## Import neccessery libraries

```
In [74]:  import pandas as pd
          import numpy as np
          from sklearn.model_selection import train_test_split
          from sklearn.metrics import confusion_matrix
          from keras.models import Sequential
          from keras.layers import Dense,Flatten, Activation,Layer,Lambda
          import seaborn as sns
          from sklearn import preprocessing
          from keras.layers import Dropout
          from keras import regularizers
          from sklearn.model_selection import train_test_split
          from matplotlib import pyplot as plt
          from sklearn.decomposition import PCA
          from mlxtend.plotting import plot_decision_regions
          from tensorflow import keras
          import warnings
          warnings.filterwarnings('ignore')
```

## Problem

**PREDICT THE BURNED AREA OF FOREST FIRES WITH NEURAL NETWORKS**

## Import data

```
In [2]:  forest_data = pd.read_csv('forestfires.csv')
         forest_data
```

Out[2]:

| | month | day | FFMC | DMC | DC | ISI | temp | RH | wind | rain | ... | monthfeb | monthjan | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | mar | fri | 86.2 | 26.2 | 94.3 | 5.1 | 8.2 | 51 | 6.7 | 0.0 | ... | 0 | 0 | |
| 1 | oct | tue | 90.6 | 35.4 | 669.1 | 6.7 | 18.0 | 33 | 0.9 | 0.0 | ... | 0 | 0 | |
| 2 | oct | sat | 90.6 | 43.7 | 686.9 | 6.7 | 14.6 | 33 | 1.3 | 0.0 | ... | 0 | 0 | |
| 3 | mar | fri | 91.7 | 33.3 | 77.5 | 9.0 | 8.3 | 97 | 4.0 | 0.2 | ... | 0 | 0 | |
| 4 | mar | sun | 89.3 | 51.3 | 102.2 | 9.6 | 11.4 | 99 | 1.8 | 0.0 | ... | 0 | 0 | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| 512 | aug | sun | 81.6 | 56.7 | 665.6 | 1.9 | 27.8 | 32 | 2.7 | 0.0 | ... | 0 | 0 | |
| 513 | aug | sun | 81.6 | 56.7 | 665.6 | 1.9 | 21.9 | 71 | 5.8 | 0.0 | ... | 0 | 0 | |
| 514 | aug | sun | 81.6 | 56.7 | 665.6 | 1.9 | 21.2 | 70 | 6.7 | 0.0 | ... | 0 | 0 | |
| 515 | aug | sat | 94.4 | 146.0 | 614.7 | 11.3 | 25.6 | 42 | 4.0 | 0.0 | ... | 0 | 0 | |
| 516 | nov | tue | 79.5 | 3.0 | 106.7 | 1.1 | 11.8 | 31 | 4.5 | 0.0 | ... | 0 | 0 | |

517 rows × 31 columns

```
In [3]:  forest_data.drop(["month","day"],axis=1,inplace = True)
```

```
In [4]:   forest_data["size_category"].value_counts()
```

Out[4]:   small    378
          large    139
          Name: size_category, dtype: int64

```
In [5]:   forest_data.isnull().sum()
```

Out[5]:   FFMC             0
          DMC              0
          DC               0
          ISI              0
          temp             0
          RH               0
          wind             0
          rain             0
          area             0
          dayfri           0
          daymon           0
          daysat           0
          daysun           0
          daythu           0
          daytue           0
          daywed           0
          monthapr         0
          monthaug         0
          monthdec         0
          monthfeb         0
          monthjan         0
          monthjul         0
          monthjun         0
          monthmar         0
          monthmay         0
          monthnov         0
          monthoct         0
          monthsep         0
          size_category    0
          dtype: int64

```
In [6]:   forest_data.shape
```

Out[6]:   (517, 29)

```
In [7]:   df = forest_data.describe().T
          df
```

Out[7]:

|      | count | mean       | std        | min  | 25%   | 50%    | 75%    | max    |
|------|-------|------------|------------|------|-------|--------|--------|--------|
| FFMC | 517.0 | 90.644681  | 5.520111   | 18.7 | 90.2  | 91.60  | 92.90  | 96.20  |
| DMC  | 517.0 | 110.872340 | 64.046482  | 1.1  | 68.6  | 108.30 | 142.40 | 291.30 |
| DC   | 517.0 | 547.940039 | 248.066192 | 7.9  | 437.7 | 664.20 | 713.90 | 860.60 |
| ISI  | 517.0 | 9.021663   | 4.559477   | 0.0  | 6.5   | 8.40   | 10.80  | 56.10  |
| temp | 517.0 | 18.889168  | 5.806625   | 2.2  | 15.5  | 19.30  | 22.80  | 33.30  |
| RH   | 517.0 | 44.288201  | 16.317469  | 15.0 | 33.0  | 42.00  | 53.00  | 100.00 |

|  | count | mean | std | min | 25% | 50% | 75% | max |
|---|---|---|---|---|---|---|---|---|
| **wind** | 517.0 | 4.017602 | 1.791653 | 0.4 | 2.7 | 4.00 | 4.90 | 9.40 |
| **rain** | 517.0 | 0.021663 | 0.295959 | 0.0 | 0.0 | 0.00 | 0.00 | 6.40 |
| **area** | 517.0 | 12.847292 | 63.655818 | 0.0 | 0.0 | 0.52 | 6.57 | 1090.84 |
| **dayfri** | 517.0 | 0.164410 | 0.371006 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **daymon** | 517.0 | 0.143133 | 0.350548 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **daysat** | 517.0 | 0.162476 | 0.369244 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **daysun** | 517.0 | 0.183752 | 0.387657 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **daythu** | 517.0 | 0.117988 | 0.322907 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **daytue** | 517.0 | 0.123791 | 0.329662 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **daywed** | 517.0 | 0.104449 | 0.306138 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthapr** | 517.0 | 0.017408 | 0.130913 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthaug** | 517.0 | 0.355899 | 0.479249 | 0.0 | 0.0 | 0.00 | 1.00 | 1.00 |
| **monthdec** | 517.0 | 0.017408 | 0.130913 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthfeb** | 517.0 | 0.038685 | 0.193029 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthjan** | 517.0 | 0.003868 | 0.062137 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthjul** | 517.0 | 0.061896 | 0.241199 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthjun** | 517.0 | 0.032882 | 0.178500 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthmar** | 517.0 | 0.104449 | 0.306138 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthmay** | 517.0 | 0.003868 | 0.062137 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthnov** | 517.0 | 0.001934 | 0.043980 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |
| **monthoct** | 517.0 | 0.029014 | 0.168007 | 0.0 | 0.0 | 0.00 | 0.00 | 1.00 |

# Outlier Check

```python
ax = sns.boxplot(forest_data['area'])
```
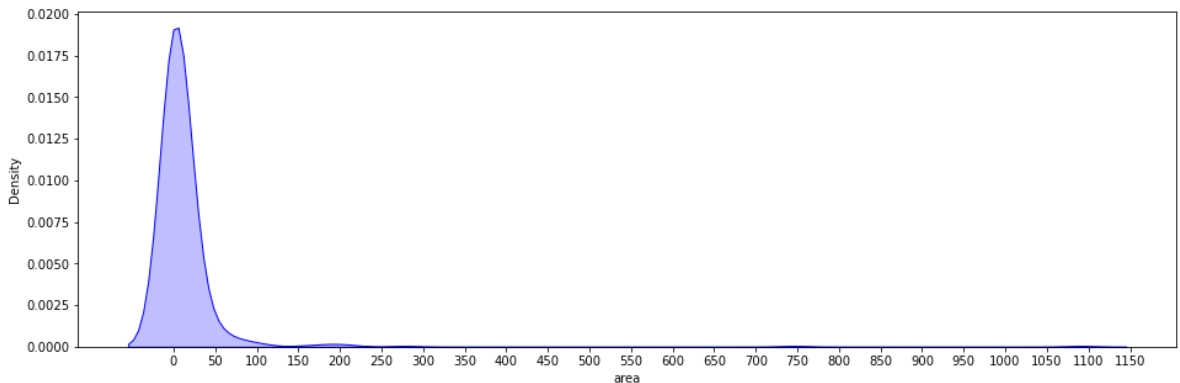
In [8]:
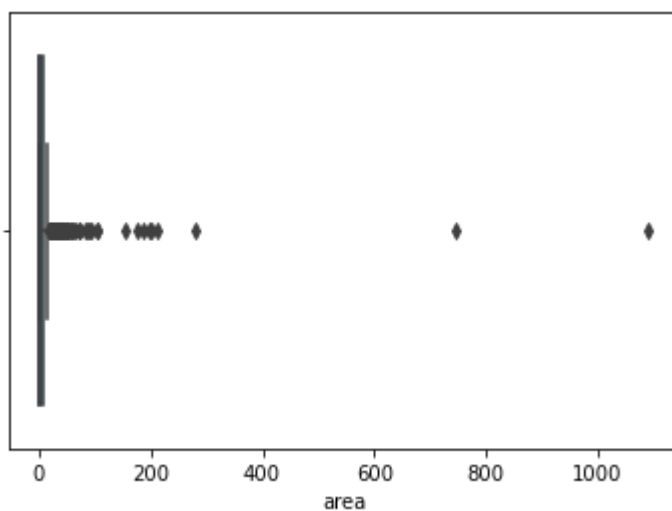


There are 3 Outlier instances in our data

```
In [9]:   plt.rcParams["figure.figsize"] = 9,5
```

```
In [10]:  plt.figure(figsize=(16,5))
          print("Skew: {}".format(forest_data['area'].skew()))
          print("Kurtosis: {}".format(forest_data['area'].kurtosis()))
          ax = sns.kdeplot(forest_data['area'],shade=True,color='b')
          plt.xticks([i for i in range(0,1200,50)])
          plt.show()
```

```
Skew: 12.846933533934868
Kurtosis: 194.1407210942299
```



The Data is highly skewed and has large kurtosis value.Majority of the forest fires do not cover a large area, most of the damaged area is under 100 hectares of land

```
In [11]:  dfa = forest_data[forest_data.columns[0:10]]
          month_colum = dfa.select_dtypes(include='object').columns.tolist()
```

```
In [12]:  plt.figure(figsize=(16,10))
          for i,col in enumerate(month_colum,1):
              plt.subplot(2,2,i)
              sns.countplot(data=dfa,y=col)
              plt.subplot(2,2,i+2)
              forest_data[col].value_counts(normalize=True).plot.bar()
              plt.ylabel(col)
              plt.xlabel('% distribution per category')
          plt.tight_layout()
          plt.show()
```

```
<Figure size 1152x720 with 0 Axes>
```

Majority of the fire accors in the month August and September

For Days Sunday and Friday have recoreded the most cases

```
In [13]:  num_columns = dfa.select_dtypes(exclude='object').columns.tolist()
```

```python
plt.figure(figsize=(18,40))
for i,col in enumerate(num_columns,1):
    plt.subplot(8,4,i)
    sns.kdeplot(forest_data[col],color='r',shade=True)
    plt.subplot(8,4,i+10)
    forest_data[col].plot.box()
plt.tight_layout()
plt.show()
num_data = forest_data[num_columns]
pd.DataFrame(data=[num_data.skew(),num_data.kurtosis()],index=['skewness',
```
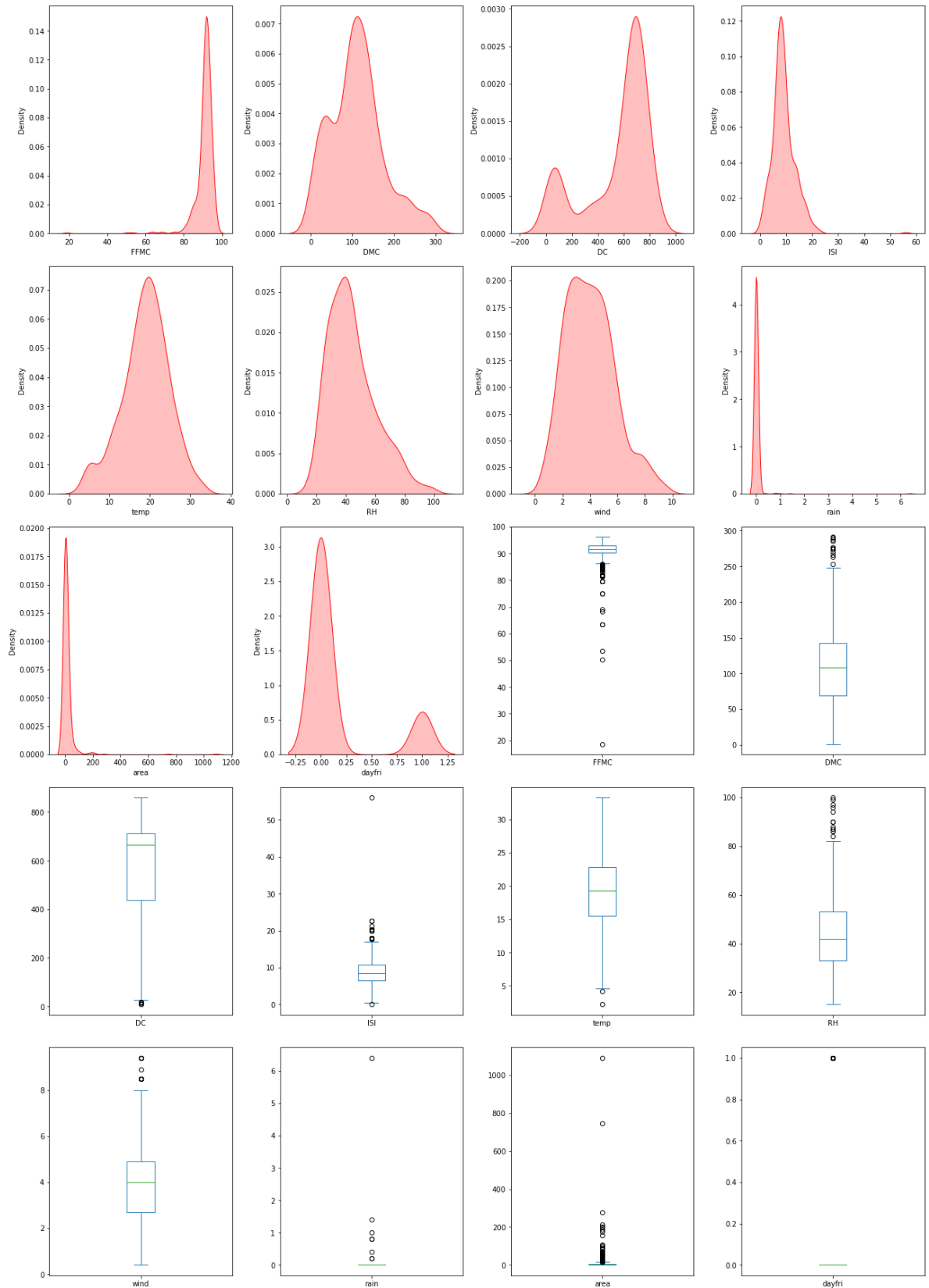
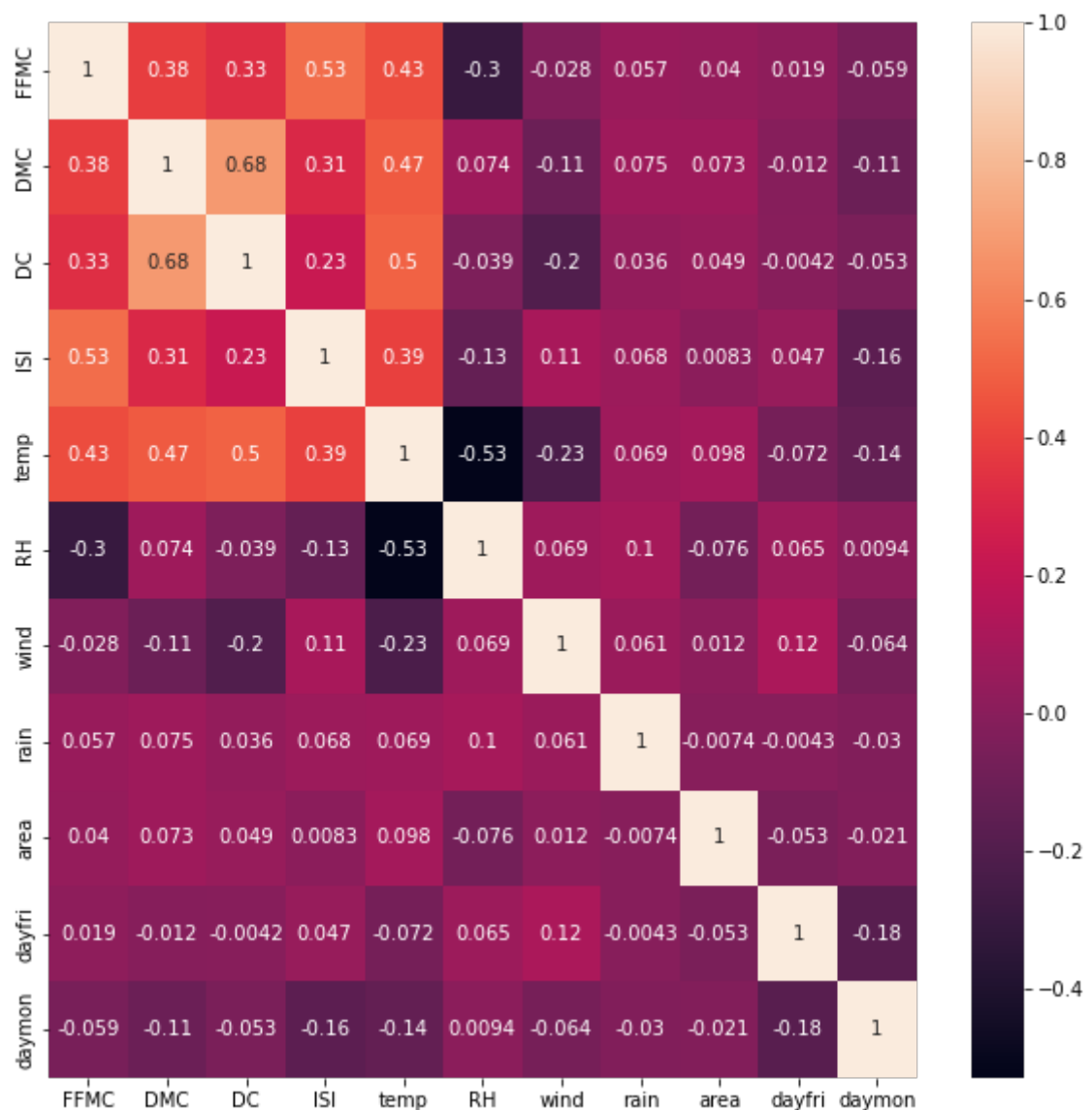|  | FFMC | DMC | DC | ISI | temp | RH | wind | rain |
|---|---|---|---|---|---|---|---|---|
| **skewness** | -6.575606 | 0.547498 | -1.100445 | 2.536325 | -0.331172 | 0.862904 | 0.571001 | 19.816344 |
| **kurtosis** | 67.066041 | 0.204822 | -0.245244 | 21.458037 | 0.136166 | 0.438183 | 0.054324 | 421.295964 | 1 |

## correlation

```
In [15]:    corr = forest_data[forest_data.columns[0:11]].corr()
```

```
In [16]:    plt.figure(figsize=(10,10))
            sns.heatmap(corr,annot=True)
```

Out[16]:    `<AxesSubplot:>`



## Neural Network Model

```
In [17]:    mapping = {'small': 1, 'large': 2}
```

```
In [18]:  df1 = forest_data.replace(mapping)
```

```
In [19]:  dataset = df1.values
```

```
In [20]:  dataset
```

```
Out[20]: array([[ 86.2,   26.2,   94.3, ...,    0. ,    0. ,    1. ],
                 [ 90.6,   35.4,  669.1, ...,    1. ,    0. ,    1. ],
                 [ 90.6,   43.7,  686.9, ...,    1. ,    0. ,    1. ],
                 ...,
                 [ 81.6,   56.7,  665.6, ...,    0. ,    0. ,    2. ],
                 [ 94.4,  146. ,  614.7, ...,    0. ,    0. ,    1. ],
                 [ 79.5,    3. ,  106.7, ...,    0. ,    0. ,    1. ]])
```

```
In [52]:  X = dataset[:,0:10]
          Y = dataset[:,10]
```

```
In [53]:  min_max_scaler = preprocessing.MinMaxScaler()
          X_scale = min_max_scaler.fit_transform(X)
```

```
In [54]:  X_scale
```

```
Out[54]: array([[0.87096774, 0.08649207, 0.1013252 , ..., 0.        , 0.        ,
                  1.        ],
                 [0.92774194, 0.11819435, 0.77541926, ..., 0.        , 0.        ,
                  0.        ],
                 [0.92774194, 0.14679531, 0.79629412, ..., 0.        , 0.        ,
                  0.        ],
                 ...,
                 [0.8116129 , 0.19159201, 0.77131465, ..., 0.        , 0.01023065,
                  0.        ],
                 [0.97677419, 0.49931082, 0.71162191, ..., 0.        , 0.        ,
                  0.        ],
                 [0.78451613, 0.00654721, 0.11586725, ..., 0.        , 0.        ,
                  0.        ]])
```

```
In [55]:  X_train, X_val_and_test, Y_train, Y_val_and_test = train_test_split(X_scale
```

```
In [57]:  X_val, X_test, Y_val, Y_test = train_test_split(X_val_and_test, Y_val_and_t
          print(X_train.shape, X_val.shape, X_test.shape, Y_train.shape, Y_val.shape,
```

```
          (361, 10) (78, 10) (78, 10) (361,) (78,) (78,)
```

```
In [58]:  model = Sequential([
              Dense(32, activation='relu', input_shape=(10,)),
              Dense(32, activation='relu'),
              Dense(1, activation='sigmoid'),
          ])
```

```
In [59]:  model.compile(optimizer='sgd',
                        loss='binary_crossentropy',
                        metrics=['accuracy'])
```

```
In [60]:  hist = model.fit(X_train, Y_train,
                   batch_size=32, epochs=100,
                   validation_data=(X_val, Y_val))
```

```
Epoch 1/100
12/12 [==============================] - 0s 9ms/step - loss: 0.6599 - accur
acy: 0.7479 - val_loss: 0.6241 - val_accuracy: 0.8333
Epoch 2/100
12/12 [==============================] - 0s 2ms/step - loss: 0.6080 - accur
acy: 0.8504 - val_loss: 0.5780 - val_accuracy: 0.8846
Epoch 3/100
12/12 [==============================] - 0s 2ms/step - loss: 0.5692 - accur
acy: 0.8560 - val_loss: 0.5356 - val_accuracy: 0.8846
Epoch 4/100
12/12 [==============================] - 0s 2ms/step - loss: 0.5337 - accur
acy: 0.8560 - val_loss: 0.5017 - val_accuracy: 0.8846
Epoch 5/100
12/12 [==============================] - 0s 3ms/step - loss: 0.5060 - accur
acy: 0.8560 - val_loss: 0.4730 - val_accuracy: 0.8846
Epoch 6/100
12/12 [==============================] - 0s 3ms/step - loss: 0.4826 - accur
acy: 0.8560 - val_loss: 0.4521 - val_accuracy: 0.8846
Epoch 7/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4660 - accur
acy: 0.8560 - val_loss: 0.4326 - val_accuracy: 0.8846
Epoch 8/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4508 - accur
acy: 0.8560 - val_loss: 0.4170 - val_accuracy: 0.8846
Epoch 9/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4390 - accur
acy: 0.8560 - val_loss: 0.4043 - val_accuracy: 0.8846
Epoch 10/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4298 - accur
acy: 0.8560 - val_loss: 0.3948 - val_accuracy: 0.8846
Epoch 11/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4230 - accur
acy: 0.8560 - val_loss: 0.3866 - val_accuracy: 0.8846
Epoch 12/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4176 - accur
acy: 0.8560 - val_loss: 0.3806 - val_accuracy: 0.8846
Epoch 13/100
12/12 [==============================] - 0s 3ms/step - loss: 0.4137 - accur
acy: 0.8560 - val_loss: 0.3757 - val_accuracy: 0.8846
Epoch 14/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4107 - accur
acy: 0.8560 - val_loss: 0.3719 - val_accuracy: 0.8846
Epoch 15/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4084 - accur
acy: 0.8560 - val_loss: 0.3687 - val_accuracy: 0.8846
Epoch 16/100
12/12 [==============================] - 0s 3ms/step - loss: 0.4066 - accur
acy: 0.8560 - val_loss: 0.3665 - val_accuracy: 0.8846
Epoch 17/100
12/12 [==============================] - 0s 5ms/step - loss: 0.4056 - accur
acy: 0.8560 - val_loss: 0.3641 - val_accuracy: 0.8846
Epoch 18/100
```

```
12/12 [==============================] - 0s 3ms/step - loss: 0.4044 - accur
acy: 0.8560 - val_loss: 0.3624 - val_accuracy: 0.8846
Epoch 19/100
12/12 [==============================] - 0s 3ms/step - loss: 0.4034 - accur
acy: 0.8560 - val_loss: 0.3614 - val_accuracy: 0.8846
Epoch 20/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4030 - accur
acy: 0.8560 - val_loss: 0.3605 - val_accuracy: 0.8846
Epoch 21/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4026 - accur
acy: 0.8560 - val_loss: 0.3600 - val_accuracy: 0.8846
Epoch 22/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4022 - accur
acy: 0.8560 - val_loss: 0.3587 - val_accuracy: 0.8846
Epoch 23/100
12/12 [==============================] - 0s 3ms/step - loss: 0.4017 - accur
acy: 0.8560 - val_loss: 0.3587 - val_accuracy: 0.8846
Epoch 24/100
12/12 [==============================] - 0s 3ms/step - loss: 0.4017 - accur
acy: 0.8560 - val_loss: 0.3581 - val_accuracy: 0.8846
Epoch 25/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4014 - accur
acy: 0.8560 - val_loss: 0.3576 - val_accuracy: 0.8846
Epoch 26/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4011 - accur
acy: 0.8560 - val_loss: 0.3566 - val_accuracy: 0.8846
Epoch 27/100
12/12 [==============================] - 0s 3ms/step - loss: 0.4007 - accur
acy: 0.8560 - val_loss: 0.3561 - val_accuracy: 0.8846
Epoch 28/100
12/12 [==============================] - 0s 3ms/step - loss: 0.4005 - accur
acy: 0.8560 - val_loss: 0.3557 - val_accuracy: 0.8846
Epoch 29/100
12/12 [==============================] - 0s 3ms/step - loss: 0.4003 - accur
acy: 0.8560 - val_loss: 0.3552 - val_accuracy: 0.8846
Epoch 30/100
12/12 [==============================] - 0s 2ms/step - loss: 0.4002 - accur
acy: 0.8560 - val_loss: 0.3547 - val_accuracy: 0.8846
Epoch 31/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3998 - accur
acy: 0.8560 - val_loss: 0.3544 - val_accuracy: 0.8846
Epoch 32/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3997 - accur
acy: 0.8560 - val_loss: 0.3546 - val_accuracy: 0.8846
Epoch 33/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3996 - accur
acy: 0.8560 - val_loss: 0.3543 - val_accuracy: 0.8846
Epoch 34/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3994 - accur
acy: 0.8560 - val_loss: 0.3537 - val_accuracy: 0.8846
Epoch 35/100
12/12 [==============================] - 0s 3ms/step - loss: 0.3992 - accur
acy: 0.8560 - val_loss: 0.3533 - val_accuracy: 0.8846
Epoch 36/100
12/12 [==============================] - 0s 3ms/step - loss: 0.3991 - accur
acy: 0.8560 - val_loss: 0.3528 - val_accuracy: 0.8846
Epoch 37/100
12/12 [==============================] - 0s 3ms/step - loss: 0.3990 - accur
acy: 0.8560 - val_loss: 0.3527 - val_accuracy: 0.8846
Epoch 38/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3989 - accur
acy: 0.8560 - val_loss: 0.3523 - val_accuracy: 0.8846
Epoch 39/100
```

```
12/12 [==============================] - 0s 2ms/step - loss: 0.3987 - accur
acy: 0.8560 - val_loss: 0.3524 - val_accuracy: 0.8846
Epoch 40/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3985 - accur
acy: 0.8560 - val_loss: 0.3523 - val_accuracy: 0.8846
Epoch 41/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3984 - accur
acy: 0.8560 - val_loss: 0.3523 - val_accuracy: 0.8846
Epoch 42/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3982 - accur
acy: 0.8560 - val_loss: 0.3523 - val_accuracy: 0.8846
Epoch 43/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3982 - accur
acy: 0.8560 - val_loss: 0.3521 - val_accuracy: 0.8846
Epoch 44/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3982 - accur
acy: 0.8560 - val_loss: 0.3519 - val_accuracy: 0.8846
Epoch 45/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3979 - accur
acy: 0.8560 - val_loss: 0.3520 - val_accuracy: 0.8846
Epoch 46/100
12/12 [==============================] - 0s 3ms/step - loss: 0.3979 - accur
acy: 0.8560 - val_loss: 0.3516 - val_accuracy: 0.8846
Epoch 47/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3976 - accur
acy: 0.8560 - val_loss: 0.3514 - val_accuracy: 0.8846
Epoch 48/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3977 - accur
acy: 0.8560 - val_loss: 0.3515 - val_accuracy: 0.8846
Epoch 49/100
12/12 [==============================] - 0s 3ms/step - loss: 0.3973 - accur
acy: 0.8560 - val_loss: 0.3510 - val_accuracy: 0.8846
Epoch 50/100
12/12 [==============================] - 0s 3ms/step - loss: 0.3973 - accur
acy: 0.8560 - val_loss: 0.3511 - val_accuracy: 0.8846
Epoch 51/100
12/12 [==============================] - 0s 3ms/step - loss: 0.3971 - accur
acy: 0.8560 - val_loss: 0.3507 - val_accuracy: 0.8846
Epoch 52/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3970 - accur
acy: 0.8560 - val_loss: 0.3506 - val_accuracy: 0.8846
Epoch 53/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3968 - accur
acy: 0.8560 - val_loss: 0.3509 - val_accuracy: 0.8846
Epoch 54/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3967 - accur
acy: 0.8560 - val_loss: 0.3509 - val_accuracy: 0.8846
Epoch 55/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3964 - accur
acy: 0.8560 - val_loss: 0.3505 - val_accuracy: 0.8846
Epoch 56/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3964 - accur
acy: 0.8560 - val_loss: 0.3507 - val_accuracy: 0.8846
Epoch 57/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3962 - accur
acy: 0.8560 - val_loss: 0.3503 - val_accuracy: 0.8846
Epoch 58/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3961 - accur
acy: 0.8560 - val_loss: 0.3505 - val_accuracy: 0.8846
Epoch 59/100
12/12 [==============================] - 0s 3ms/step - loss: 0.3960 - accur
acy: 0.8560 - val_loss: 0.3502 - val_accuracy: 0.8846
Epoch 60/100
```

```
12/12 [==============================] - 0s 2ms/step - loss: 0.3960 - accur
acy: 0.8560 - val_loss: 0.3498 - val_accuracy: 0.8846
Epoch 61/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3957 - accur
acy: 0.8560 - val_loss: 0.3494 - val_accuracy: 0.8846
Epoch 62/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3958 - accur
acy: 0.8560 - val_loss: 0.3495 - val_accuracy: 0.8846
Epoch 63/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3954 - accur
acy: 0.8560 - val_loss: 0.3495 - val_accuracy: 0.8846
Epoch 64/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3953 - accur
acy: 0.8560 - val_loss: 0.3500 - val_accuracy: 0.8846
Epoch 65/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3952 - accur
acy: 0.8560 - val_loss: 0.3495 - val_accuracy: 0.8846
Epoch 66/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3951 - accur
acy: 0.8560 - val_loss: 0.3493 - val_accuracy: 0.8846
Epoch 67/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3948 - accur
acy: 0.8560 - val_loss: 0.3492 - val_accuracy: 0.8846
Epoch 68/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3948 - accur
acy: 0.8560 - val_loss: 0.3492 - val_accuracy: 0.8846
Epoch 69/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3946 - accur
acy: 0.8560 - val_loss: 0.3489 - val_accuracy: 0.8846
Epoch 70/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3945 - accur
acy: 0.8560 - val_loss: 0.3484 - val_accuracy: 0.8846
Epoch 71/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3944 - accur
acy: 0.8560 - val_loss: 0.3482 - val_accuracy: 0.8846
Epoch 72/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3942 - accur
acy: 0.8560 - val_loss: 0.3480 - val_accuracy: 0.8846
Epoch 73/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3943 - accur
acy: 0.8560 - val_loss: 0.3482 - val_accuracy: 0.8846
Epoch 74/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3938 - accur
acy: 0.8560 - val_loss: 0.3479 - val_accuracy: 0.8846
Epoch 75/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3938 - accur
acy: 0.8560 - val_loss: 0.3478 - val_accuracy: 0.8846
Epoch 76/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3935 - accur
acy: 0.8560 - val_loss: 0.3475 - val_accuracy: 0.8846
Epoch 77/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3933 - accur
acy: 0.8560 - val_loss: 0.3477 - val_accuracy: 0.8846
Epoch 78/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3933 - accur
acy: 0.8560 - val_loss: 0.3474 - val_accuracy: 0.8846
Epoch 79/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3931 - accur
acy: 0.8560 - val_loss: 0.3471 - val_accuracy: 0.8846
Epoch 80/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3931 - accur
acy: 0.8560 - val_loss: 0.3469 - val_accuracy: 0.8846
Epoch 81/100
```

```
12/12 [==============================] - 0s 2ms/step - loss: 0.3927 - accur
acy: 0.8560 - val_loss: 0.3466 - val_accuracy: 0.8846
Epoch 82/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3927 - accur
acy: 0.8560 - val_loss: 0.3461 - val_accuracy: 0.8846
Epoch 83/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3925 - accur
acy: 0.8560 - val_loss: 0.3461 - val_accuracy: 0.8846
Epoch 84/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3923 - accur
acy: 0.8560 - val_loss: 0.3461 - val_accuracy: 0.8846
Epoch 85/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3922 - accur
acy: 0.8560 - val_loss: 0.3460 - val_accuracy: 0.8846
Epoch 86/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3920 - accur
acy: 0.8560 - val_loss: 0.3460 - val_accuracy: 0.8846
Epoch 87/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3920 - accur
acy: 0.8560 - val_loss: 0.3462 - val_accuracy: 0.8846
Epoch 88/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3920 - accur
acy: 0.8560 - val_loss: 0.3459 - val_accuracy: 0.8846
Epoch 89/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3918 - accur
acy: 0.8560 - val_loss: 0.3458 - val_accuracy: 0.8846
Epoch 90/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3916 - accur
acy: 0.8560 - val_loss: 0.3458 - val_accuracy: 0.8846
Epoch 91/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3915 - accur
acy: 0.8560 - val_loss: 0.3461 - val_accuracy: 0.8846
Epoch 92/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3913 - accur
acy: 0.8560 - val_loss: 0.3461 - val_accuracy: 0.8846
Epoch 93/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3914 - accur
acy: 0.8560 - val_loss: 0.3454 - val_accuracy: 0.8846
Epoch 94/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3911 - accur
acy: 0.8560 - val_loss: 0.3451 - val_accuracy: 0.8846
Epoch 95/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3910 - accur
acy: 0.8560 - val_loss: 0.3452 - val_accuracy: 0.8846
Epoch 96/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3908 - accur
acy: 0.8560 - val_loss: 0.3452 - val_accuracy: 0.8846
Epoch 97/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3907 - accur
acy: 0.8560 - val_loss: 0.3452 - val_accuracy: 0.8846
Epoch 98/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3907 - accur
acy: 0.8560 - val_loss: 0.3448 - val_accuracy: 0.8846
Epoch 99/100
12/12 [==============================] - 0s 2ms/step - loss: 0.3905 - accur
acy: 0.8560 - val_loss: 0.3447 - val_accuracy: 0.8846
Epoch 100/100
```

In [61]:
```python
model.evaluate(X_test, Y_test)[1]
```
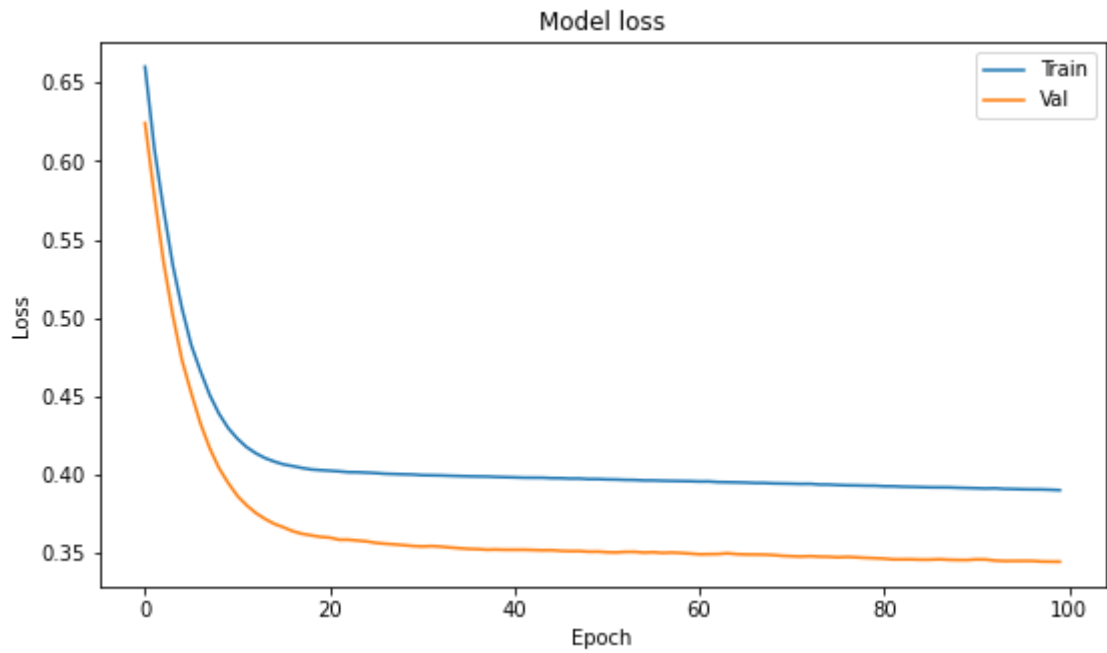
```
3/3 [==============================] - 0s 997us/step - loss: 0.4276 - accur
acy: 0.8333
```

0.8333333134651184

# Visualizing Loss and Accuracy

In [66]:
```python
plt.plot(hist.history['loss'])
plt.plot(hist.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='upper right')
plt.show()
```



In [69]:
```python
plt.plot(hist.history['accuracy'])
plt.plot(hist.history['val_accuracy'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='lower right')
plt.show()
```
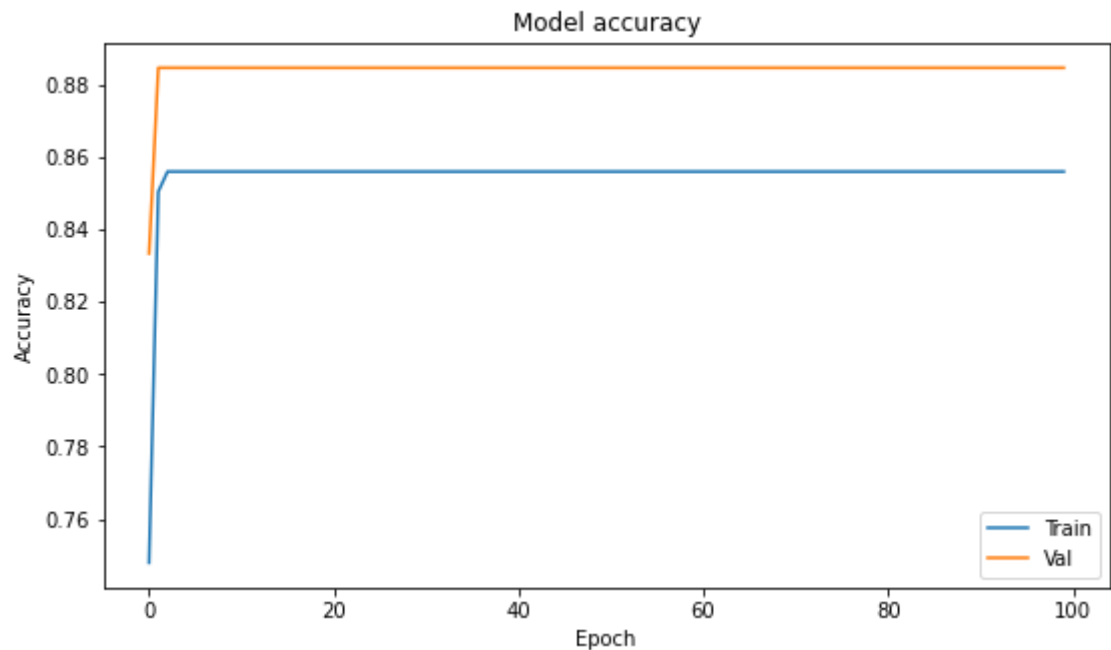
## Adding Regularization to our Neural Network

In [70]:
```python
model_2 = Sequential([
    Dense(1000, activation='relu', input_shape=(10,)),
    Dense(1000, activation='relu'),
    Dense(1000, activation='relu'),
    Dense(1000, activation='relu'),
    Dense(1, activation='sigmoid'),
])

model_2.compile(optimizer='adam',
            loss='binary_crossentropy',
            metrics=['accuracy'])

hist_2 = model_2.fit(X_train, Y_train,
        batch_size=32, epochs=100,
        validation_data=(X_val, Y_val))
```

```
Epoch 1/100
12/12 [==============================] - 1s 32ms/step - loss: 0.4316 - accu
racy: 0.8560 - val_loss: 0.3390 - val_accuracy: 0.8846
Epoch 2/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3928 - accu
racy: 0.8560 - val_loss: 0.3187 - val_accuracy: 0.8846
Epoch 3/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3771 - accu
racy: 0.8560 - val_loss: 0.3126 - val_accuracy: 0.8846
Epoch 4/100
12/12 [==============================] - 0s 24ms/step - loss: 0.3684 - accu
racy: 0.8560 - val_loss: 0.3125 - val_accuracy: 0.8846
Epoch 5/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3931 - accu
racy: 0.8560 - val_loss: 0.3088 - val_accuracy: 0.8846
Epoch 6/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3665 - accu
racy: 0.8560 - val_loss: 0.3059 - val_accuracy: 0.8846
Epoch 7/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3571 - accu
racy: 0.8560 - val_loss: 0.3045 - val_accuracy: 0.8846
Epoch 8/100
```

```
12/12 [==============================] - 0s 25ms/step - loss: 0.3633 - accu
racy: 0.8560 - val_loss: 0.3105 - val_accuracy: 0.8846
Epoch 9/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3702 - accu
racy: 0.8560 - val_loss: 0.3017 - val_accuracy: 0.8846
Epoch 10/100
12/12 [==============================] - 0s 28ms/step - loss: 0.3692 - accu
racy: 0.8560 - val_loss: 0.3087 - val_accuracy: 0.8846
Epoch 11/100
12/12 [==============================] - 0s 27ms/step - loss: 0.3567 - accu
racy: 0.8560 - val_loss: 0.2948 - val_accuracy: 0.8846
Epoch 12/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3506 - accu
racy: 0.8560 - val_loss: 0.2961 - val_accuracy: 0.8846
Epoch 13/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3402 - accu
racy: 0.8560 - val_loss: 0.2909 - val_accuracy: 0.8846
Epoch 14/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3443 - accu
racy: 0.8643 - val_loss: 0.3159 - val_accuracy: 0.8846
Epoch 15/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3877 - accu
racy: 0.8587 - val_loss: 0.3007 - val_accuracy: 0.8718
Epoch 16/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3473 - accu
racy: 0.8615 - val_loss: 0.3022 - val_accuracy: 0.8846
Epoch 17/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3414 - accu
racy: 0.8615 - val_loss: 0.2963 - val_accuracy: 0.8718
Epoch 18/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3286 - accu
racy: 0.8615 - val_loss: 0.3077 - val_accuracy: 0.8718
Epoch 19/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3328 - accu
racy: 0.8643 - val_loss: 0.3006 - val_accuracy: 0.8718
Epoch 20/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3303 - accu
racy: 0.8643 - val_loss: 0.3067 - val_accuracy: 0.8718
Epoch 21/100
12/12 [==============================] - 0s 27ms/step - loss: 0.3149 - accu
racy: 0.8698 - val_loss: 0.2872 - val_accuracy: 0.8718
Epoch 22/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3213 - accu
racy: 0.8670 - val_loss: 0.3016 - val_accuracy: 0.8718
Epoch 23/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3313 - accu
racy: 0.8615 - val_loss: 0.3025 - val_accuracy: 0.8718
Epoch 24/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3096 - accu
racy: 0.8698 - val_loss: 0.2933 - val_accuracy: 0.8718
Epoch 25/100
12/12 [==============================] - 0s 27ms/step - loss: 0.3320 - accu
racy: 0.8670 - val_loss: 0.3522 - val_accuracy: 0.8718
Epoch 26/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3469 - accu
racy: 0.8643 - val_loss: 0.3117 - val_accuracy: 0.8718
Epoch 27/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3214 - accu
racy: 0.8643 - val_loss: 0.2898 - val_accuracy: 0.8718
Epoch 28/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3437 - accu
racy: 0.8643 - val_loss: 0.3258 - val_accuracy: 0.8718
Epoch 29/100
```

```
12/12 [==============================] - 0s 25ms/step - loss: 0.3242 - accu
racy: 0.8615 - val_loss: 0.2981 - val_accuracy: 0.8718
Epoch 30/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3127 - accu
racy: 0.8615 - val_loss: 0.2901 - val_accuracy: 0.8718
Epoch 31/100
12/12 [==============================] - 0s 25ms/step - loss: 0.3005 - accu
racy: 0.8615 - val_loss: 0.2986 - val_accuracy: 0.8718
Epoch 32/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2897 - accu
racy: 0.8670 - val_loss: 0.3018 - val_accuracy: 0.8718
Epoch 33/100
12/12 [==============================] - 0s 29ms/step - loss: 0.3004 - accu
racy: 0.8670 - val_loss: 0.2877 - val_accuracy: 0.8718
Epoch 34/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2801 - accu
racy: 0.8781 - val_loss: 0.3068 - val_accuracy: 0.8846
Epoch 35/100
12/12 [==============================] - 0s 27ms/step - loss: 0.2727 - accu
racy: 0.8809 - val_loss: 0.3125 - val_accuracy: 0.8846
Epoch 36/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2731 - accu
racy: 0.8809 - val_loss: 0.3740 - val_accuracy: 0.8333
Epoch 37/100
12/12 [==============================] - 0s 24ms/step - loss: 0.2756 - accu
racy: 0.8753 - val_loss: 0.3008 - val_accuracy: 0.8846
Epoch 38/100
12/12 [==============================] - 0s 27ms/step - loss: 0.3018 - accu
racy: 0.8670 - val_loss: 0.2893 - val_accuracy: 0.8718
Epoch 39/100
12/12 [==============================] - 0s 24ms/step - loss: 0.2738 - accu
racy: 0.8726 - val_loss: 0.3052 - val_accuracy: 0.8718
Epoch 40/100
12/12 [==============================] - 0s 24ms/step - loss: 0.2423 - accu
racy: 0.8892 - val_loss: 0.3229 - val_accuracy: 0.8718
Epoch 41/100
12/12 [==============================] - 0s 24ms/step - loss: 0.2526 - accu
racy: 0.8920 - val_loss: 0.3207 - val_accuracy: 0.8718
Epoch 42/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2707 - accu
racy: 0.8753 - val_loss: 0.3609 - val_accuracy: 0.8846
Epoch 43/100
12/12 [==============================] - 0s 26ms/step - loss: 0.3053 - accu
racy: 0.8698 - val_loss: 0.2919 - val_accuracy: 0.8718
Epoch 44/100
12/12 [==============================] - 0s 23ms/step - loss: 0.2721 - accu
racy: 0.8809 - val_loss: 0.3259 - val_accuracy: 0.8462
Epoch 45/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2476 - accu
racy: 0.8920 - val_loss: 0.3313 - val_accuracy: 0.8718
Epoch 46/100
12/12 [==============================] - 0s 27ms/step - loss: 0.2402 - accu
racy: 0.8864 - val_loss: 0.3097 - val_accuracy: 0.8974
Epoch 47/100
12/12 [==============================] - 0s 28ms/step - loss: 0.2448 - accu
racy: 0.8809 - val_loss: 0.3221 - val_accuracy: 0.8846
Epoch 48/100
12/12 [==============================] - 0s 26ms/step - loss: 0.2465 - accu
racy: 0.8892 - val_loss: 0.3427 - val_accuracy: 0.8590
Epoch 49/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2541 - accu
racy: 0.8864 - val_loss: 0.3118 - val_accuracy: 0.8590
Epoch 50/100
```

```
12/12 [==============================] - 0s 28ms/step - loss: 0.2443 - accu
racy: 0.8809 - val_loss: 0.3906 - val_accuracy: 0.8590
Epoch 51/100
12/12 [==============================] - 0s 24ms/step - loss: 0.2579 - accu
racy: 0.9003 - val_loss: 0.2950 - val_accuracy: 0.8718
Epoch 52/100
12/12 [==============================] - 0s 24ms/step - loss: 0.2354 - accu
racy: 0.8892 - val_loss: 0.3443 - val_accuracy: 0.8205
Epoch 53/100
12/12 [==============================] - 0s 29ms/step - loss: 0.2601 - accu
racy: 0.8864 - val_loss: 0.3230 - val_accuracy: 0.8590
Epoch 54/100
12/12 [==============================] - 0s 26ms/step - loss: 0.2719 - accu
racy: 0.8726 - val_loss: 0.2829 - val_accuracy: 0.9103
Epoch 55/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2339 - accu
racy: 0.9030 - val_loss: 0.3110 - val_accuracy: 0.8718
Epoch 56/100
12/12 [==============================] - 0s 24ms/step - loss: 0.2247 - accu
racy: 0.8975 - val_loss: 0.3901 - val_accuracy: 0.8205
Epoch 57/100
12/12 [==============================] - 0s 27ms/step - loss: 0.2360 - accu
racy: 0.9003 - val_loss: 0.2978 - val_accuracy: 0.8846
Epoch 58/100
12/12 [==============================] - 0s 28ms/step - loss: 0.2130 - accu
racy: 0.8975 - val_loss: 0.3724 - val_accuracy: 0.8590
Epoch 59/100
12/12 [==============================] - 0s 26ms/step - loss: 0.2157 - accu
racy: 0.9030 - val_loss: 0.3632 - val_accuracy: 0.8718
Epoch 60/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2229 - accu
racy: 0.9058 - val_loss: 0.3355 - val_accuracy: 0.8590
Epoch 61/100
12/12 [==============================] - 0s 24ms/step - loss: 0.1913 - accu
racy: 0.8947 - val_loss: 0.4383 - val_accuracy: 0.8590
Epoch 62/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2070 - accu
racy: 0.9030 - val_loss: 0.3222 - val_accuracy: 0.8462
Epoch 63/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2532 - accu
racy: 0.9141 - val_loss: 0.2825 - val_accuracy: 0.8846
Epoch 64/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2150 - accu
racy: 0.9169 - val_loss: 0.3282 - val_accuracy: 0.8974
Epoch 65/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2018 - accu
racy: 0.9114 - val_loss: 0.4163 - val_accuracy: 0.8462
Epoch 66/100
12/12 [==============================] - 0s 27ms/step - loss: 0.2922 - accu
racy: 0.8864 - val_loss: 0.2872 - val_accuracy: 0.8718
Epoch 67/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2572 - accu
racy: 0.8947 - val_loss: 0.3535 - val_accuracy: 0.8590
Epoch 68/100
12/12 [==============================] - 0s 23ms/step - loss: 0.2253 - accu
racy: 0.8947 - val_loss: 0.3635 - val_accuracy: 0.8846
Epoch 69/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2031 - accu
racy: 0.8947 - val_loss: 0.3683 - val_accuracy: 0.8846
Epoch 70/100
12/12 [==============================] - 0s 28ms/step - loss: 0.2065 - accu
racy: 0.9030 - val_loss: 0.4701 - val_accuracy: 0.8846
Epoch 71/100
```

```
12/12 [==============================] - 0s 24ms/step - loss: 0.2574 - accu
racy: 0.9003 - val_loss: 0.2965 - val_accuracy: 0.8974
Epoch 72/100
12/12 [==============================] - 0s 26ms/step - loss: 0.2196 - accu
racy: 0.8947 - val_loss: 0.3904 - val_accuracy: 0.8462
Epoch 73/100
12/12 [==============================] - 0s 24ms/step - loss: 0.2063 - accu
racy: 0.9058 - val_loss: 0.3151 - val_accuracy: 0.8718
Epoch 74/100
12/12 [==============================] - 0s 27ms/step - loss: 0.1897 - accu
racy: 0.9197 - val_loss: 0.4009 - val_accuracy: 0.8590
Epoch 75/100
12/12 [==============================] - 0s 26ms/step - loss: 0.1643 - accu
racy: 0.9307 - val_loss: 0.5197 - val_accuracy: 0.8718
Epoch 76/100
12/12 [==============================] - 0s 24ms/step - loss: 0.2227 - accu
racy: 0.9141 - val_loss: 0.3429 - val_accuracy: 0.8974
Epoch 77/100
12/12 [==============================] - 0s 26ms/step - loss: 0.1701 - accu
racy: 0.9280 - val_loss: 0.3196 - val_accuracy: 0.8846
Epoch 78/100
12/12 [==============================] - 0s 26ms/step - loss: 0.1680 - accu
racy: 0.9307 - val_loss: 0.4103 - val_accuracy: 0.8846
Epoch 79/100
12/12 [==============================] - 0s 24ms/step - loss: 0.1767 - accu
racy: 0.9335 - val_loss: 0.3969 - val_accuracy: 0.8846
Epoch 80/100
12/12 [==============================] - 0s 23ms/step - loss: 0.2094 - accu
racy: 0.8975 - val_loss: 0.3562 - val_accuracy: 0.8846
Epoch 81/100
12/12 [==============================] - 0s 23ms/step - loss: 0.1695 - accu
racy: 0.9280 - val_loss: 0.4328 - val_accuracy: 0.8462
Epoch 82/100
12/12 [==============================] - 0s 26ms/step - loss: 0.1691 - accu
racy: 0.9224 - val_loss: 0.3936 - val_accuracy: 0.8846
Epoch 83/100
12/12 [==============================] - 0s 24ms/step - loss: 0.1365 - accu
racy: 0.9557 - val_loss: 0.3536 - val_accuracy: 0.8974
Epoch 84/100
12/12 [==============================] - 0s 24ms/step - loss: 0.1393 - accu
racy: 0.9446 - val_loss: 0.4879 - val_accuracy: 0.7949
Epoch 85/100
12/12 [==============================] - 0s 26ms/step - loss: 0.1962 - accu
racy: 0.9030 - val_loss: 0.5662 - val_accuracy: 0.8333
Epoch 86/100
12/12 [==============================] - 0s 24ms/step - loss: 0.1860 - accu
racy: 0.9252 - val_loss: 0.4006 - val_accuracy: 0.8718
Epoch 87/100
12/12 [==============================] - 0s 26ms/step - loss: 0.1778 - accu
racy: 0.9224 - val_loss: 0.3889 - val_accuracy: 0.8205
Epoch 88/100
12/12 [==============================] - 0s 25ms/step - loss: 0.1406 - accu
racy: 0.9474 - val_loss: 0.3560 - val_accuracy: 0.8718
Epoch 89/100
12/12 [==============================] - 0s 24ms/step - loss: 0.1194 - accu
racy: 0.9474 - val_loss: 0.4761 - val_accuracy: 0.8205
Epoch 90/100
12/12 [==============================] - 0s 27ms/step - loss: 0.1285 - accu
racy: 0.9474 - val_loss: 0.4399 - val_accuracy: 0.8333
Epoch 91/100
12/12 [==============================] - 0s 23ms/step - loss: 0.1313 - accu
racy: 0.9474 - val_loss: 0.4035 - val_accuracy: 0.8205
Epoch 92/100
```

```
12/12 [==============================] - 0s 26ms/step - loss: 0.1706 - accu
racy: 0.9252 - val_loss: 0.5791 - val_accuracy: 0.8846
Epoch 93/100
12/12 [==============================] - 0s 23ms/step - loss: 0.2398 - accu
racy: 0.8975 - val_loss: 0.4048 - val_accuracy: 0.9103
Epoch 94/100
12/12 [==============================] - 0s 26ms/step - loss: 0.2582 - accu
racy: 0.8864 - val_loss: 0.3005 - val_accuracy: 0.8846
Epoch 95/100
12/12 [==============================] - 0s 25ms/step - loss: 0.2174 - accu
racy: 0.9030 - val_loss: 0.2741 - val_accuracy: 0.8846
Epoch 96/100
12/12 [==============================] - 0s 23ms/step - loss: 0.1804 - accu
racy: 0.9335 - val_loss: 0.3465 - val_accuracy: 0.8974
Epoch 97/100
12/12 [==============================] - 0s 26ms/step - loss: 0.1626 - accu
racy: 0.9307 - val_loss: 0.2817 - val_accuracy: 0.8846
Epoch 98/100
12/12 [==============================] - 0s 24ms/step - loss: 0.1542 - accu
racy: 0.9280 - val_loss: 0.3053 - val_accuracy: 0.8590
Epoch 99/100
12/12 [==============================] - 0s 26ms/step - loss: 0.1467 - accu
racy: 0.9391 - val_loss: 0.3768 - val_accuracy: 0.8590
Epoch 100/100
12/12 [==============================] - 0s 23ms/step - loss: 0.1407 - accu
```
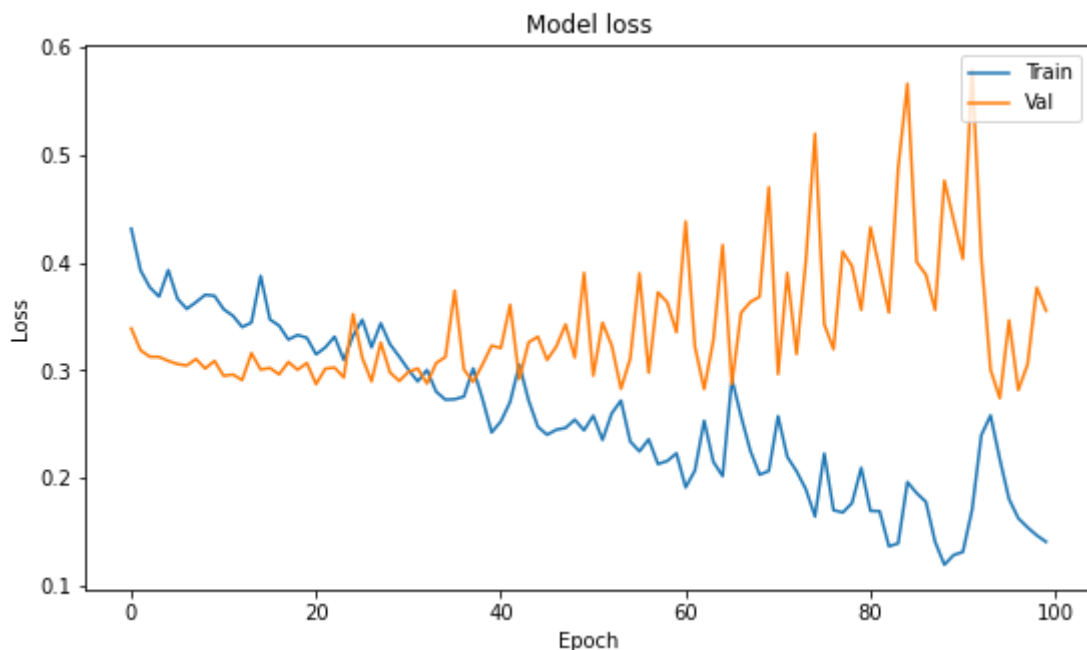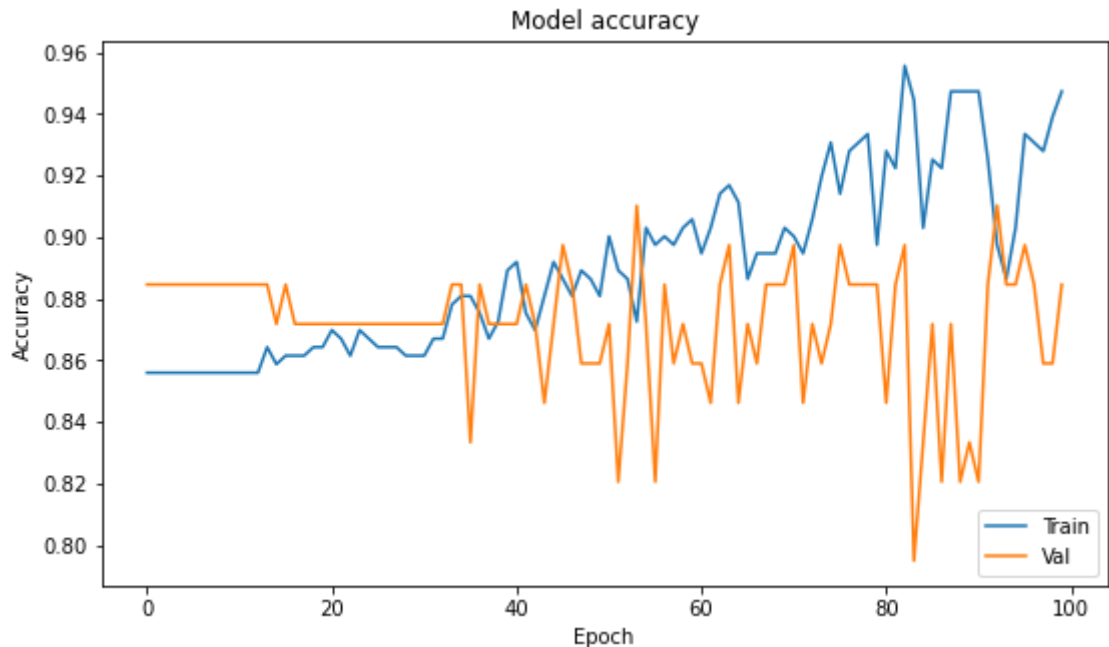
In [71]:
```python
plt.plot(hist_2.history['loss'])
plt.plot(hist_2.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='upper right')
plt.show()
```

```
In [73]:   plt.plot(hist_2.history['accuracy'])
           plt.plot(hist_2.history['val_accuracy'])
           plt.title('Model accuracy')
           plt.ylabel('Accuracy')
           plt.xlabel('Epoch')
           plt.legend(['Train', 'Val'], loc='lower right')
           plt.show()
```



```
In [75]:   model_3 = Sequential([
               Dense(1000, activation='relu', kernel_regularizer=regularizers.l2(0.01)
               Dropout(0.3),
               Dense(1000, activation='relu', kernel_regularizer=regularizers.l2(0.01)
               Dropout(0.3),
               Dense(1000, activation='relu', kernel_regularizer=regularizers.l2(0.01)
               Dropout(0.3),
               Dense(1000, activation='relu', kernel_regularizer=regularizers.l2(0.01)
               Dropout(0.3),
               Dense(1, activation='sigmoid', kernel_regularizer=regularizers.l2(0.01)
           ])
```

```
In [76]:   model_3.compile(optimizer='adam',
                           loss='binary_crossentropy',
                           metrics=['accuracy'])

           hist_3 = model_3.fit(X_train, Y_train,
                   batch_size=32, epochs=100,
                   validation_data=(X_val, Y_val))
```

```
Epoch 1/100
12/12 [==============================] - 1s 48ms/step - loss: 23.5925 - acc
uracy: 0.8199 - val_loss: 15.5078 - val_accuracy: 0.8846
Epoch 2/100
12/12 [==============================] - 0s 39ms/step - loss: 11.4112 - acc
uracy: 0.8560 - val_loss: 6.9854 - val_accuracy: 0.8846
Epoch 3/100
12/12 [==============================] - 0s 38ms/step - loss: 5.0096 - accu
racy: 0.8560 - val_loss: 2.9277 - val_accuracy: 0.8846
Epoch 4/100
```

```
12/12 [==============================] - 0s 39ms/step - loss: 2.1268 - accu
racy: 0.8560 - val_loss: 1.2712 - val_accuracy: 0.8846
Epoch 5/100
12/12 [==============================] - 0s 38ms/step - loss: 1.0031 - accu
racy: 0.8560 - val_loss: 0.6730 - val_accuracy: 0.8846
Epoch 6/100
12/12 [==============================] - 0s 41ms/step - loss: 0.6291 - accu
racy: 0.8560 - val_loss: 0.5209 - val_accuracy: 0.8846
Epoch 7/100
12/12 [==============================] - 0s 39ms/step - loss: 0.5240 - accu
racy: 0.8560 - val_loss: 0.4398 - val_accuracy: 0.8846
Epoch 8/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4897 - accu
racy: 0.8560 - val_loss: 0.4287 - val_accuracy: 0.8846
Epoch 9/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4781 - accu
racy: 0.8560 - val_loss: 0.4197 - val_accuracy: 0.8846
Epoch 10/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4616 - accu
racy: 0.8560 - val_loss: 0.4097 - val_accuracy: 0.8846
Epoch 11/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4640 - accu
racy: 0.8560 - val_loss: 0.4210 - val_accuracy: 0.8846
Epoch 12/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4590 - accu
racy: 0.8560 - val_loss: 0.4019 - val_accuracy: 0.8846
Epoch 13/100
12/12 [==============================] - 1s 43ms/step - loss: 0.4580 - accu
racy: 0.8560 - val_loss: 0.4007 - val_accuracy: 0.8846
Epoch 14/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4637 - accu
racy: 0.8560 - val_loss: 0.4153 - val_accuracy: 0.8846
Epoch 15/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4551 - accu
racy: 0.8560 - val_loss: 0.3982 - val_accuracy: 0.8846
Epoch 16/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4475 - accu
racy: 0.8560 - val_loss: 0.3984 - val_accuracy: 0.8846
Epoch 17/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4468 - accu
racy: 0.8560 - val_loss: 0.3992 - val_accuracy: 0.8846
Epoch 18/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4452 - accu
racy: 0.8560 - val_loss: 0.3955 - val_accuracy: 0.8846
Epoch 19/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4502 - accu
racy: 0.8560 - val_loss: 0.3955 - val_accuracy: 0.8846
Epoch 20/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4411 - accu
racy: 0.8560 - val_loss: 0.3965 - val_accuracy: 0.8846
Epoch 21/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4441 - accu
racy: 0.8560 - val_loss: 0.3940 - val_accuracy: 0.8846
Epoch 22/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4451 - accu
racy: 0.8560 - val_loss: 0.3960 - val_accuracy: 0.8846
Epoch 23/100
12/12 [==============================] - 0s 37ms/step - loss: 0.4449 - accu
racy: 0.8560 - val_loss: 0.3958 - val_accuracy: 0.8846
Epoch 24/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4459 - accu
racy: 0.8560 - val_loss: 0.3955 - val_accuracy: 0.8846
Epoch 25/100
```

```
12/12 [==============================] - 0s 37ms/step - loss: 0.4423 - accu
racy: 0.8560 - val_loss: 0.3924 - val_accuracy: 0.8846
Epoch 26/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4466 - accu
racy: 0.8560 - val_loss: 0.3949 - val_accuracy: 0.8846
Epoch 27/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4485 - accu
racy: 0.8560 - val_loss: 0.3966 - val_accuracy: 0.8846
Epoch 28/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4438 - accu
racy: 0.8560 - val_loss: 0.3956 - val_accuracy: 0.8846
Epoch 29/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4380 - accu
racy: 0.8560 - val_loss: 0.3909 - val_accuracy: 0.8846
Epoch 30/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4434 - accu
racy: 0.8560 - val_loss: 0.3927 - val_accuracy: 0.8846
Epoch 31/100
12/12 [==============================] - 0s 42ms/step - loss: 0.4432 - accu
racy: 0.8560 - val_loss: 0.3961 - val_accuracy: 0.8846
Epoch 32/100
12/12 [==============================] - 1s 46ms/step - loss: 0.4400 - accu
racy: 0.8560 - val_loss: 0.3895 - val_accuracy: 0.8846
Epoch 33/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4452 - accu
racy: 0.8560 - val_loss: 0.3927 - val_accuracy: 0.8846
Epoch 34/100
12/12 [==============================] - 1s 48ms/step - loss: 0.4436 - accu
racy: 0.8560 - val_loss: 0.3900 - val_accuracy: 0.8846
Epoch 35/100
12/12 [==============================] - 1s 43ms/step - loss: 0.4395 - accu
racy: 0.8560 - val_loss: 0.3887 - val_accuracy: 0.8846
Epoch 36/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4417 - accu
racy: 0.8560 - val_loss: 0.3938 - val_accuracy: 0.8846
Epoch 37/100
12/12 [==============================] - 1s 44ms/step - loss: 0.4443 - accu
racy: 0.8560 - val_loss: 0.3885 - val_accuracy: 0.8846
Epoch 38/100
12/12 [==============================] - 1s 43ms/step - loss: 0.4390 - accu
racy: 0.8560 - val_loss: 0.3936 - val_accuracy: 0.8846
Epoch 39/100
12/12 [==============================] - 1s 44ms/step - loss: 0.4441 - accu
racy: 0.8560 - val_loss: 0.3882 - val_accuracy: 0.8846
Epoch 40/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4420 - accu
racy: 0.8560 - val_loss: 0.3907 - val_accuracy: 0.8846
Epoch 41/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4432 - accu
racy: 0.8560 - val_loss: 0.3867 - val_accuracy: 0.8846
Epoch 42/100
12/12 [==============================] - 1s 43ms/step - loss: 0.4425 - accu
racy: 0.8560 - val_loss: 0.3934 - val_accuracy: 0.8846
Epoch 43/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4392 - accu
racy: 0.8560 - val_loss: 0.3909 - val_accuracy: 0.8846
Epoch 44/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4355 - accu
racy: 0.8560 - val_loss: 0.3837 - val_accuracy: 0.8846
Epoch 45/100
12/12 [==============================] - 1s 43ms/step - loss: 0.4390 - accu
racy: 0.8560 - val_loss: 0.3865 - val_accuracy: 0.8846
Epoch 46/100
```

```
12/12 [==============================] - 0s 39ms/step - loss: 0.4360 - accu
racy: 0.8560 - val_loss: 0.3885 - val_accuracy: 0.8846
Epoch 47/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4349 - accu
racy: 0.8560 - val_loss: 0.3823 - val_accuracy: 0.8846
Epoch 48/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4330 - accu
racy: 0.8560 - val_loss: 0.3820 - val_accuracy: 0.8846
Epoch 49/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4326 - accu
racy: 0.8560 - val_loss: 0.3815 - val_accuracy: 0.8846
Epoch 50/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4309 - accu
racy: 0.8560 - val_loss: 0.3798 - val_accuracy: 0.8846
Epoch 51/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4320 - accu
racy: 0.8560 - val_loss: 0.3811 - val_accuracy: 0.8846
Epoch 52/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4290 - accu
racy: 0.8560 - val_loss: 0.3773 - val_accuracy: 0.8846
Epoch 53/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4279 - accu
racy: 0.8560 - val_loss: 0.3775 - val_accuracy: 0.8846
Epoch 54/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4250 - accu
racy: 0.8560 - val_loss: 0.3753 - val_accuracy: 0.8846
Epoch 55/100
12/12 [==============================] - 0s 42ms/step - loss: 0.4265 - accu
racy: 0.8560 - val_loss: 0.3744 - val_accuracy: 0.8846
Epoch 56/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4241 - accu
racy: 0.8560 - val_loss: 0.3756 - val_accuracy: 0.8846
Epoch 57/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4260 - accu
racy: 0.8560 - val_loss: 0.3716 - val_accuracy: 0.8846
Epoch 58/100
12/12 [==============================] - 0s 42ms/step - loss: 0.4242 - accu
racy: 0.8560 - val_loss: 0.3741 - val_accuracy: 0.8846
Epoch 59/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4248 - accu
racy: 0.8560 - val_loss: 0.3721 - val_accuracy: 0.8846
Epoch 60/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4222 - accu
racy: 0.8560 - val_loss: 0.3766 - val_accuracy: 0.8846
Epoch 61/100
12/12 [==============================] - 1s 45ms/step - loss: 0.4245 - accu
racy: 0.8560 - val_loss: 0.3733 - val_accuracy: 0.8846
Epoch 62/100
12/12 [==============================] - 0s 42ms/step - loss: 0.4235 - accu
racy: 0.8560 - val_loss: 0.3761 - val_accuracy: 0.8846
Epoch 63/100
12/12 [==============================] - 1s 43ms/step - loss: 0.4249 - accu
racy: 0.8560 - val_loss: 0.3729 - val_accuracy: 0.8846
Epoch 64/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4227 - accu
racy: 0.8560 - val_loss: 0.3694 - val_accuracy: 0.8846
Epoch 65/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4208 - accu
racy: 0.8560 - val_loss: 0.3735 - val_accuracy: 0.8846
Epoch 66/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4246 - accu
racy: 0.8560 - val_loss: 0.3758 - val_accuracy: 0.8846
Epoch 67/100
```

```
12/12 [==============================] - 0s 38ms/step - loss: 0.4236 - accu
racy: 0.8560 - val_loss: 0.3706 - val_accuracy: 0.8846
Epoch 68/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4215 - accu
racy: 0.8560 - val_loss: 0.3775 - val_accuracy: 0.8846
Epoch 69/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4204 - accu
racy: 0.8560 - val_loss: 0.3715 - val_accuracy: 0.8846
Epoch 70/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4208 - accu
racy: 0.8560 - val_loss: 0.3685 - val_accuracy: 0.8846
Epoch 71/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4236 - accu
racy: 0.8560 - val_loss: 0.3696 - val_accuracy: 0.8846
Epoch 72/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4211 - accu
racy: 0.8560 - val_loss: 0.3731 - val_accuracy: 0.8846
Epoch 73/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4211 - accu
racy: 0.8560 - val_loss: 0.3700 - val_accuracy: 0.8846
Epoch 74/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4203 - accu
racy: 0.8560 - val_loss: 0.3740 - val_accuracy: 0.8846
Epoch 75/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4201 - accu
racy: 0.8560 - val_loss: 0.3702 - val_accuracy: 0.8846
Epoch 76/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4209 - accu
racy: 0.8560 - val_loss: 0.3704 - val_accuracy: 0.8846
Epoch 77/100
12/12 [==============================] - 1s 42ms/step - loss: 0.4224 - accu
racy: 0.8560 - val_loss: 0.3746 - val_accuracy: 0.8846
Epoch 78/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4208 - accu
racy: 0.8560 - val_loss: 0.3709 - val_accuracy: 0.8846
Epoch 79/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4203 - accu
racy: 0.8560 - val_loss: 0.3682 - val_accuracy: 0.8846
Epoch 80/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4196 - accu
racy: 0.8560 - val_loss: 0.3703 - val_accuracy: 0.8846
Epoch 81/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4210 - accu
racy: 0.8560 - val_loss: 0.3684 - val_accuracy: 0.8846
Epoch 82/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4216 - accu
racy: 0.8560 - val_loss: 0.3704 - val_accuracy: 0.8846
Epoch 83/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4209 - accu
racy: 0.8560 - val_loss: 0.3690 - val_accuracy: 0.8846
Epoch 84/100
12/12 [==============================] - 0s 38ms/step - loss: 0.4202 - accu
racy: 0.8560 - val_loss: 0.3703 - val_accuracy: 0.8846
Epoch 85/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4209 - accu
racy: 0.8560 - val_loss: 0.3730 - val_accuracy: 0.8846
Epoch 86/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4208 - accu
racy: 0.8560 - val_loss: 0.3690 - val_accuracy: 0.8846
Epoch 87/100
12/12 [==============================] - 1s 43ms/step - loss: 0.4189 - accu
racy: 0.8560 - val_loss: 0.3672 - val_accuracy: 0.8846
Epoch 88/100
```

```
12/12 [==============================] - 1s 43ms/step - loss: 0.4208 - accu
racy: 0.8560 - val_loss: 0.3682 - val_accuracy: 0.8846
Epoch 89/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4184 - accu
racy: 0.8560 - val_loss: 0.3680 - val_accuracy: 0.8846
Epoch 90/100
12/12 [==============================] - 0s 42ms/step - loss: 0.4185 - accu
racy: 0.8560 - val_loss: 0.3699 - val_accuracy: 0.8846
Epoch 91/100
12/12 [==============================] - 1s 42ms/step - loss: 0.4205 - accu
racy: 0.8560 - val_loss: 0.3671 - val_accuracy: 0.8846
Epoch 92/100
12/12 [==============================] - 1s 43ms/step - loss: 0.4197 - accu
racy: 0.8560 - val_loss: 0.3718 - val_accuracy: 0.8846
Epoch 93/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4190 - accu
racy: 0.8560 - val_loss: 0.3688 - val_accuracy: 0.8846
Epoch 94/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4214 - accu
racy: 0.8560 - val_loss: 0.3702 - val_accuracy: 0.8846
Epoch 95/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4211 - accu
racy: 0.8560 - val_loss: 0.3672 - val_accuracy: 0.8846
Epoch 96/100
12/12 [==============================] - 0s 40ms/step - loss: 0.4205 - accu
racy: 0.8560 - val_loss: 0.3697 - val_accuracy: 0.8846
Epoch 97/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4178 - accu
racy: 0.8560 - val_loss: 0.3668 - val_accuracy: 0.8846
Epoch 98/100
12/12 [==============================] - 0s 39ms/step - loss: 0.4187 - accu
racy: 0.8560 - val_loss: 0.3659 - val_accuracy: 0.8846
Epoch 99/100
12/12 [==============================] - 0s 41ms/step - loss: 0.4175 - accu
racy: 0.8560 - val_loss: 0.3665 - val_accuracy: 0.8846
Epoch 100/100
```
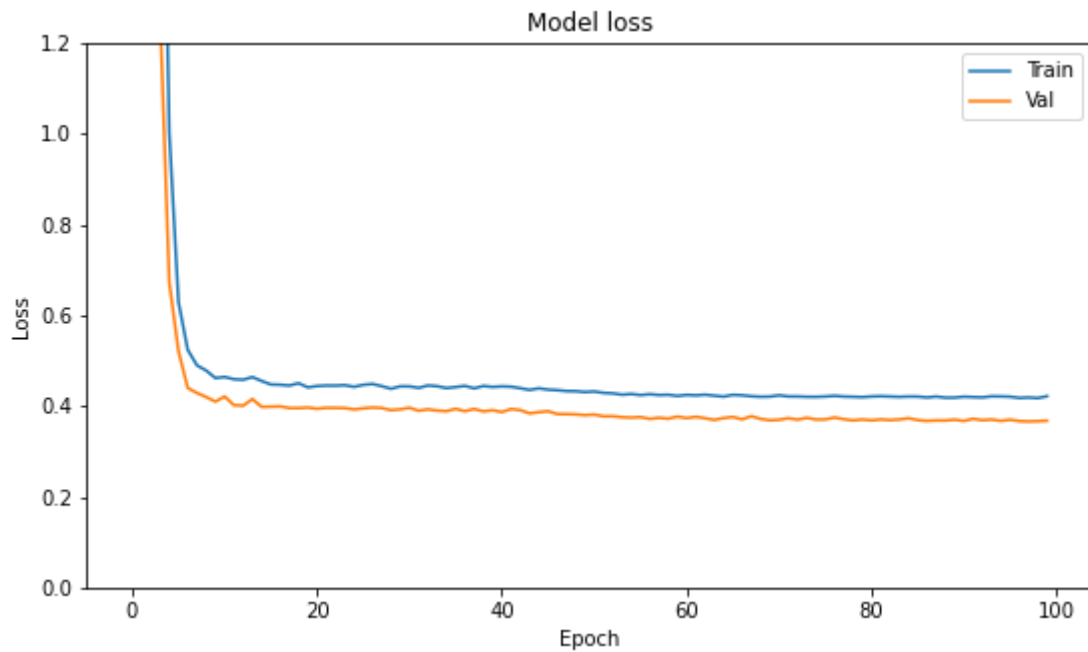
In [77]:
```python
plt.plot(hist_3.history['loss'])
plt.plot(hist_3.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='upper right')
plt.ylim(top=1.2, bottom=0)
plt.show()
```

Model loss

```python
plt.plot(hist_3.history['accuracy'])
plt.plot(hist_3.history['val_accuracy'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='lower right')
plt.show()
```



Model accuracy
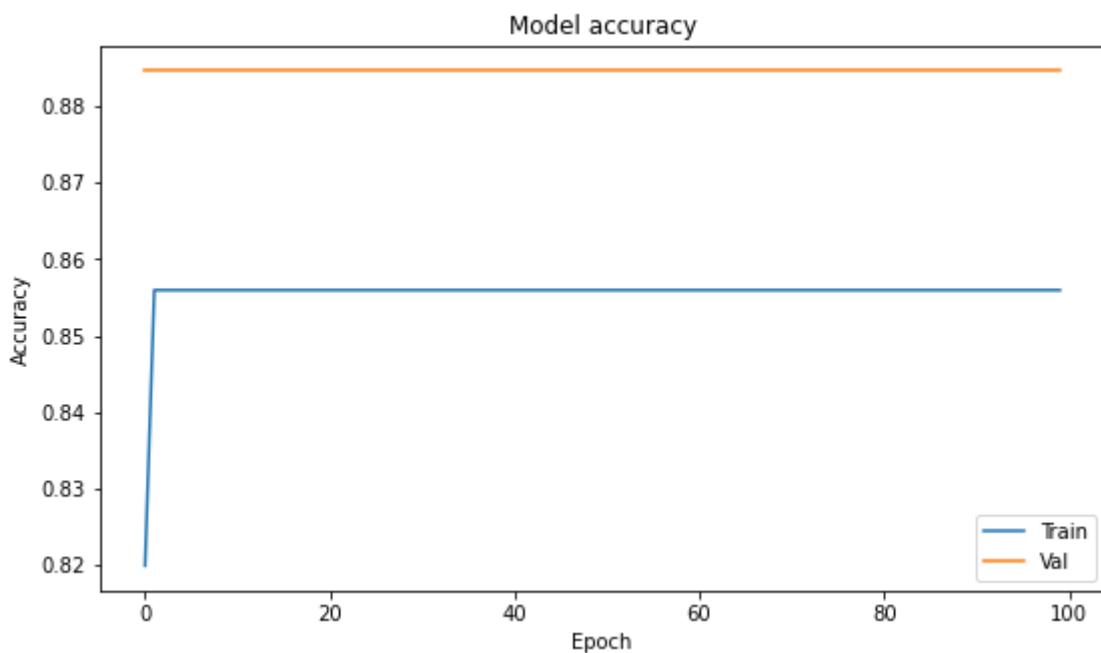
## conclusion

```python
predictions = model.predict(X_train)
```

```python
for i in range(5):
    print('%s => %d (expected %d)' % (X[i].tolist(), predictions[i], y[i]))
```

```
[86.2, 26.2, 94.3, 5.1, 8.2, 51.0, 6.7, 0.0, 0.0, 1.0] => 0 (expected 1)
```

```
[90.6, 35.4, 669.1, 6.7, 18.0, 33.0, 0.9, 0.0, 0.0, 0.0] => 0 (expected 1)
[90.6, 43.7, 686.9, 6.7, 14.6, 33.0, 1.3, 0.0, 0.0, 0.0] => 0 (expected 1)
[91.7, 33.3, 77.5, 9.0, 8.3, 97.0, 4.0, 0.2, 0.0, 1.0] => 0 (expected 1)
[89.3, 51.3, 102.2, 9.6, 11.4, 99.0, 1.8, 0.0, 0.0, 0.0] => 0 (expected 1)
```

In [ ]: