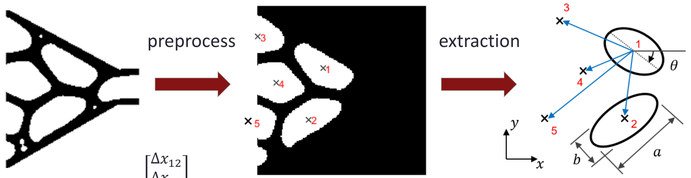
- Microfluidics plays an important role in techniques for screening in biochemistry.
- Screening throughput limited by hydrodynamic instability of droplets.
- Stability of droplet entering microchannel currently classified using 2 features [1].



- Machine learning useful for building classification model in the bistable region.

METHODS

- Baseline: image feature extraction

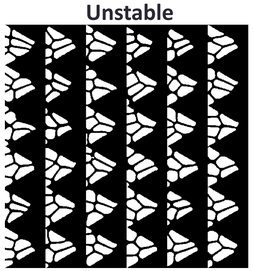


Feature vector, $x = \begin{bmatrix} \Delta x_{12} \\ \Delta x_{13} \\ \Delta x_{14} \\ \Delta x_{15} \\ \Delta y_{12} \\ \Delta y_{13} \\ \Delta y_{14} \\ \Delta y_{15} \\ a_1 \\ a_2 \\ b_1 \\ b_2 \\ \theta_1 \\ \theta_2 \end{bmatrix}$

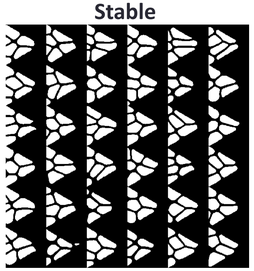
With features and labels defined, any supervised learning algorithm may be applied

- Deep learning: convolutional and non-convolutional

Unstable



Stable



- Transfer learning using pretrained MNIST classifier
- 660 droplet images with class imbalance of 57%

BASELINE RESULTS

- Classifier performance on feature extraction:

	Log. Reg	GDA	SVM	RF
Accuracy (%)	70.2	68.6	86.8	86.2

- Clustering on extracted features to group similar droplet configurations.

Cluster 1

Found pattern in droplet skewness

Cluster 2

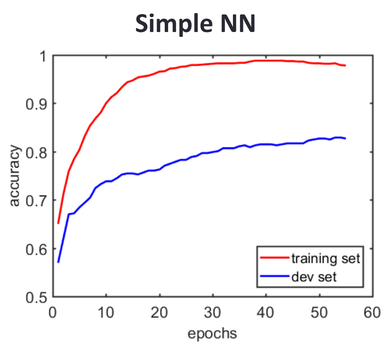
Found unfavorable packing pattern

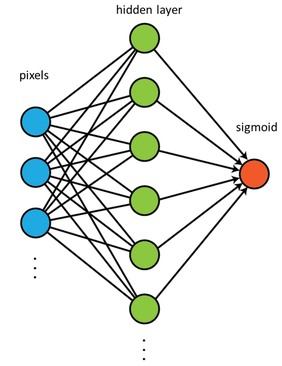
- Variable feature importance from random forest

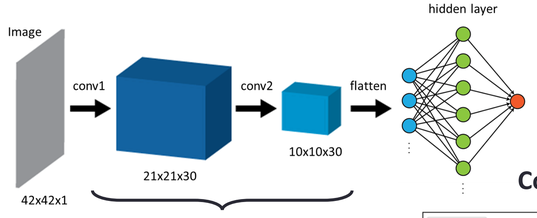
Features associated with leading droplets are most important

Other features are not negligible (could add more features by including more droplets in frame)

DEEP LEARNING RESULTS

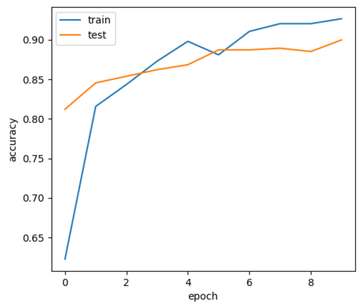






MNIST weights

ConvNet



	Simple NN	ConvNet
Accuracy (%)	81.7	89.9

CONCLUSIONS

- Droplet stability classifiers developed using broad variety of approaches
- Important features identified using decision trees.
- Prevalent droplet configurations assessed using k-means clustering.

REFERENCES

[1] W. Khor, M. Kim, S. Schütz, T. Schneider, and S. K. Y. Tang. “Time-varying droplet configuration determines break-up probability of drops within a concentrated emulsion”, Applied Physics Letters, 111, 124102, 2017.

[1]Thank you to Professor Sindy Tang, Neal Jean, Jian Wei Khor, and Ya Gai for providing data and feedback through the duration of the project.