



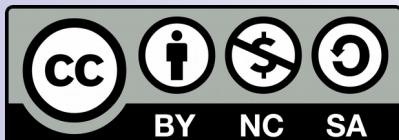
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Satellite Image Time Series (SITS)

**Rolf Simoes, Gilberto Camara, Gilberto Queiroz,
Alexandre Carvalho, Lorena Santos, Victor Maus,
Adeline Marinho, Luiz Assis**

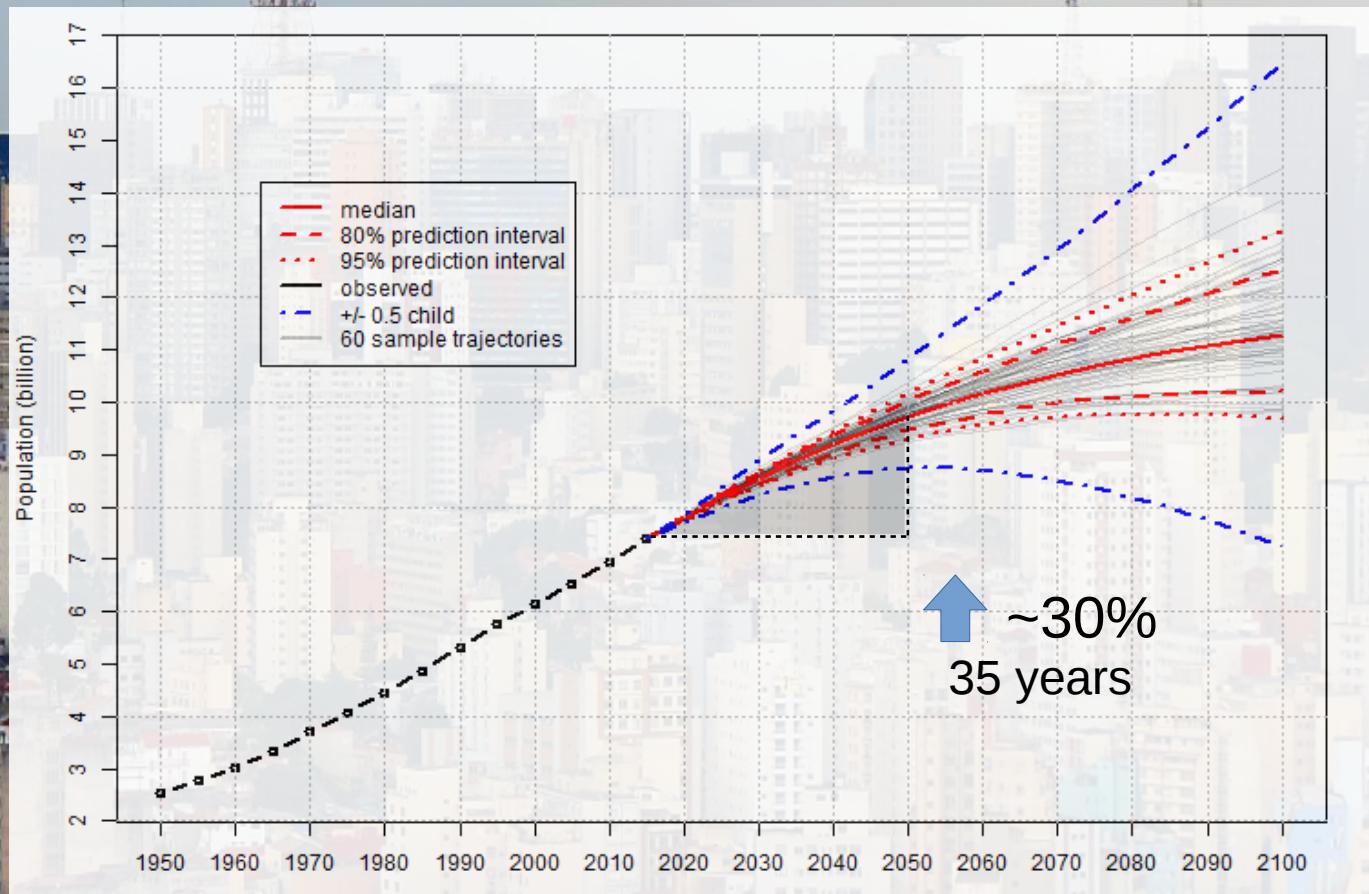
e-sensing
www.esensing.org

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INOVAÇÕES E COMUNICAÇÕES



World Total Population

Source: United Nations, Dept. Econ. Social Affairs, Pop. Division (2017)

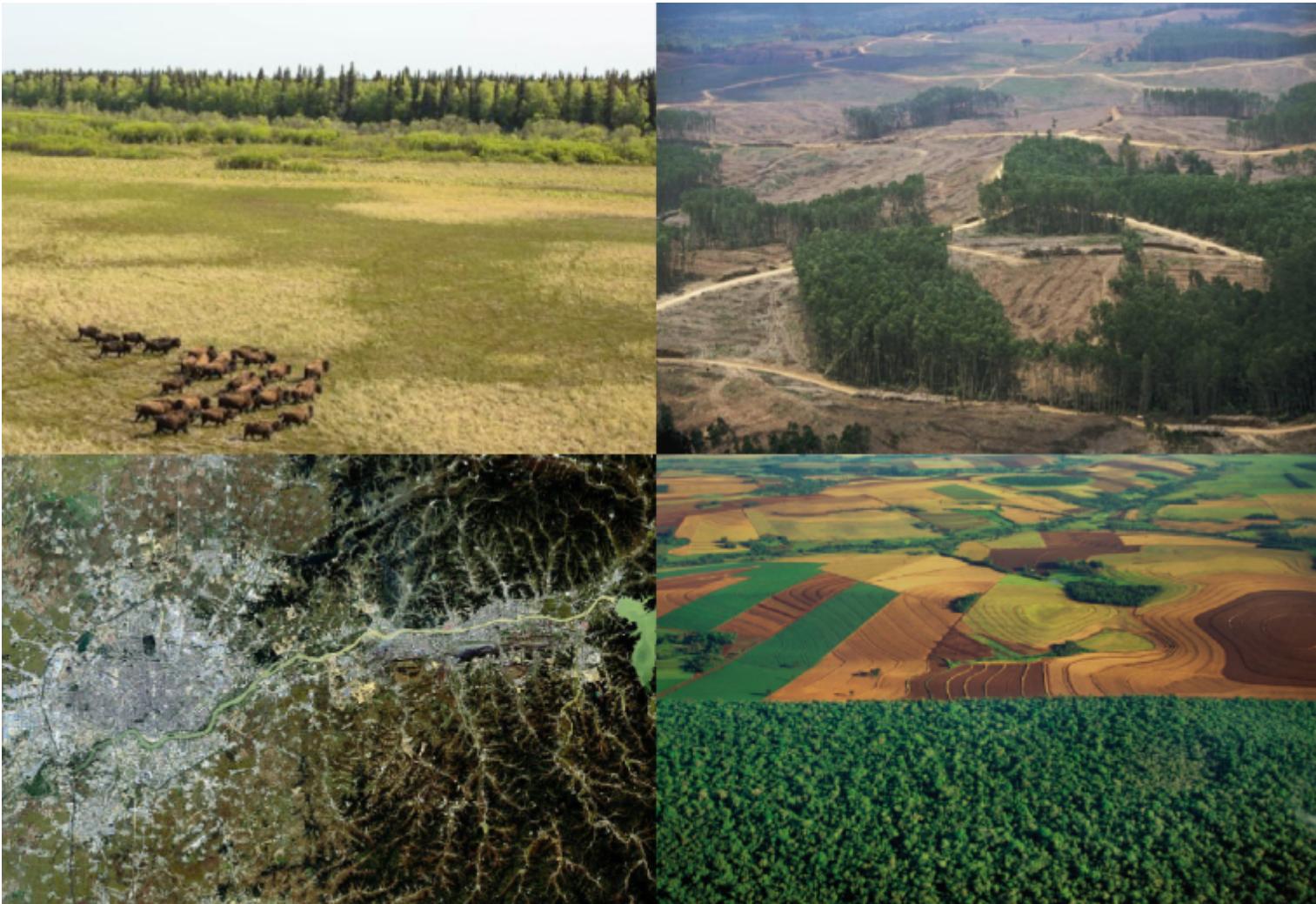


November 13, 1986

Land Use and Land Cover Change

October 30, 2016

Motivation

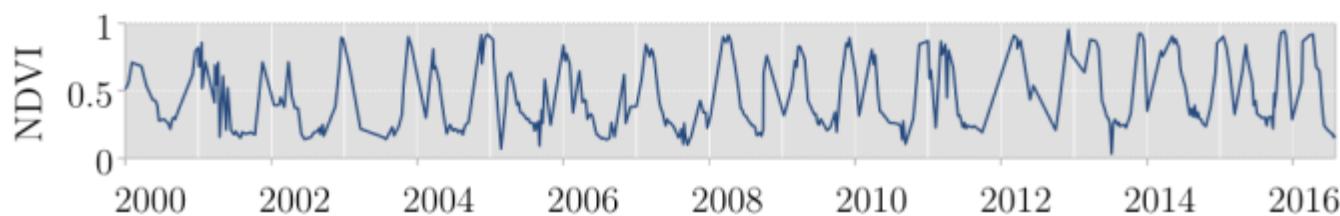
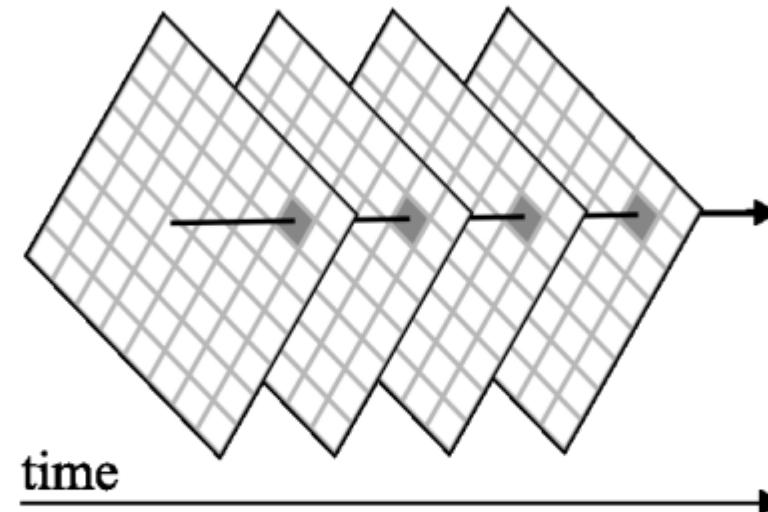


Motivation



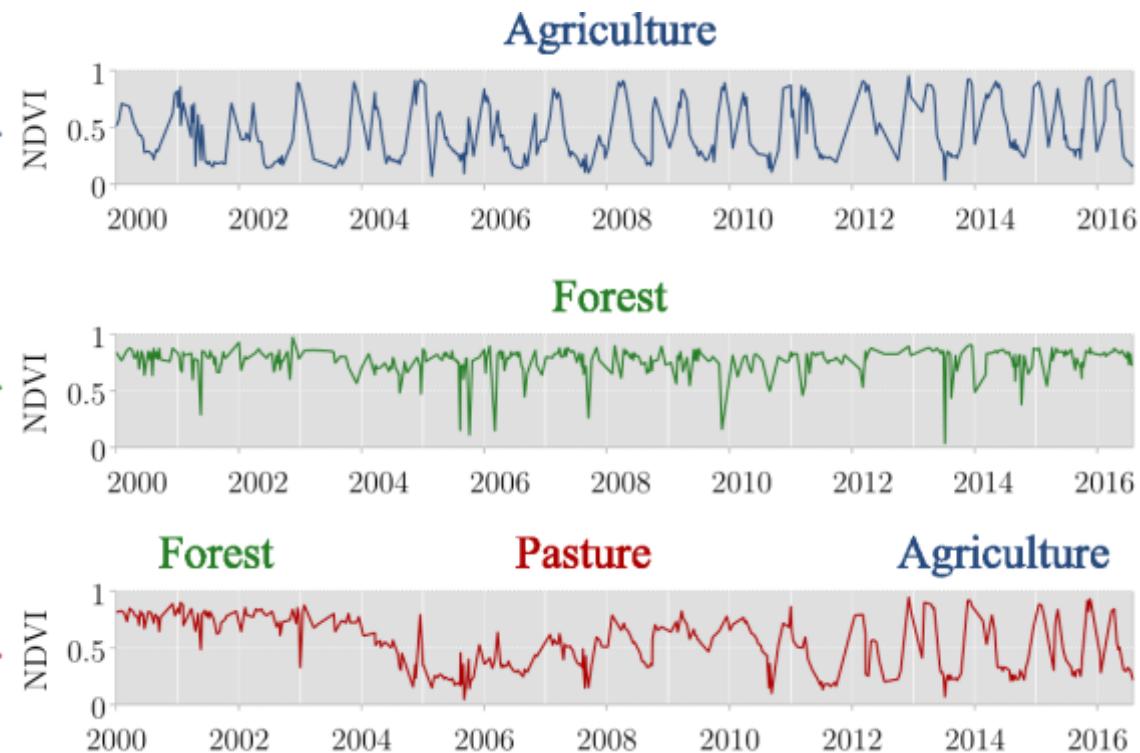
Motivation

Satellite images



Satellite Image Time Series

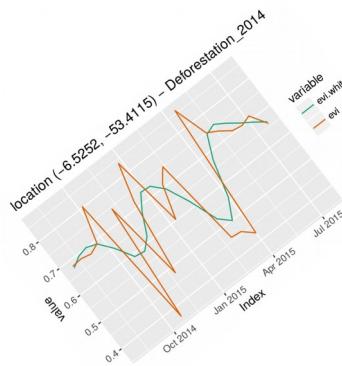
Motivation



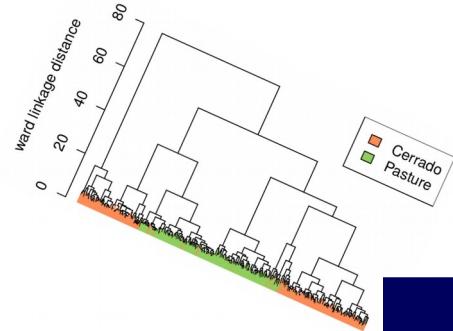
Land Trajectory

“The transformations of land cover due to actions of land use” (Camara, 2017). Adapted from: Maus, V. (IIASA, INPE)

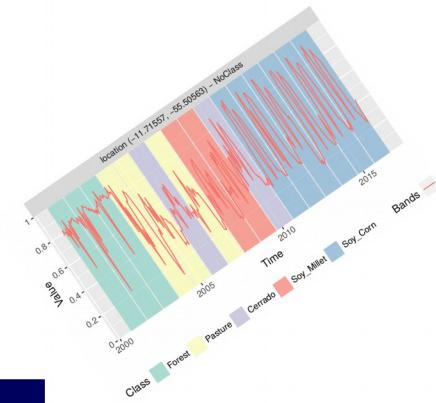
SITS package (R language)



```
## Confusion Matrix and Statistics
##          Reference
##          Cerrado Pasture
##          398     2      9    337
##          Prediction
##          Cerrado Pasture
##          398     2      9    337
##          Accuracy : 0.9853
##          95% CI : (0.9738, 0.9926)
##          Kappa : 0.9703
##          Prod Acc  Cerrado : 0.9950
##          Prod Acc  Pasture : 0.9740
##          User Acc  Cerrado : 0.9779
##          User Acc  Pasture : 0.9941
```



github.com/e-sensing/sits



Classification

Linear and Quadratic Discriminant Analysis
Random Forest
Multinomial Log-linear
Lasso Multinomial Regression
Support Vector Machine

Discriminant Analysis: Linear (LDA) and Quadratic (QDA)

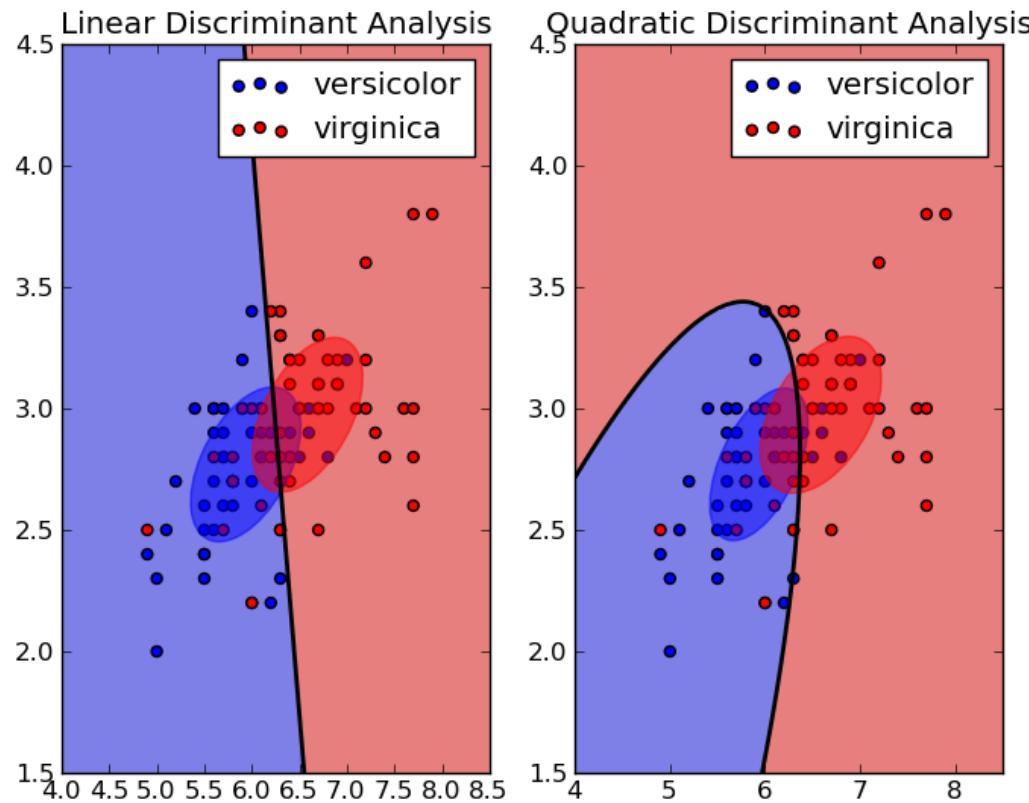


Image source:

http://scikit-learn.sourceforge.net/0.5/auto_examples/plot_lda_vs_qda.html

Random Forest (RF)

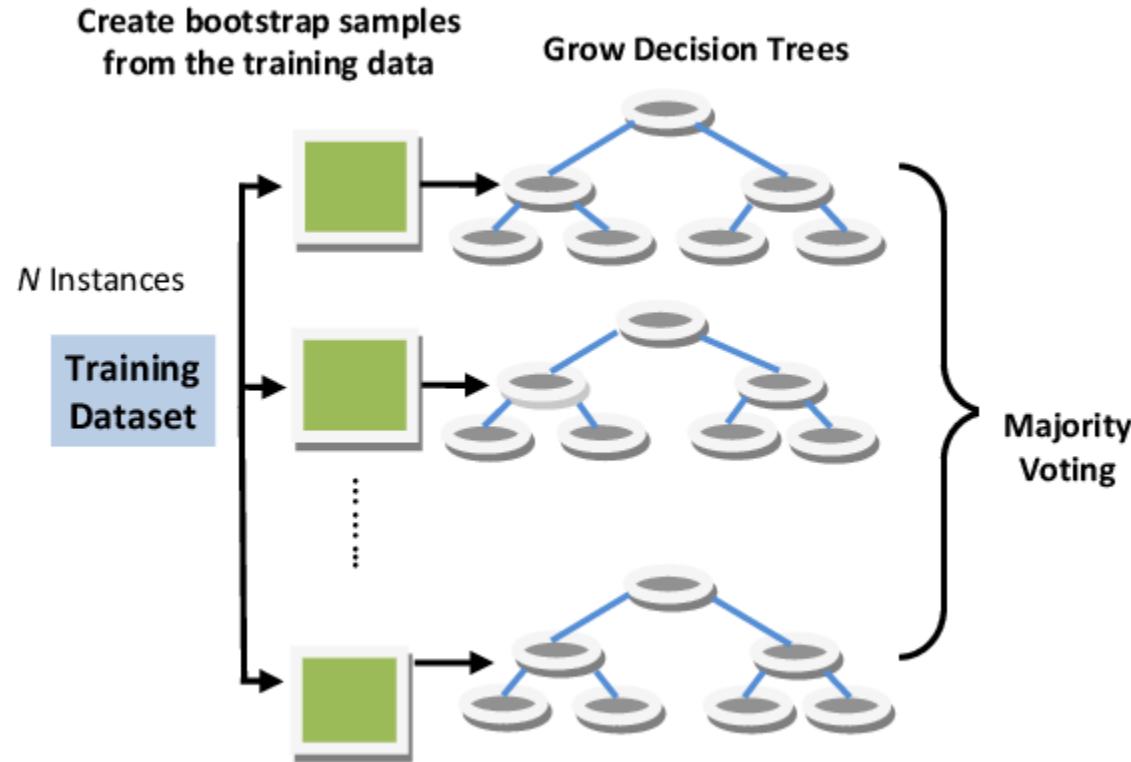


Image source:

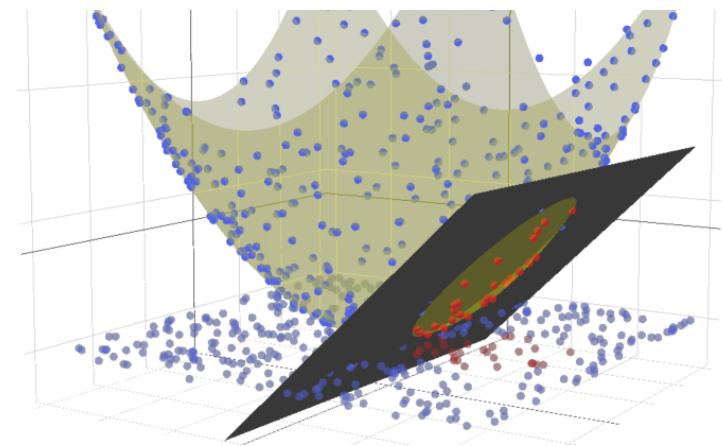
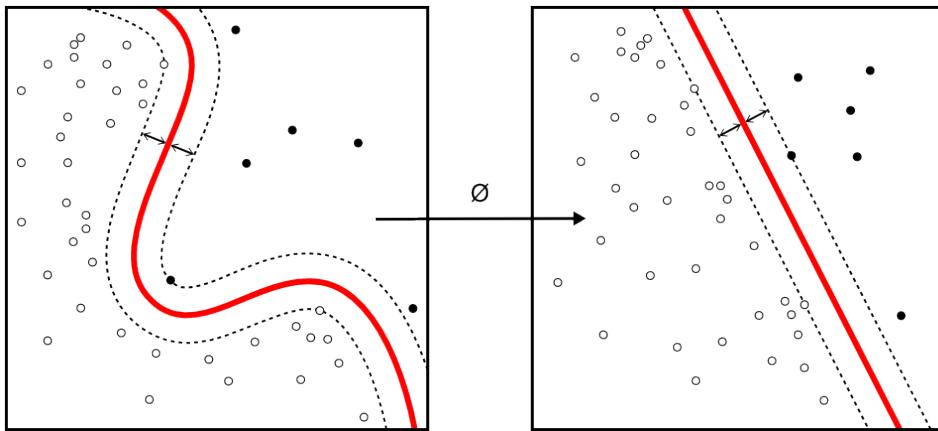
https://www.researchgate.net/publication/292676858_Churn_Prediction_System_for_Telecom_usin_g_Filter-Wrapper_and_Ensemble_Classification

Lasso Multinomial (LASSO)

$$\sum_{i=1}^n \left(y_i - \beta_0 - \sum_{j=1}^p \beta_j x_{ij} \right)^2 + \lambda \sum_{j=1}^p |\beta_j| = \text{RSS} + \lambda \sum_{j=1}^p |\beta_j|$$

$$\underset{\beta}{\text{minimize}} \left\{ \sum_{i=1}^n \left(y_i - \beta_0 - \sum_{j=1}^p \beta_j x_{ij} \right)^2 \right\} \quad \text{subject to} \quad \sum_{j=1}^p |\beta_j| \leq s$$

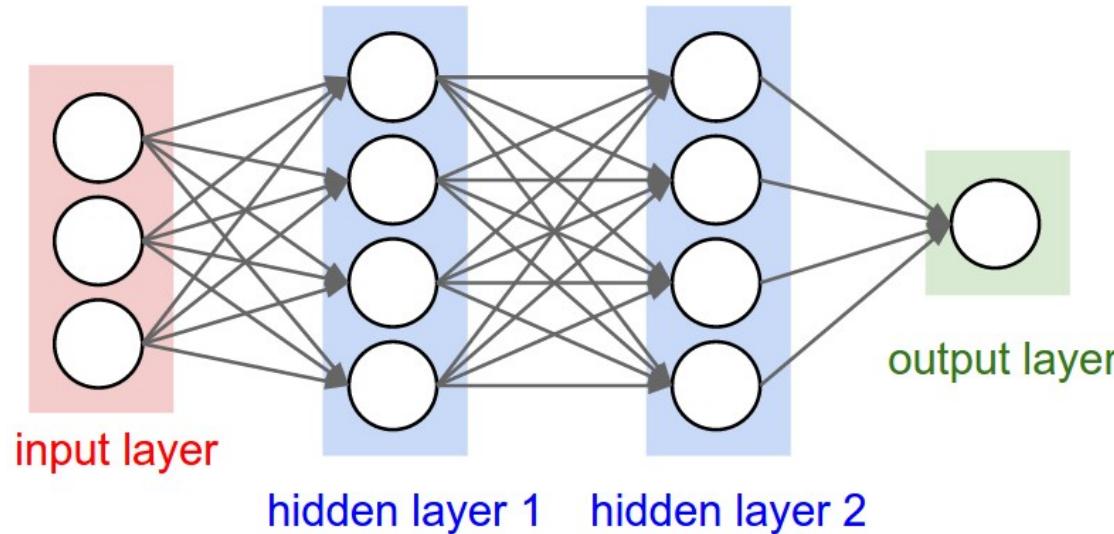
Support Vector Machine (SVM)



Images sources:

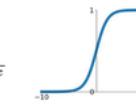
Upper left: <https://github.com/nicolaspanel/node-svm>; Lower right: <http://efavdb.com/svm-classification/>

Multi Layer Perceptrons

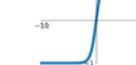


Activation Functions

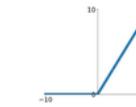
Sigmoid
 $\sigma(x) = \frac{1}{1+e^{-x}}$



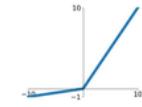
tanh
 $\tanh(x)$



ReLU
 $\max(0, x)$



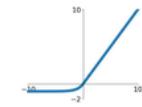
Leaky ReLU
 $\max(0.1x, x)$



Maxout
 $\max(w_1^T x + b_1, w_2^T x + b_2)$

ELU

$$\begin{cases} x & x \geq 0 \\ \alpha(e^x - 1) & x < 0 \end{cases}$$

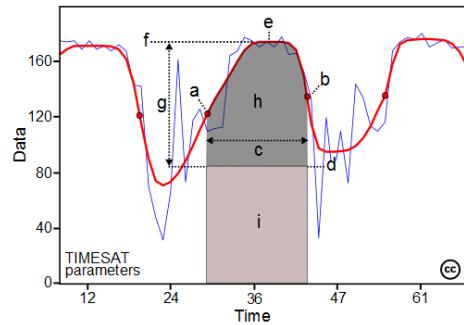


Images sources:

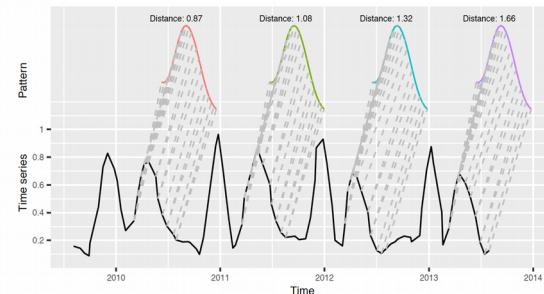
Upper left: <https://stats.stackexchange.com/questions/256342/how-many-learnable-parameters-does-a-fully-connected-layer-have-without-the-bias>; Lower right: <https://www.quora.com/Why-is-ReLU-the-most-common-activation-function-used-in-neural-networks>

Time series & LULC classification

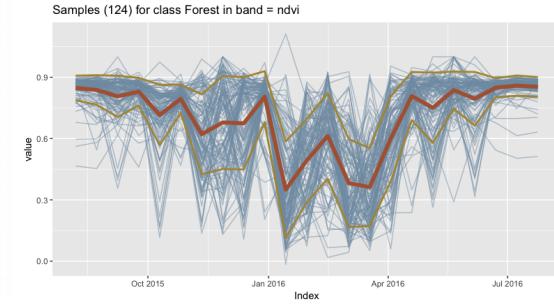
TIMESAT



TWDTW



Our approach



Dimensional Reduction

Classification Model

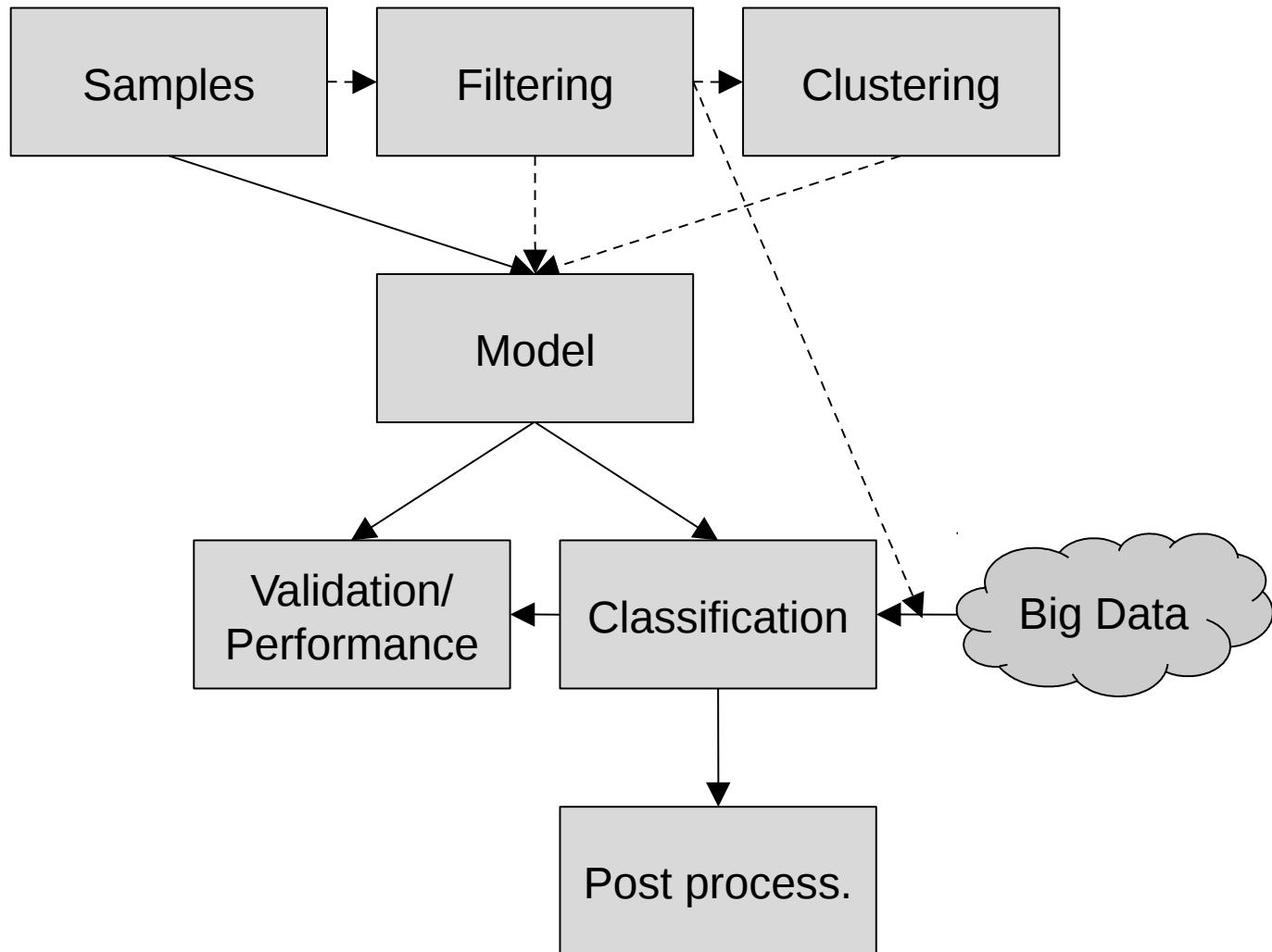
Shape-based search

Nearest Prototype Distance

n-dimensional Input space

Machine Learning Classification

SITS workflow



E-sensing software development repository

github.com/e-sensing/