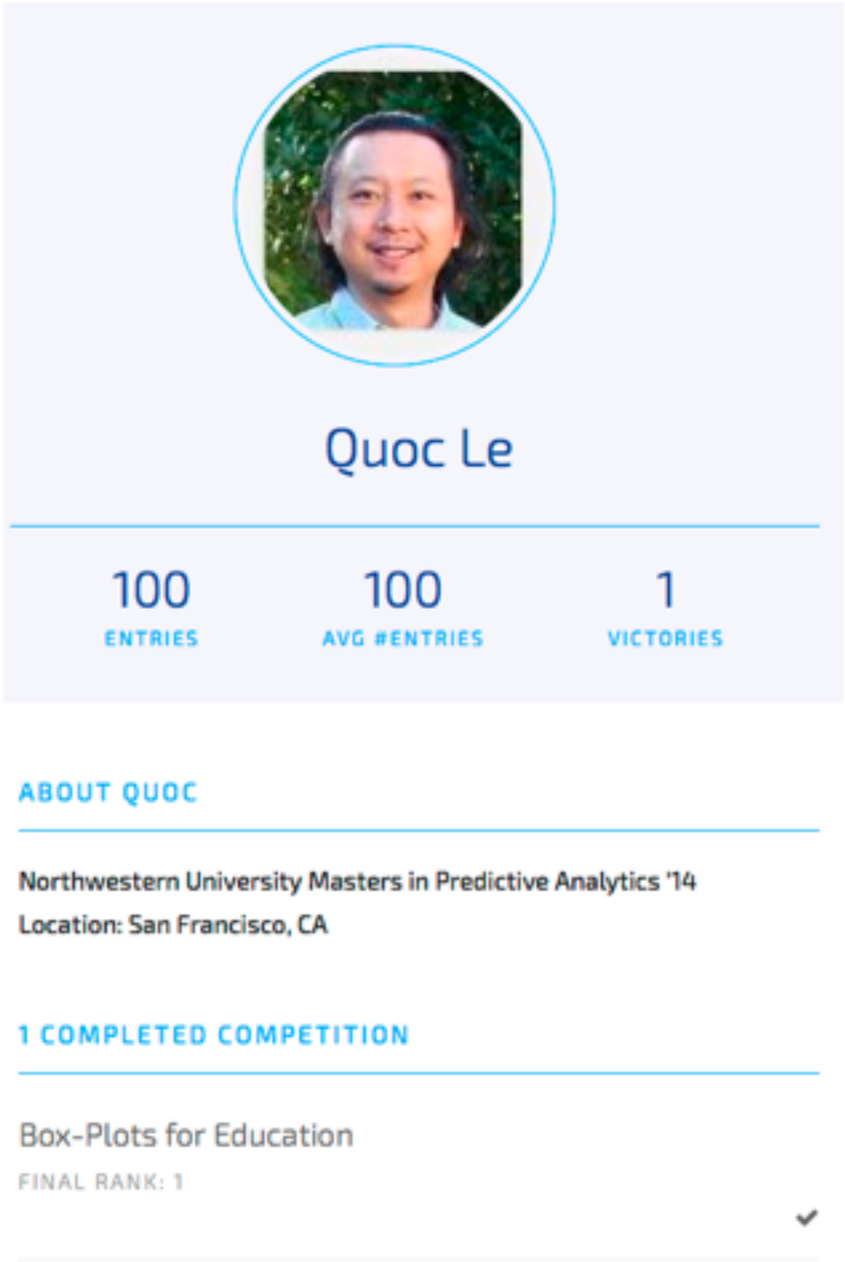
MACHINE LEARNING WITH THE EXPERTS: SCHOOL BUDGETS

Learning from the expert: processing

Learning from the expert

- Text processing
- Statistical methods
- Computational efficiency



Quoc Le

100	100	1
ENTRIES	AVG #ENTRIES	VICTORIES

ABOUT QUOC

Northwestern University Masters in Predictive Analytics '14
Location: San Francisco, CA

1 COMPLETED COMPETITION

Box-Plots for Education
FINAL RANK: 1

Learning from the expert: text preprocessing

- NLP tricks for text data
  - Tokenize on punctuation to avoid hyphens, underscores, etc.
  - Include unigrams **and** bi-grams in the model to capture important information involving multiple tokens - e.g., ‘middle school’

N-grams and tokenization

```
In [1]: vec = CountVectorizer(token_pattern=TOKENS_ALPHANUMERIC,
   ...:                        ngram_range=(1, 2))
```

- Simple changes to CountVectorizer
    - alphanumeric tokenization
    - ngram_range=(1, 2)

Range of n-grams in scikit-learn

```
In [2]: pl.fit(X_train, y_train)
Out[2]:
Pipeline(steps=[('union', FeatureUnion(n_jobs=1,
       transformer_list=[('numeric_features',
Pipeline(steps=[('selector',
FunctionTransformer(accept_sparse=False,
          func=<function <lambda> at 0x11441f7b8>, pass_y=False,
          validate=False)), ('imputer', Imputer(axis=0, copy=True,
missing_valu...=None, solver='liblinear', tol=0.0001,
          verbose=0, warm_start=False),
          n_jobs=1))])
```

Range of n-grams in scikit-learn

```
In [3]: holdout = pd.read_csv('HoldoutData.csv', index_col=0)

In [4]: predictions = pl.predict_proba(holdout)

In [5]: prediction_df = pd.DataFrame(columns=pd.get_dummies(
   ...:                 df[LABELS]).columns, index=holdout.index,
   ...:                 data=predictions)

In [6]: prediction_df.to_csv('predictions.csv')

In [7]: score = score_submission(pred_path='predictions.csv')
```

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Let’s practice!

Learning from the expert: a stats trick

Learning from the expert: interaction terms

- Statistical tool that the winner used: interaction terms
- Example
    - English teacher for 2nd grade
    - 2nd grade - budget for English teacher
- Interaction terms mathematically describe when tokens appear together

Interaction terms: the math

$$\beta_1 x_1 + \beta_2 x_2 + \beta_3 (x_1 \times x_2)$$

X1	X2
0	1
1	1

X3
X1*X2 = 0*1 = 0
X1*X2 = 1*1 = 1

Adding interaction features with scikit-learn

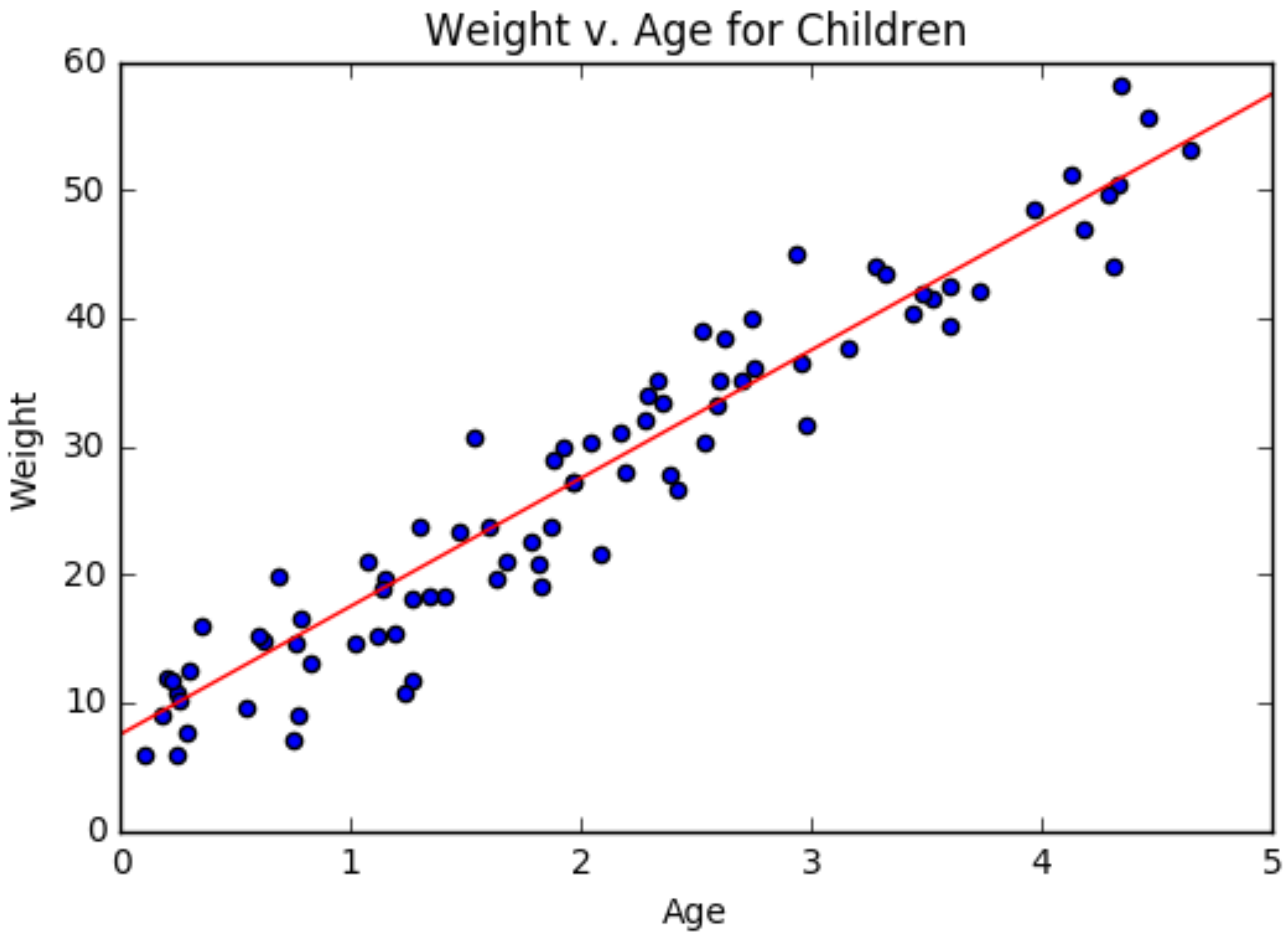
```
In [1]: from sklearn.preprocessing import PolynomialFeatures

In [2]: x
Out[2]:
   x1  x2
a   0   1
b   1   1

In [3]: interaction = PolynomialFeatures(degree=2,
   ...:                                  interaction_only=True,
   ...:                                  include_bias=False)

In [4]: interaction.fit_transform(x)
Out[4]:
array([[ 0.,  1.,  0.],
       [ 1.,  1.,  1.]])
```

A note about bias terms



- Bias term allows model to have non-zero y value when x value is zero

Sparse interaction features

```
In [5]: SparseInteractions(degree=2).fit_transform(x).toarray()
Out[5]:
array([[ 0.,  1.,  0.],
       [ 1.,  1.,  1.]])
```

- The number of interaction terms grows exponentially
- Our vectorizer saves memory by using a sparse matrix
- PolynomialFeatures does not support sparse matrices
- We have provided SparseInteractions to work for this problem

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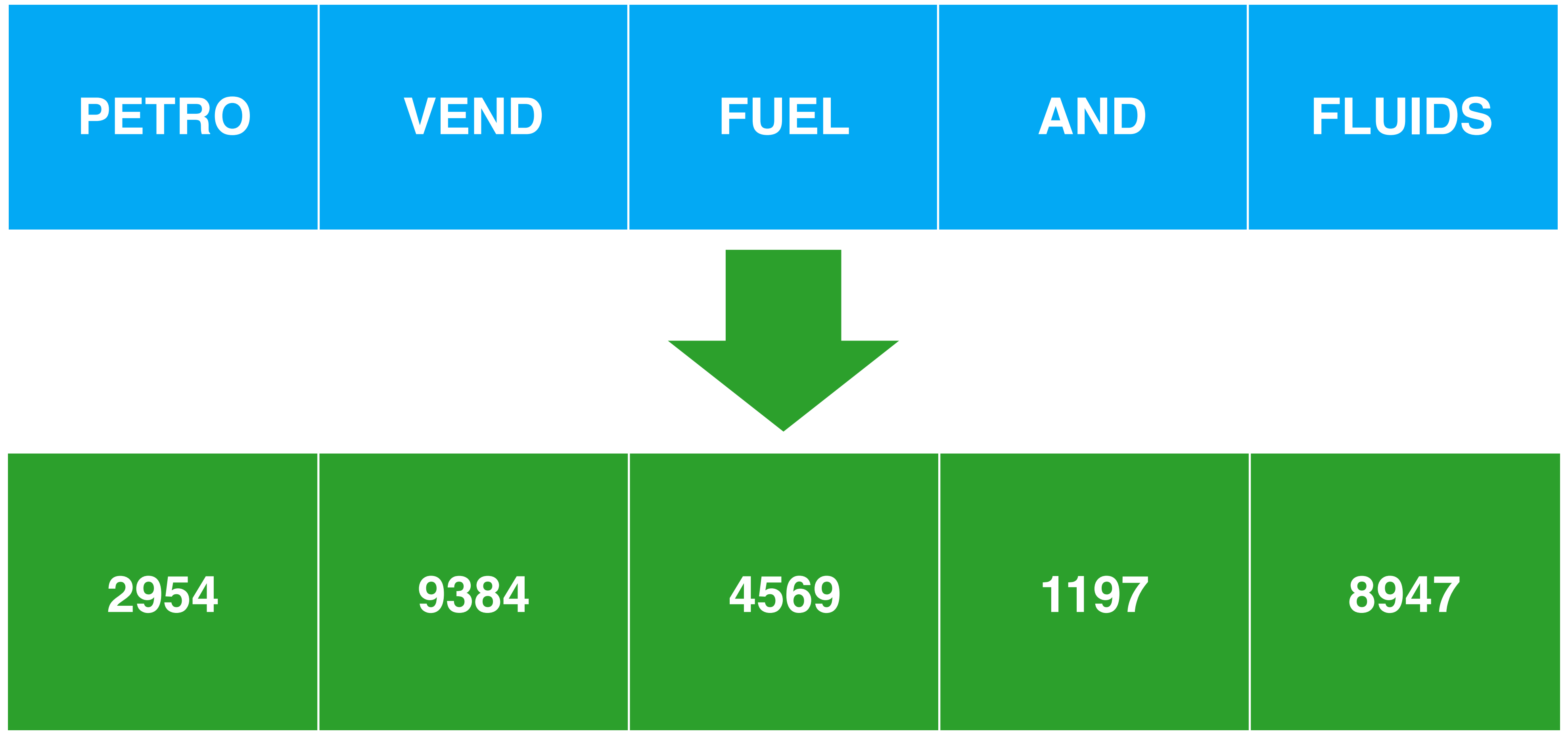
Let’s practice!

Learning from the expert: a computational trick and the winning model

Learning from the expert: hashing trick

- Adding new features may cause enormous increase in array size
- Hashing is a way of increasing memory efficiency



PETRO	VEND	FUEL	AND	FLUIDS
2954	9384	4569	1197	8947

- Hash function limits possible outputs, fixing array size

When to use the hashing trick

- Want to make array of features as small as possible
    - Dimensionality reduction
- Particularly useful on large datasets
    - e.g., lots of text data!

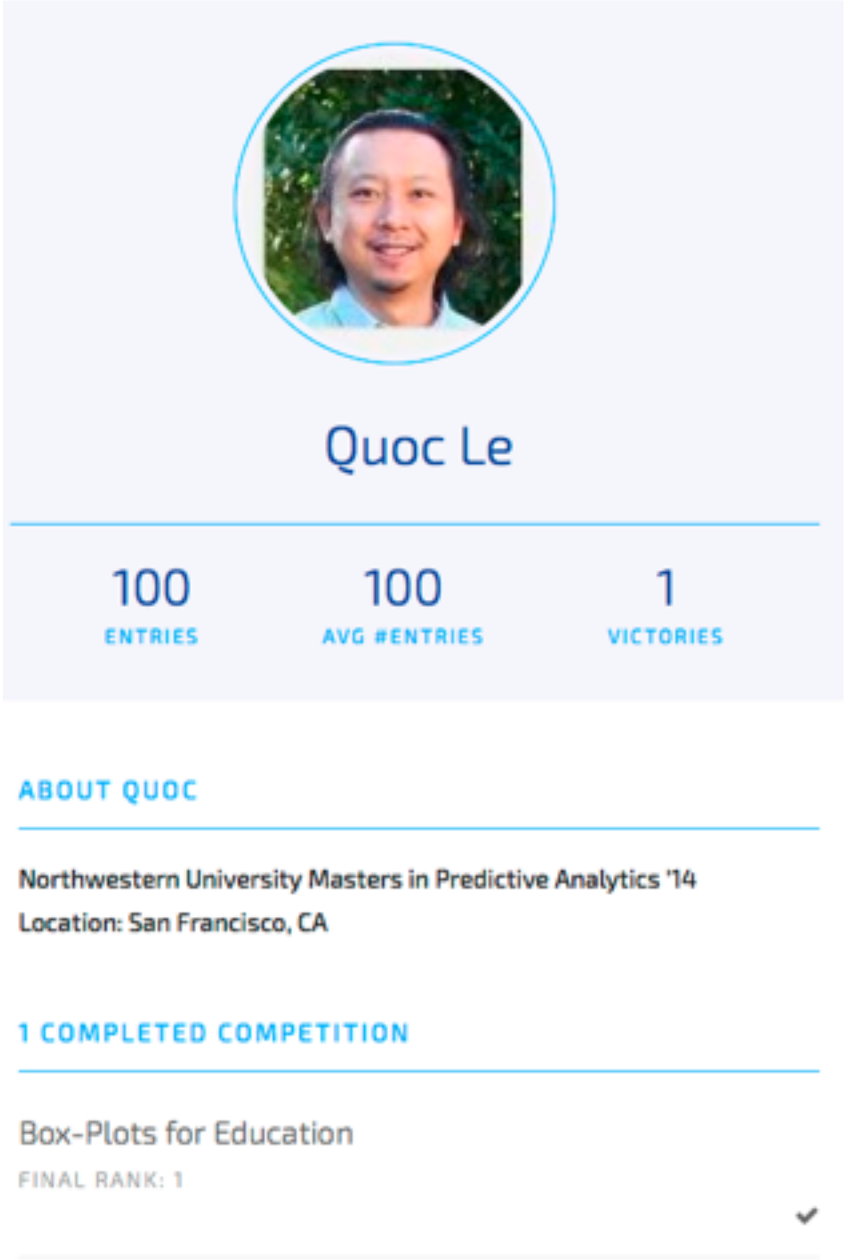
Implementing the hashing trick in scikit-learn

```
In [5]: from sklearn.feature_extraction.text import HashingVectorizer

In [6]: vec = HashingVectorizer(norm=None,
   ...:                         non_negative=True,
   ...:                         token_pattern=TOKENS_ALPHANUMERIC,
   ...:                         ngram_range=(1, 2))
```

The model that won it all

- You now know all the expert moves to make on this dataset
    - NLP: Range of n-grams, punctuation tokenization
    - Stats: Interaction terms
    - Computation: Hashing trick
- What class of model was used?



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The model that won it all

- And the winning model was...
- Logistic regression!
  - Carefully create features
  - Easily implemented tricks
- Favor simplicity over complexity and see how far it takes you!

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Let’s practice!

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Next steps and the social impact of your work

Can you do better?

- You've seen the flexibility of the pipeline steps
- Quickly test ways of improving your submission
    - NLP: Stemming, stop-word removal
    - Model: RandomForest, k-NN, Naïve Bayes
    - Numeric Preprocessing: Imputation strategies
    - Optimization: Grid search over pipeline objects
    - Experiment with new scikit-learn techniques
- Work with the full dataset at DrivenData!

Hundreds of hours saved

- Make schools more efficient by improving their budgeting decisions
- Saves hundreds of hours each year that humans spent labeling line items
- Can spend more time on the decisions that really matter

DrivenData: Data Science to save the world

- Other ways to use data science to have a social impact at www.drivendata.org
    - Improve your data science skills while helping meaningful organizations thrive
    - Win some cash prizes while you're at it!

Go out and change the world!