

Brain Synapse Density

Jay Miller

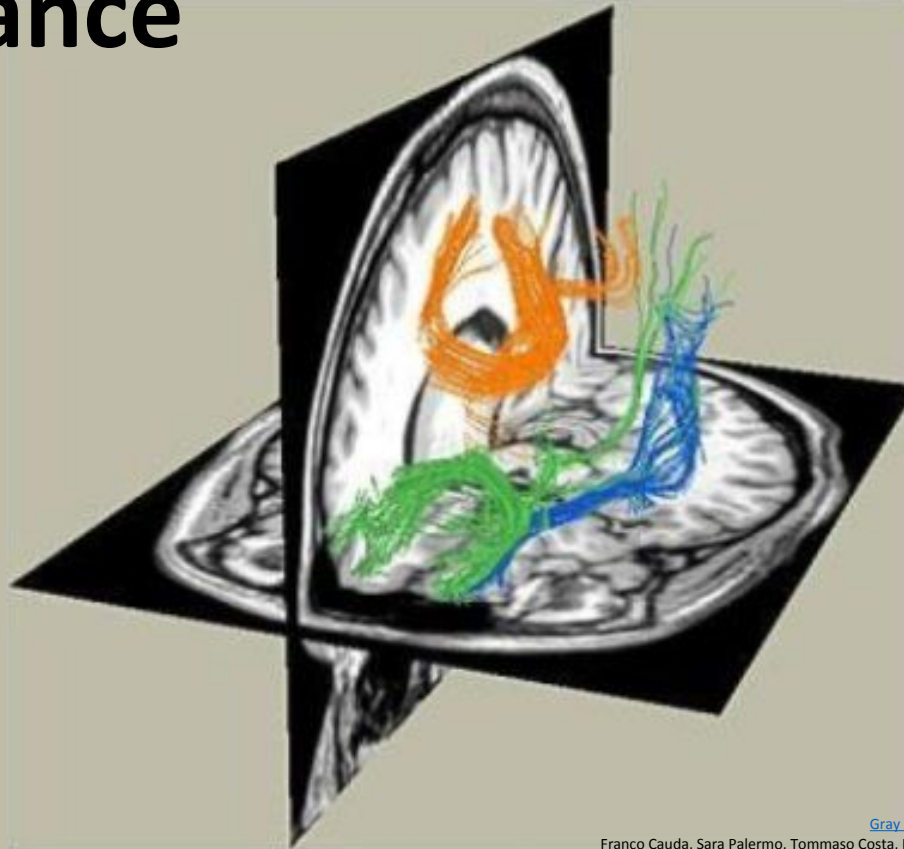
Akash Ray

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Significance

Significance



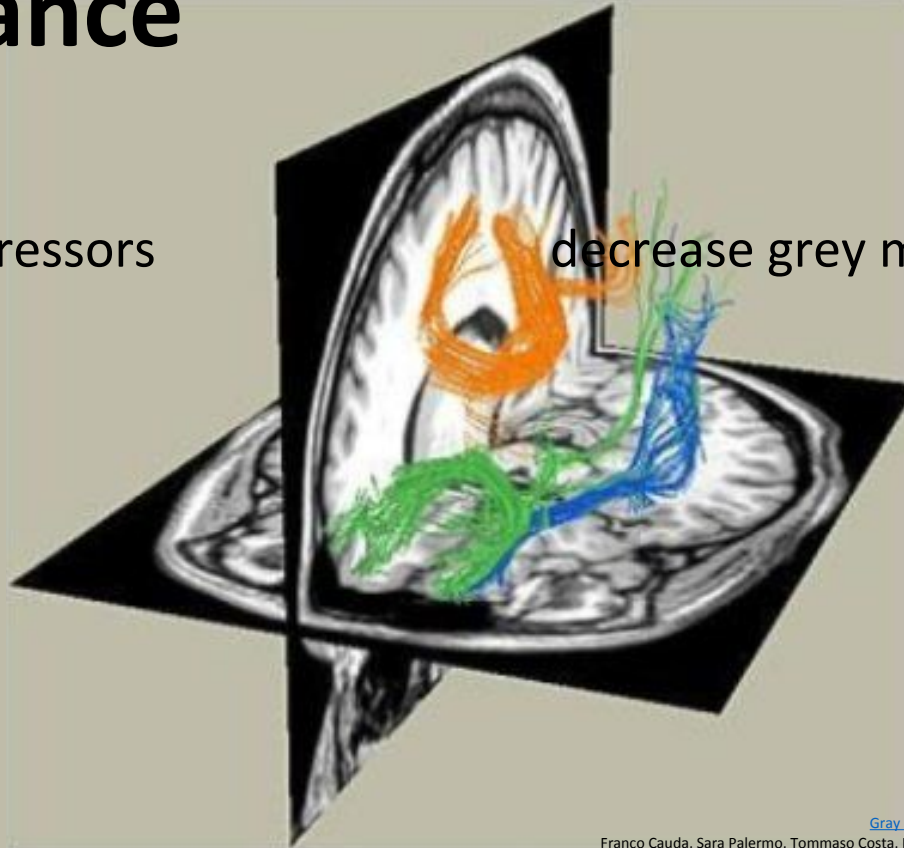
[Gray matter alterations in chronic pain: A network-oriented meta-analytic approach](#)

Franco Cauda, Sara Palermo, Tommaso Costa, Riccardo Torta, Sergio Duca, Ugo Vercelli, Giuliano Geminiani, Diana M.E. Torta
Neuroimage Clin. 2014; 4: 676–686. Published online 2014 April 16. doi: 10.1016/j.nicl.2014.04.007

Significance

Physiological stressors

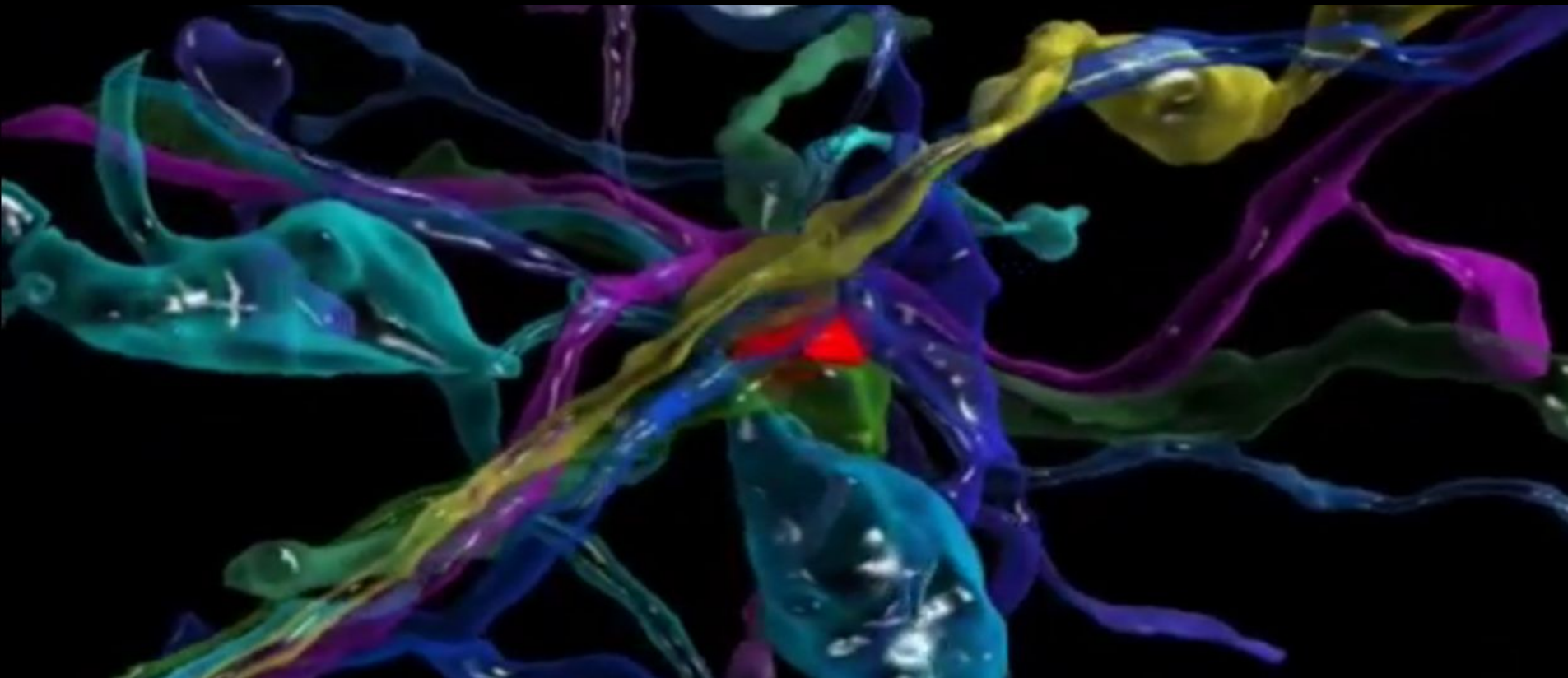
decrease grey matter density



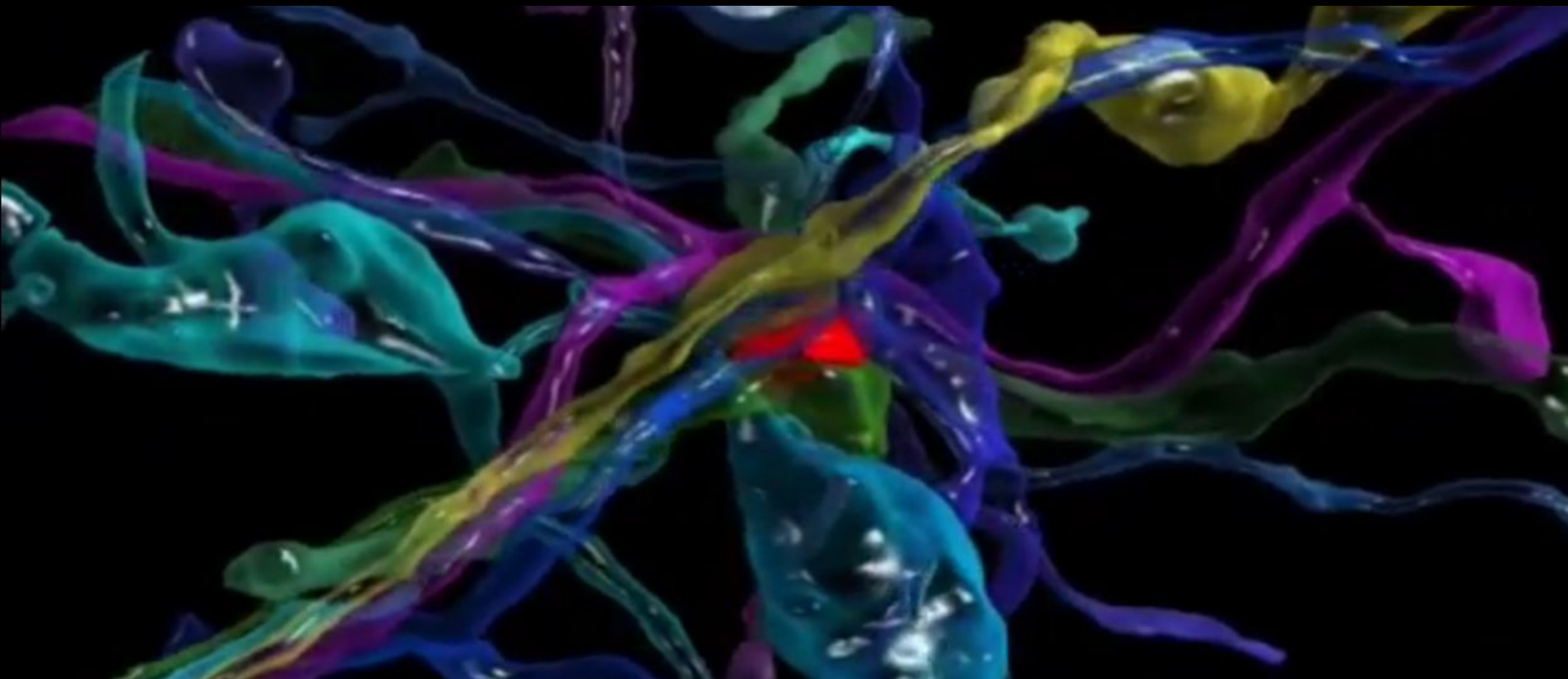
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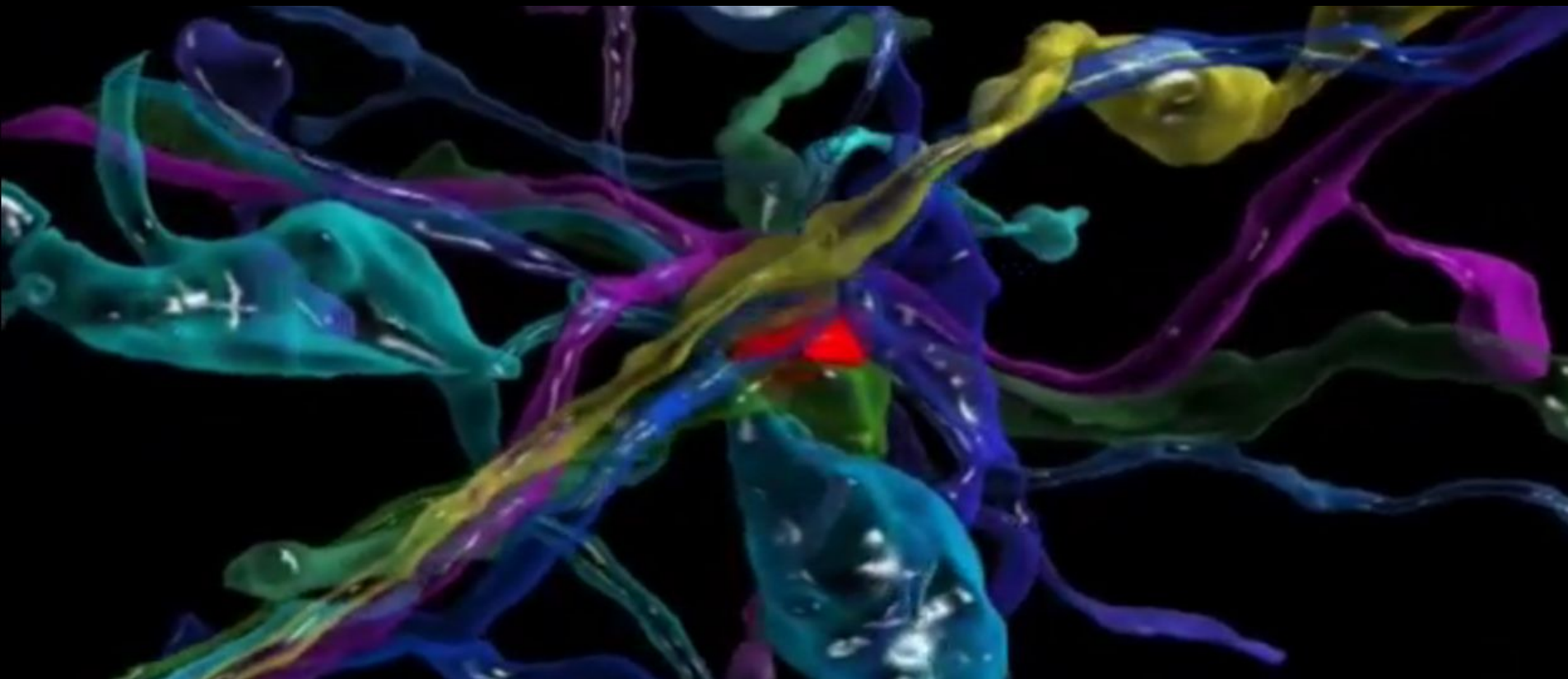
Synapse
Density

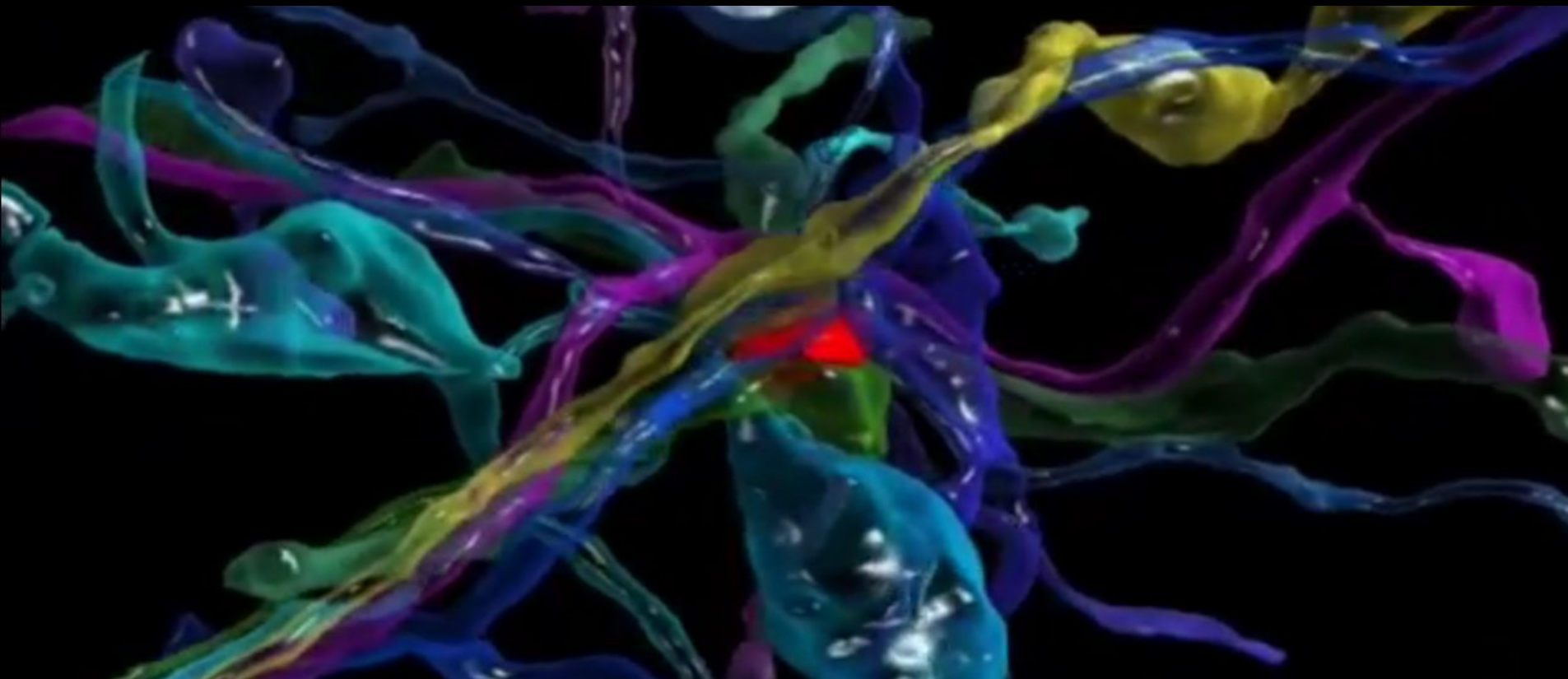


Synapse
Density → Neural
Structure



Synapse Density → Neural Structure → Neural Network Activity





Gap



Gap

Incomplete
understanding of
neural networks



Gap

Incomplete
understanding of
neural networks

Incomplete
modeling of
distributed synapses



Challenge

Large data set

Lack of clarity & labels

Only do regression

Difficult to
interpret & understand

Formal Statement of Problem

Independent variables: $X \in \mathbb{R}^4$ s.t. $x_i = (c_x, c_y, c_z, s)$

Dependent variables: $Y \in \mathbb{R}$

Unknown parameters: $\theta \in \Theta$

Regression: find a conditional distribution for $Y|X$, parameterized by θ

$$\text{i.e. } y_i = f(x_i; \theta)$$

For estimated $\hat{\theta}$, loss is function of y_i, \hat{y}_i s.t. $\hat{y}_i = f(x_i; \hat{\theta})$

In other words, $\hat{\theta} = \operatorname{argmin}_{\theta} l(y_i, \hat{y}_i)$

Model assumptions

- (X, Y) are iid
- Y is conditionally dependent on X

Algorithms

- Linear Regression

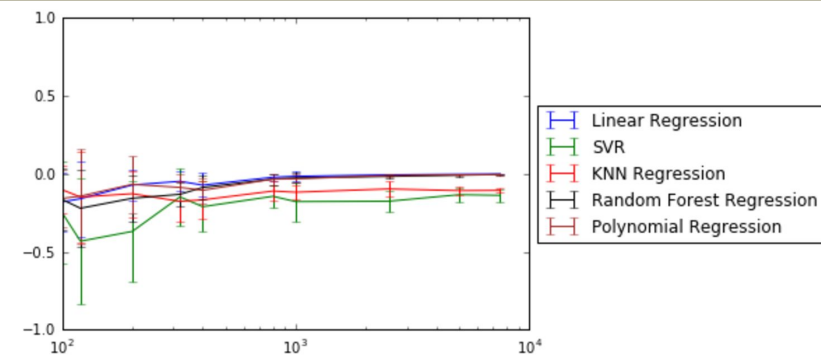
-Support Vector Regression (SVR)

-K-Nearest Neighbor Regression (KNN)

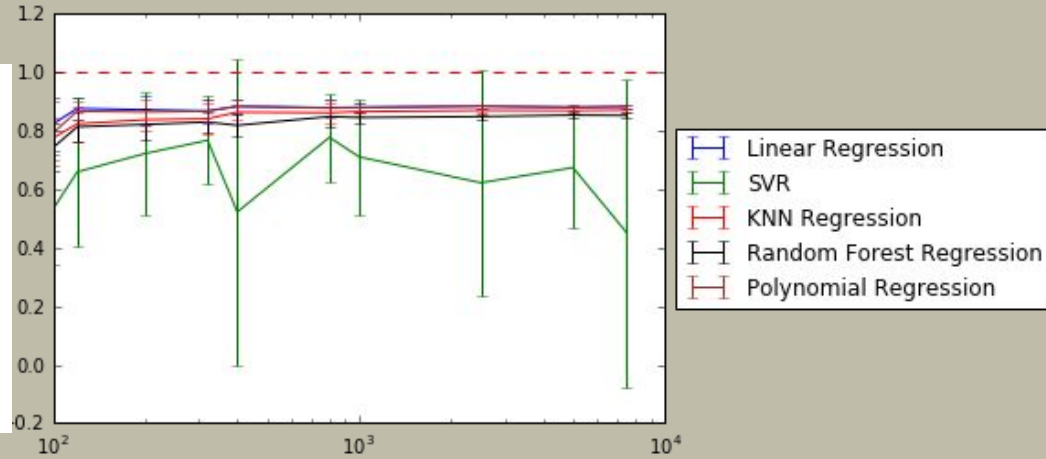
-Random Forest Regression (RF)

-Polynomial Regression (degree = 2)

Simulated regressions (10 fold cross validation)



Null model



Alternate model

Regressions on actual data (10 fold cross validation)

R² of Linear Regression: 0.62 (+/- 0.40)

R² of SVR: 0.57 (+/- 0.18)

R² of KNN Regression: 0.25 (+/- 2.54)

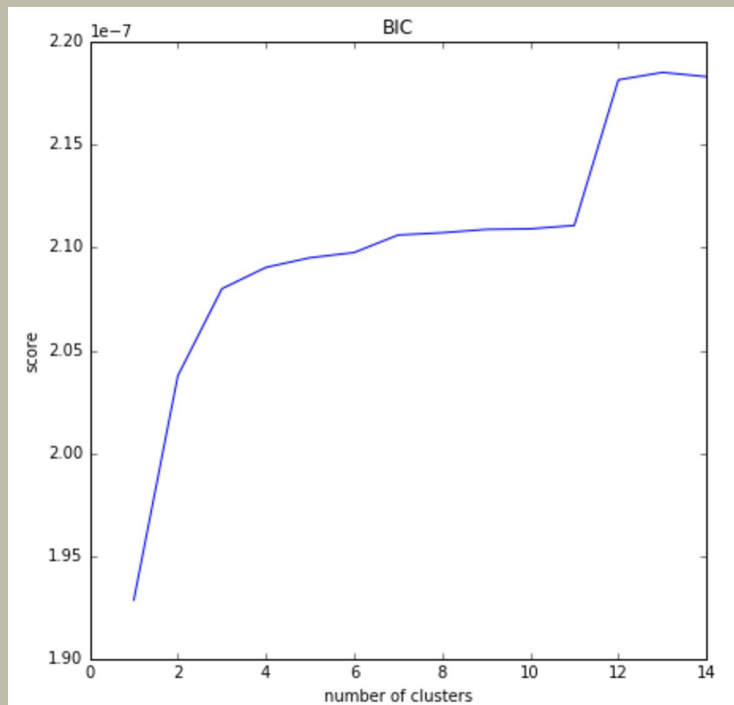
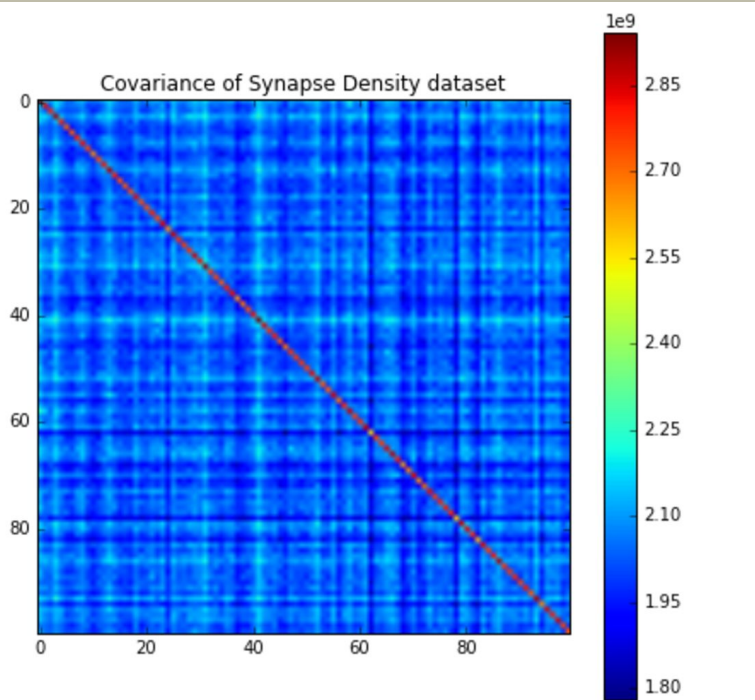
R² of Random Forest Regression: 0.79 (+/- 0.51)

R² of Polynomial Regression: 0.85 (+/- 0.27)

Model checking

Independence? Yes

Identical distributions? No



What's next?

- Interpret regression results

R^2 of Linear Regression: 0.62 (+/- 0.40)

R^2 of SVR: 0.57 (+/- 0.18)

R^2 of KNN Regression: 0.25 (+/- 2.54)

R^2 of Random Forest Regression: 0.79 (+/- 0.51)

R^2 of Polynomial Regression: 0.85 (+/- 0.27)

- More regressions? Is the success of our regressions mainly due to strong dependence between synapses and unmasked?
 - I.e. what's the marginal distribution for synapses?