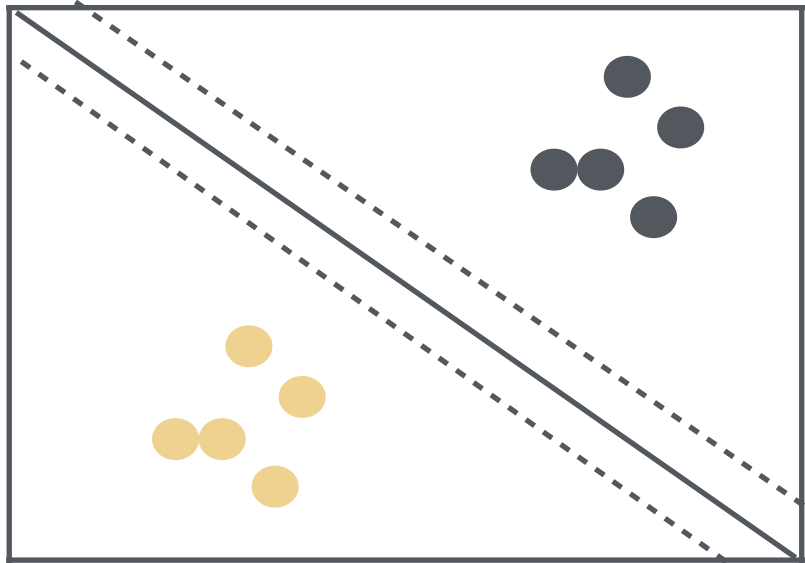


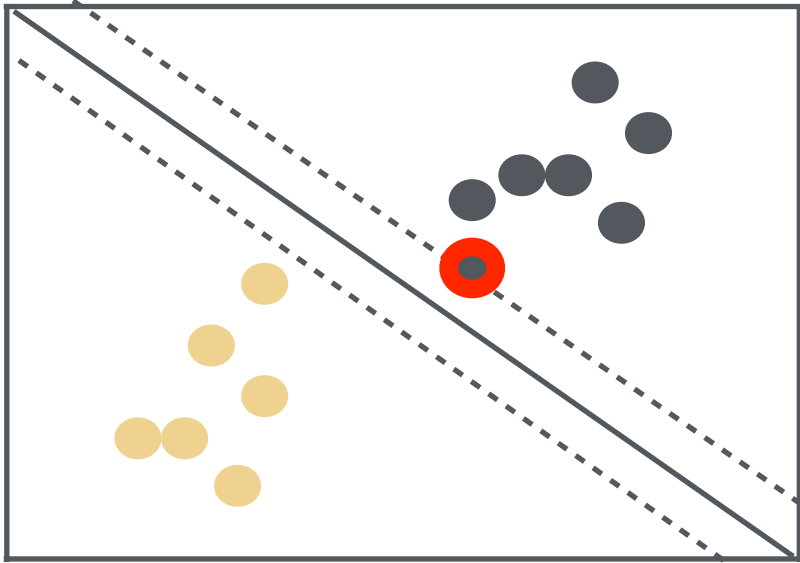
# Support Vector Machine

# Support Vector Machines

$$y = t(w^T x + b)$$



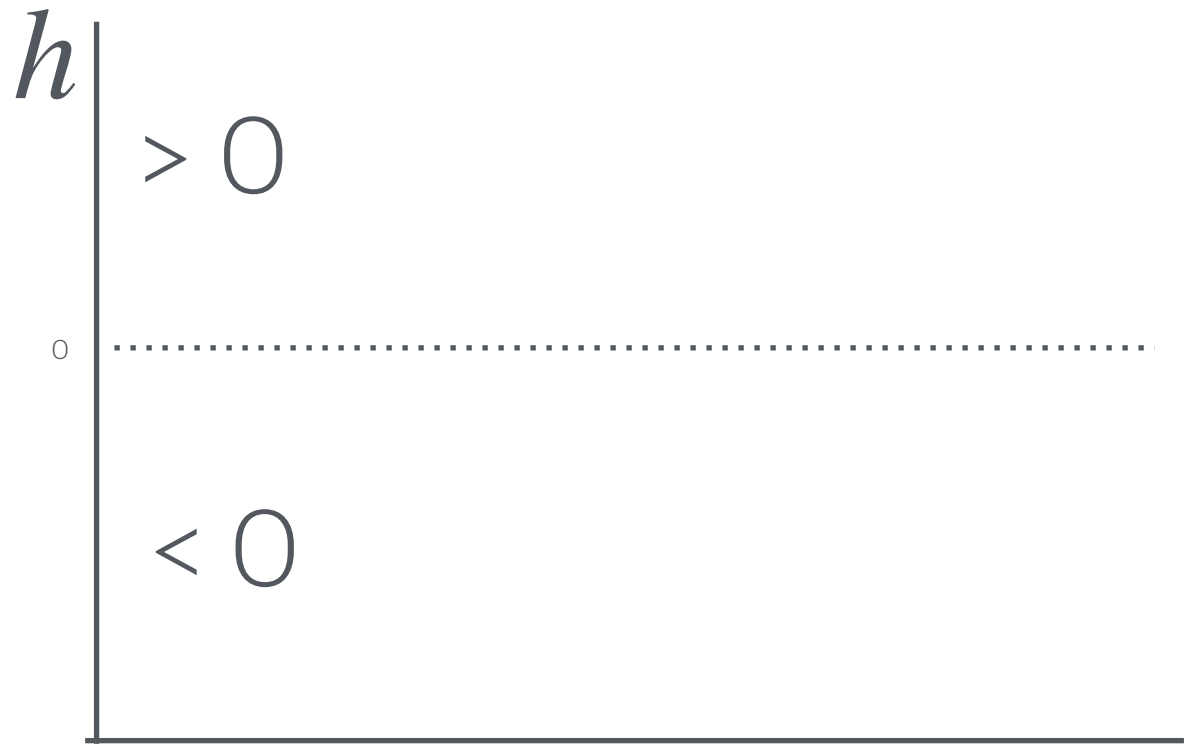
Hard Margin-  
No instances can live inside the margin



Soft Margin-  
Limit violations

Prediction

$$h \begin{cases} 0 & \text{if } w^T x + b < 0 \\ 1 & \text{if } w^T x + b \geq 0 \end{cases}$$



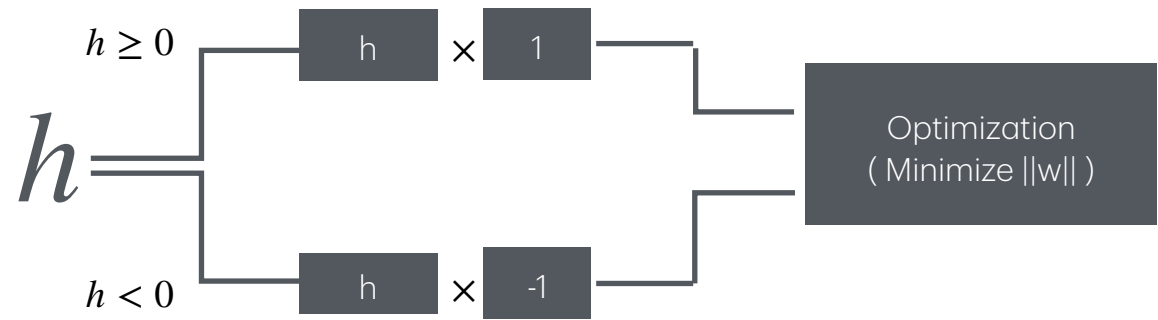
Label = Cancer = 1

Label = Not Cancer = -1

Goal is to create a model which widens the margin ( by minimizing weight vector )

Goal is to create a model which wides the margin ( by minimizing weight vector )

| x1  | x2  | Label (t) |
|-----|-----|-----------|
| ... | ... | 1         |
| ... | ... | -1        |
| ... | ... | 1         |
| ... | ... | -1        |

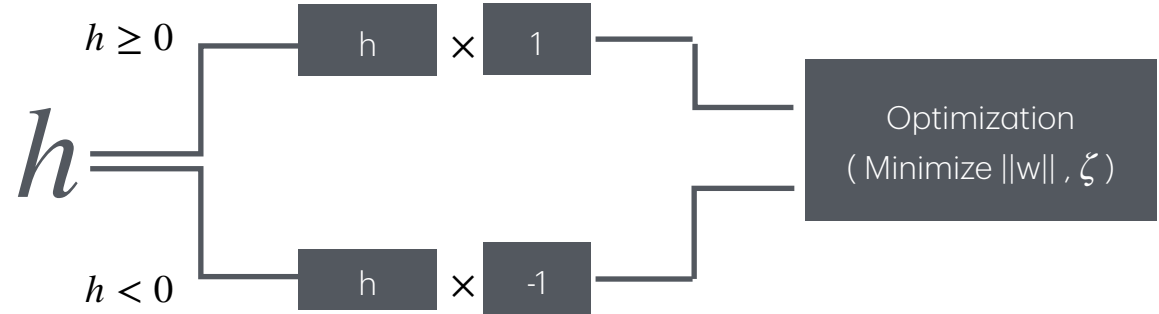


**Trainable elements:**

- weights and bias
- train to make the model as large as possible without producing violations

$$\text{minimize}_{w,b,c} \frac{1}{2} w^T w$$

| X1  | x2  | Label (t) | Slack |
|-----|-----|-----------|-------|
| ... | ... | 1         |       |
| ... | ... | -1        |       |
| ... | ... | 1         |       |
| ... | ... | -1        |       |



**Trainable elements:**

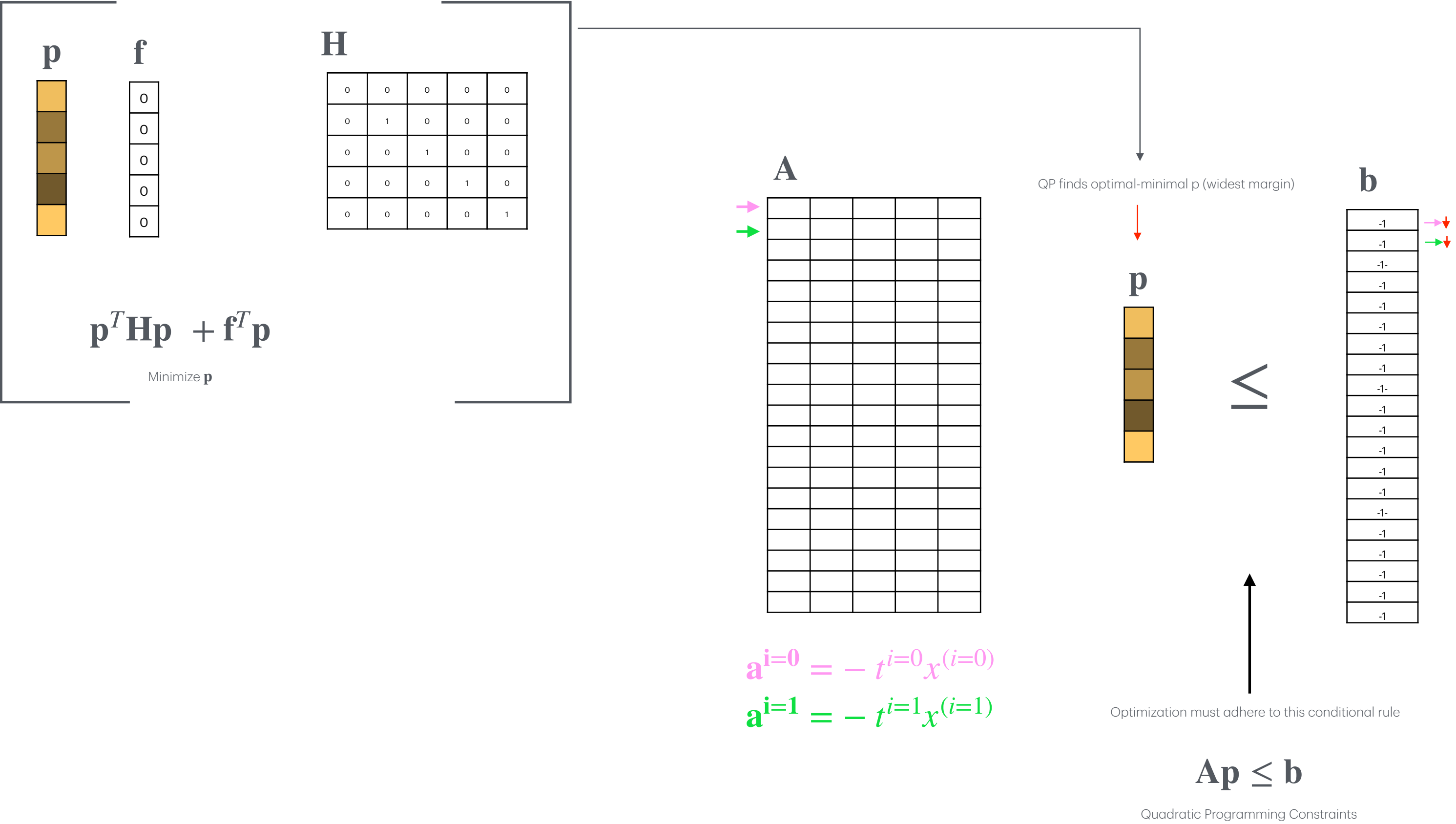
- weights and bias
- train to make the margin as large as possible without producing violations
  - Minimize weights widens margin

$$\text{minimize}_{w,b,c} \frac{1}{2} w^T w + C \sum_{i=1}^m \zeta$$

- slack variable  $\zeta$ , how much an instance is allowed to violate margin
- train to make this small
  - Minimize slack variable



Quadratic Problem: Hard



<

## Quadratic Problem: Soft

## Features

|      |              |             |               |             |
|------|--------------|-------------|---------------|-------------|
| Bias | Petal Length | Petal Width | Septal Length | Sepal Width |
|------|--------------|-------------|---------------|-------------|

## Target

| Iris Virsonica | Not Iris Virsonica |
|----------------|--------------------|
|----------------|--------------------|

**p**

**f**

Initially computed using random function

Additional Parameters

**b**[illegible]

A

The diagram illustrates the structure of a linear model, showing the relationship between bias, features, and additional parameters ( $m$ ).

**Top Section: Bias and Features**

- bias**: A vertical column of 1s, representing the bias term.
- features**: A grid of 1s, representing the feature matrix.

**Bottom Section: Additional Parameters ( $m$ )**

- Additional: Constraints ( $m$ )**: A vertical column of 1s, representing the constraints.
- Additional params ( $m$ )**: A grid of 1s, representing the additional parameters.

**Relationships and Constraints**

- The **bias** and **features** are combined to form the **Additional: Constraints ( $m$ )**.
- The **Additional: Constraints ( $m$ )** and **Additional params ( $m$ )** are combined to form the **Additional params ( $m$ )**.
- The **Additional params ( $m$ )** are used to calculate the **Additional: Constraints ( $m$ )**.

**Mathematical Representation**

The diagram shows the relationship between the bias, features, and additional parameters ( $m$ ) in a linear model. The bias is represented by a vector of 1s, and the features are represented by a matrix of 1s. The additional parameters ( $m$ ) are represented by a matrix of 1s. The constraints are represented by a vector of 1s. The diagram illustrates how the bias and features are combined to form the constraints, and how the constraints and additional parameters are combined to form the additional parameters.

$$\mathbf{a}^{i=0} = -t^{i=0}x^{(i=0)}$$

Params  
create a  
identity  
matrix

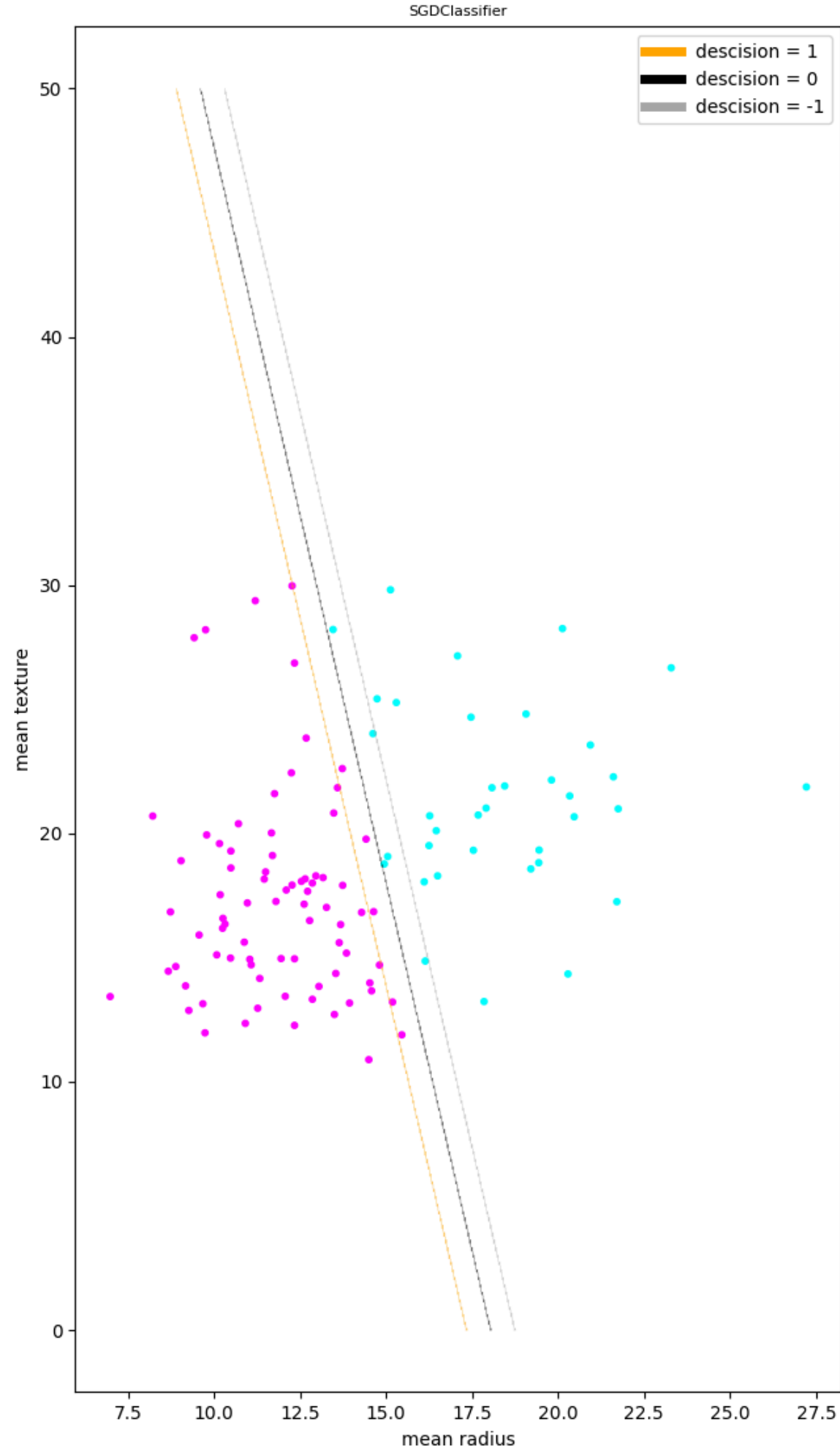
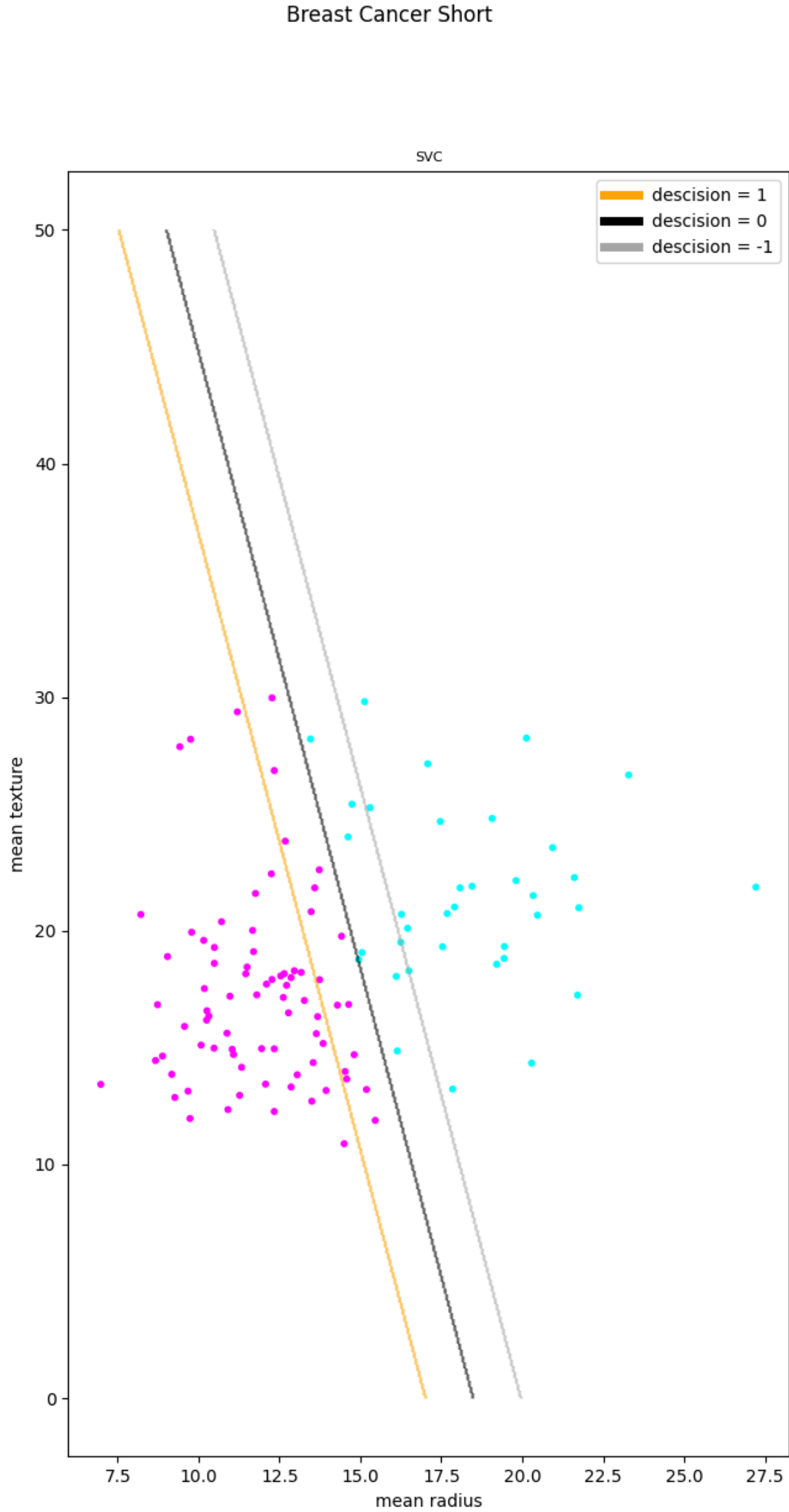
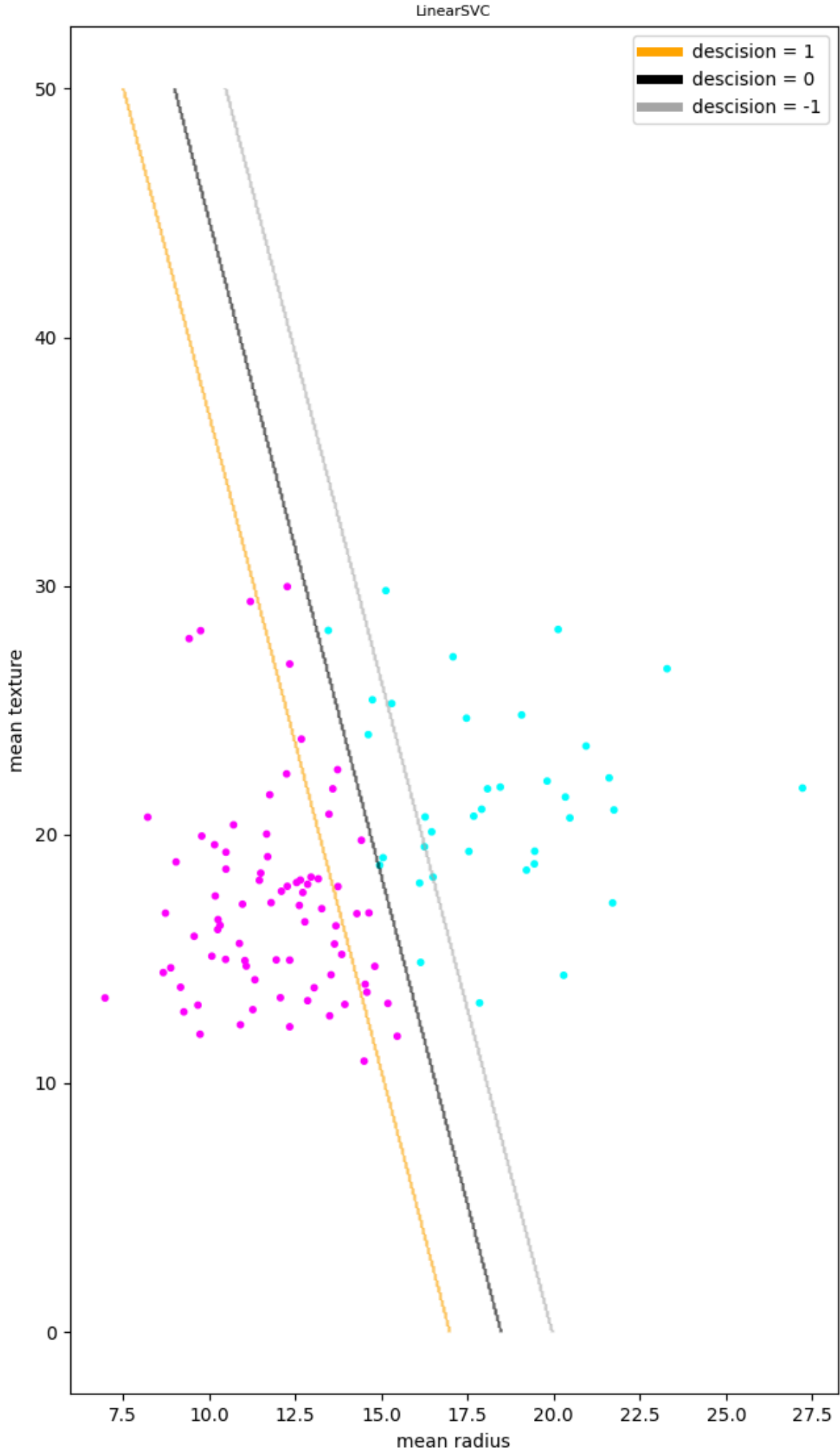
Params  
create a  
identity  
matrix



Breast Cancer:

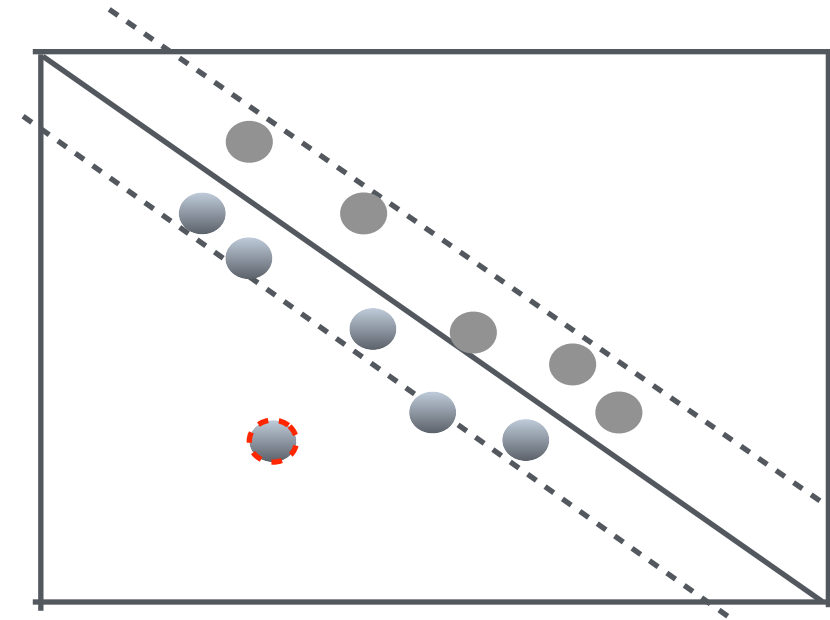
|           |        |
|-----------|--------|
| Malignant | Benign |
|-----------|--------|

[  
  '**mean radius**'  
  '**mean texture**'  
  'mean perimeter'  
  'mean area'  
  'mean smoothness'  
  'mean compactness'  
  'mean concavity'  
  'mean concave points'  
  'mean symmetry'  
  'mean fractal dimension'  
  'radius error'  
  'texture error'  
  'perimeter error'  
  'area error'  
  'smoothness error'  
  'compactness error'  
  'concavity error'  
  'concave points error'  
  'symmetry error'  
  'fractal dimension error'  
  'worst radius'  
  'worst texture'  
  'worst perimeter'  
  'worst area'  
  'worst smoothness'  
  'worst compactness'  
  'worst concavity'  
  'worst concave points'  
  'worst symmetry'  
  'worst fractal dimension'  
]





# Support Vector Regression



Fit dataset instances 'inside the street'

Can be used to find non-conforming outliers within a dataset