NamUs: Unidentified Persons

...

Using Machine Learning to Predict the “Identification Potential” 5-star rating

Target Response: "Identification Potential" 'IP'

- High
- Medium-High
- Medium
- Low-Medium
- Low
- Extremely-Low ★

Scraped using Requests and BeautifulSoup, and put into Pandas

Recoded to 0, 1, 2, 3, 4, 5

Predicting Unidentified Case 5-Star Rating:

Star ratings are automatically calculated when data is entered into the system.

If I ***can*** predict the star rating:

1. Which features predict “Identification Potential”?
2. How do these compare with those identified by NamUs in their Help.PDF?

If I ***cannot*** predict the star rating:

1. This may indicate key information is not available to the public on NamUs.
2. Indicate a re-write of the Help.PDF is required.

Namus Help PDF

3 Stars
A fingerprint classification or fingerprint card has been entered or uploaded, AND/OR, information has been entered in at least one of the tooth boxes on the dental chart page, AND/OR the "Recognizable Face" option has been selected in the "Body Condition" section and a facial photo or artist's rendering has been uploaded

4 Stars

5 Stars
The face is recognizable, a facial photo or rendering has been uploaded, fingerprint information has been entered or uploaded, a DNA profile has been established and specific tooth information has been entered.

Examples of Binary Features:

- Capture what is *KNOWN* vs what is *UN*KNOWN

tattoos	piercings
scars_and_marks	skeletal_findings
n-hands_not_recovered	**_dna**
_dental	**_fingerprints**
_sex	**_face**
weight_bin	height_bin

_face (recoded from Recognizable_face):

```
In [48]: namusdb.recognizable_face.unique()
Out[48]:
array(['Not recognizable - Decomposing/putrefaction', 'Recognizable face',
       'Not recognizable - Charred/burned',
       'Not recognizable - Insect/animal activity',
       'Not recognizable - Partial remains with soft tissues',
       'Not recognizable - Partial skeletal parts only', '',
       'Not recognizable - Near complete or complete skeleton',
       'Not recognizable - Mummified',
       'Not recognizable - Traumatic injuries'], dtype=object)
```

Examples of Text and Numeric Features:

-

tattoos_description	piercings_description
scars_and_marks_description	skeletal_findings_description
clothing_on_body	footwear
eyewear	jewelry
head_hair	facial_hair
body_hair	**circumstances**
images	**age_range**

Linear Regression Model

```
#  Create features for linear regression: all fea
linreg_features = ['all_parts_recovered',
                   'amputations',
                   'artificial_parts_aids',
                   'deformities',
                   'finger_toe_nails',
                   'foreign_objects',
                   'head_not_recovered',
                    'images',
                   'medical_implants',
                   'n-hands_not_recovered',
                   'n-limbs_not_recovered',
                   'organ_absent',
                   'other_distinctive_features',
                   'other_medical_information',
                   'piercings',
                   'prior_surgery',
                   'scars_and_marks',
                   'skeletal_findings',
                   'tattoos',
                   'torso_not_recovered',
                   '_sex',
                   '_dna',
                   '_dental',
                   '_fingerprints',
                   '_face',
                   'l_eye',
                   'r_eye',
                   'height_bin',
                   'weight_bin',
                   'age_range']
```

```
linreg = LinearRegression
(normalize=True)
```

Null: RMSE = 1.19 Train-test-split RMSE = 0.8159

A prediction of IP from 0-5 can be off by ~ 0.82 stars.

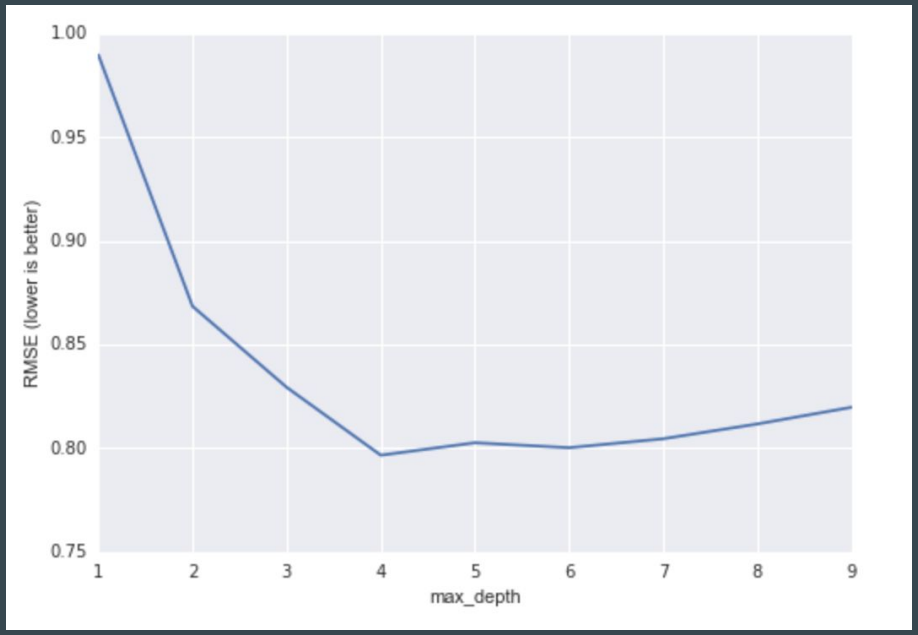
REGULARIZATION:

RidgeCV: RMSE = 0.8158
LassoCV: RMSE = 0.8154

Features with zero coefficients:

```
'artificial_parts_aids',  'deformities',
'foreign_objects',        'r_eye',
'medical_implants',       'torso_not_recovered'
```

Decision Tree Regression Model

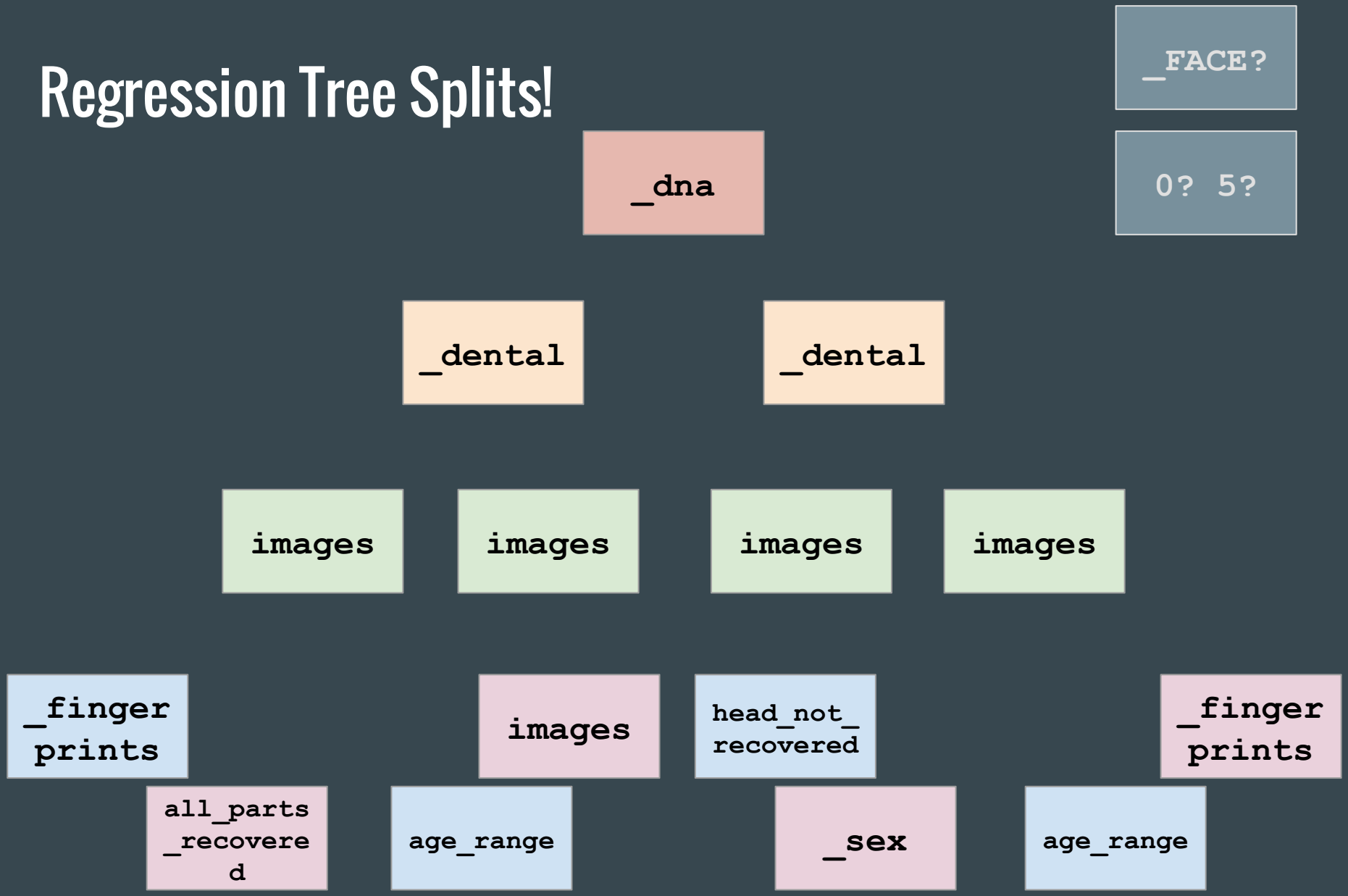



```
treereg = DecisionTreeRegressor
(max_depth=depth,
random_state=1)
```

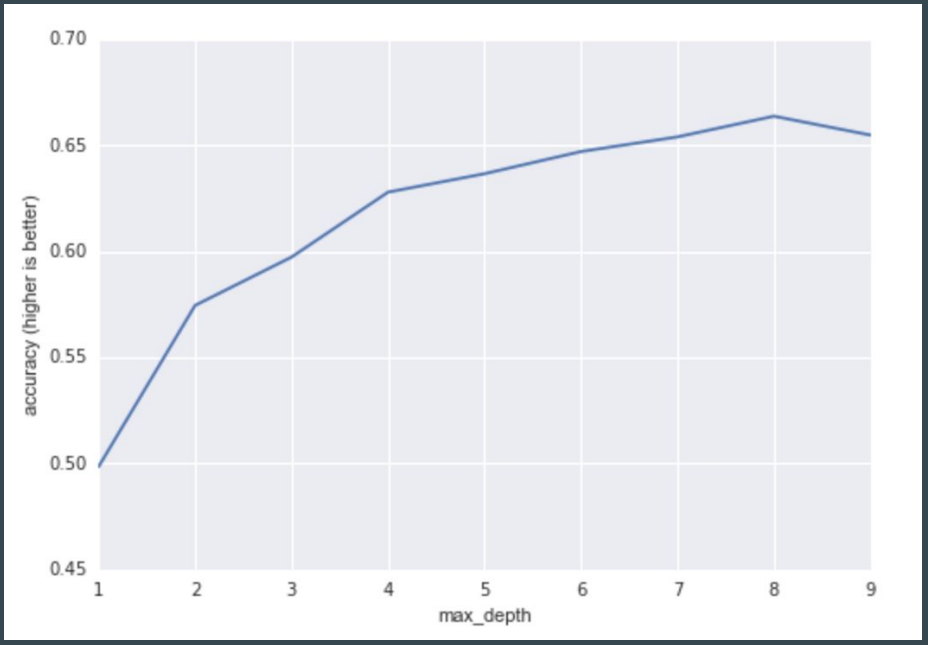
`max_depth range 1-10, cv=100`
Best: 4 splits, RMSE of 0.7966.

`cv=1000,` RMSE = 0.7316.
Improvement due to better sampling of skewed data?

Regression Tree Splits!



Decision Tree Classification Model



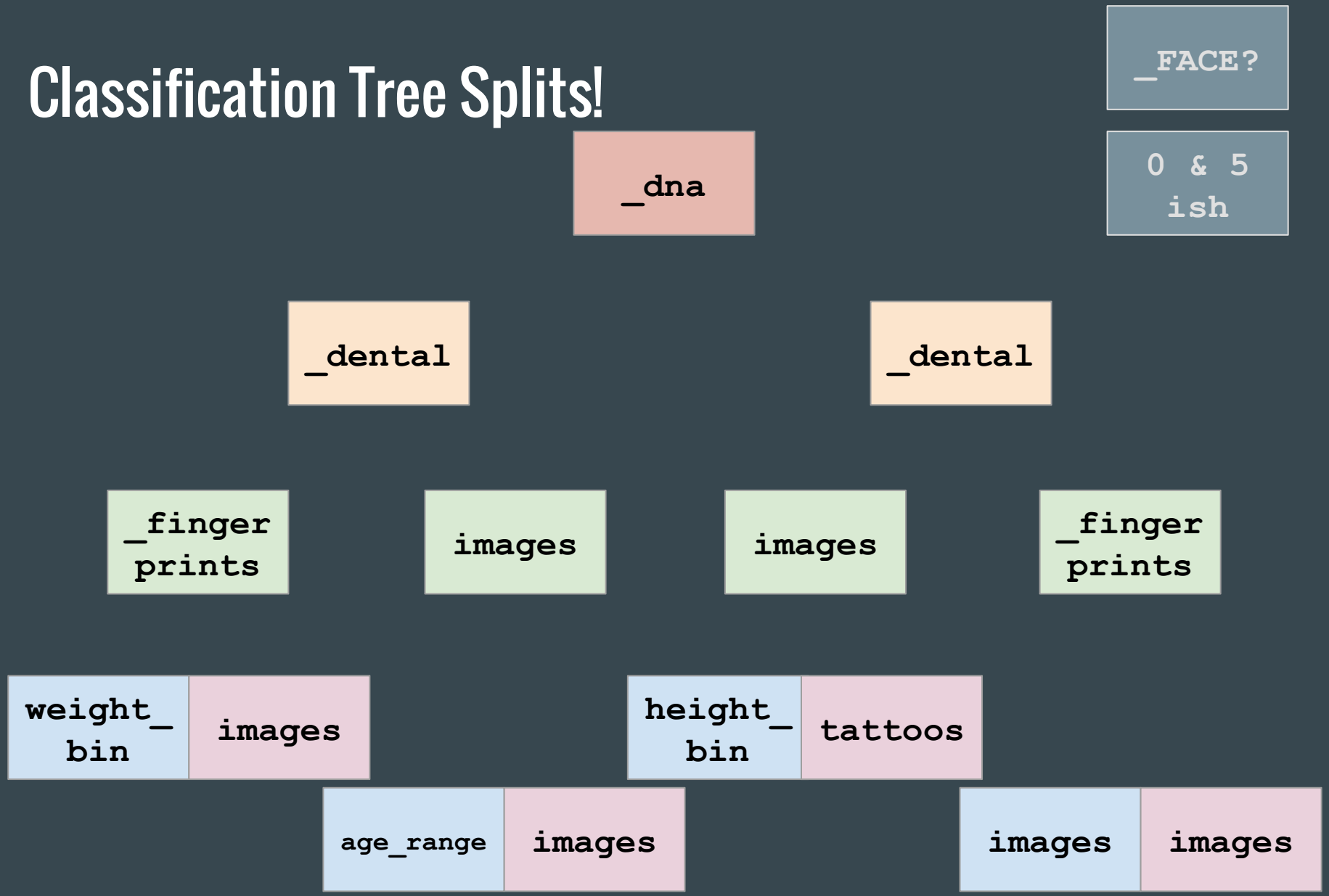

```
treeclf = DecisionTreeClassifier
(max_depth=depth,
random_state=1)
```

`max_depth range 1-10, cv=100`

Best: 8 splits! , Accuracy 64%

4 Splits: All 5-Star cases in one Leaf (gini 0.65)

Classification Tree Splits!



Random Forest Regression

After Tuning:

```
rfreg = RandomForestRegressor(n_estimators=270,
max_features=5, oob_score=True, random_state=1)

rfreg.fit(X, y)
```

R^2 Out-of-Bag Score: **0.5626271142334848 8**

24	_face	0.023
23	_fingerprints	0.039
7	images	0.107
29	age_range	0.180
22	_dental	0.197
21	_dna	0.277

Random Forest Classification

After Tuning:

```
rfclf_test = RandomForestClassifier(n_estimators=65,
max_features=10, random_state=1, oob_score=True) rfclf_test.fit
(X, y)                                                scores =
cross_val_score(rfclf, X, y, cv=10, scoring='accuracy') predicted
= cross_val_predict(rfclf, X, y, cv=10)
```

R^2 Out-of-Bag Score: **0.65**

24	**_face**	**0.03**
23	**_fingerprints**	**0.05**
7	**_dental**	**0.09**
29	**images**	**0.11**
22	**_dna**	**0.18**
21	**age_range**	**0.24**

Discussion / Conclusions

- Regression better than classification? Difficult to compare performance between %age accuracy and RMSE and $\mathbf{R^2}$...
- Why is `'_face'` so hard to get? Yet it's critical in the NamUs model. Why?
  - This may be due to smaller numbers of 5-Star cases
  - This may also be the reason 5-Star ratings are hard to predict.
  - Same goes for the 0-Stars
- Add binary `hair_color` !!?
- Images are a **`count`** and not separated by actual **FACE** images and **NON-FACE** images
- Improve Decision Tree performance by merging some features together?
- One Versus Rest better able to model the 0-Star and 5-Star?
- Ensembling
- Ordinal Logistic Regression? Made for multiple, ordered classes.
- Continue working on the Text data...current NB accuracy 48% (wowzers)
- Better exploration / visualization of model performance (eg AUC)

New Questions and Future Additions:

- Submit a FOIA?
  - Request data on solved cases - what features lead to the resolution?
    - Do they update their algorithm based on evidence from solved cases?
- Create an interactive map for the find-locations and case summary
- Create other visuals