# Predicting Change in BMI Using MyFitnessPal

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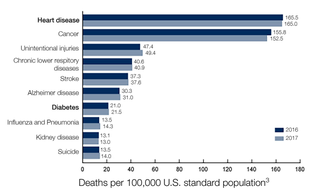
## Motivation

- 65% of US adults are clinically overweight or obese[1]
- Increased risk for issues including heart disease and diabetes[2]
- Calorie-tracking apps like MyFitnessPal aid in weight loss pursuits[7]
- Predicting weight loss (or lack thereof) might allow for early intervention
- Understanding factors related to weight provides insight to successful behavior




## Dataset

- 1.7M users, 99M weighs, 3.2B food logs, 169M workouts
- Features
  - User demographics
  - Goals (weight, weight change/week, cal/day)
  - Weighs
  - Food logs
  - Exercise logs
- Weighs 4 and 12 weeks from arbitrary start weigh

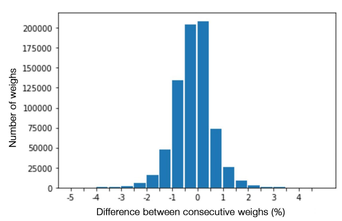
| Users | Weighs | Food logs | Workouts |
|---|---|---|---|
| 43.2K | 884.2K | 21.6M | 500.6K |


## Data Engineering

**Data Credibility and Integrity**

- Weight measurement data
  - Manual entry vs. **bluetooth: 20%** error reduction
- Sparsity
  - Threshold for number of log days to reduce noise
  - Feature indicators for sparse intra-day logging


*Bluetooth scale*




- Weight fluctuations
  - Fluctuates by **1 lb or 0.6%** daily (N = 500k)
- Outlier detection
  - Using statistical modeling to remove bad data[4]

## Features

**Linear Regression & Gradient Boosted Trees Features**

- 53 features
- Features were normalized to have zero mean and unit variance
  - Related features, ex. weighs or calorie counts, were normalized together

| Type | Count | Example |
|---|---|---|
| Static | 7 | Age, height |
| Engineered | 22 | Days >500 kcal |
| Aggregated | 24 | Sum protein (g) |
| Dynamic (RNN) | 448 | Protein day 1 |

**Recurrent Neural Network Features**

- 16 features per day, 28 log days
  - Daily aggregated nutrition logs
  - 448 total features
  - Zero-padded on missed days

## Modeling

**Linear Regression (LR) & Gradient Boosted Trees (GBM)**

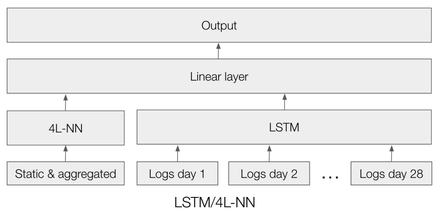
- Linear Regression run with and without L1 and L2 regularization
  - l1_ratio of 0.3 and regularization coefficient of 10e-4
- Traditional and Gradient Boosted Decision Trees were hypertuned with relevant tree and boosting-related parameters
  - Depth of 8, 190 estimators, min of 500 samples per split and 90 per leaf, subsample of 0.8, and alpha and learning rate of 10e-1

**Neural Network (NN)**

- Four-layer neural network (including input and output layers)
- Take in 53 features as input size. Two hidden layers of size 400
- Rectified linear units (ReLU)[5] for the activation functions

**Recurrent Neural Network (RNN)**

- Combines static and dynamic features
- Static features fed through above 4L-NN. Dynamic fed through LSTM[6]
- Both NN outputs stacked and fed through final layer
- LSTM configuration
  - Hidden size of 1
  - Three-layered





## References

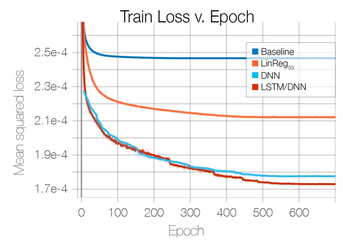
[1] WHO. Obesity and overweight. *World Obesity Federation*, 2018.
[2] C. Ogden. Overweight & obesity statistics. *National Institute of Diabetes and Digestive and Kidney Diseases*, 2017.
[3] S. L. Murphy et al. Mortality in the United States, 2017. *National Center for Health Statistics*, 2018.
[4] J. Gaspar et al. A systematic review of outliers detection techniques in medical data. *Proceedings of the International Conference on Health Informatics*, 2011.
[5] V. Nair and G.E. Hinton. Rectified linear units improve restricted boltzmann machines. *Proceedings of the 27th International Conference on International Conference on Machine Learning*, 2010.
[6] S. Hochreiter and J. Schmidhuber. Long short-term memory. *Neural Computation*, 1997.
[7] S. Chin et al. Successful weight reduction and maintenance by using a smartphone application in those with overweight & obesity. *Scientific Reports*, 2016.

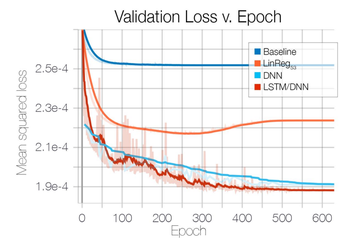

## Results and Discussion

| Model | Mean squared error (% weight) | | Mean absolute error (% weight) | |
|---|---|---|---|---|
| | train | test | train | test |
| Baseline*$_{16}$ | 1.23e1 | 1.05e1 | 2.12 | 2.10 |
| Baseline$_{16}$ | 2.47e-2 | 2.52e-2 | 1.27 | 1.29 |
| LinReg$_{53}$ | 2.12e-2 | 2.24e-2 | 1.18 | 1.18 |
| GBM$_{53}$ | 1.55e-2 | 1.99e-2 | 1.01 | 1.14 |
| 4L-NN | 1.78e-2 | 1.91e-2 | 1.08 | 1.10 |
| LSTM/4L-NN | 1.73e-2 | 1.88e-2 | 1.06 | 1.09 |

**Contains examples before data credibility enhancements (as compared to Baseline, which contains examples after enhancements)*

- **Best model**: LSTM/4L-NN.
  - Mean absolute error: 1.09%, **0.49%** above daily weight fluctuation
- **Data engineering** beat model engineering
  - **38.6%** reduction in mean absolute error (test) through data engineering vs. a **15.5%** reduction via model engineering
- Error analysis
  - Data bias → imbalanced predictions: ~30% better for weight losers
  - Inherent tradeoffs between model expressiveness and accuracy
- Additive feature selection in GBM
  - **Top 5:** Days with >500 calories logged; % basal metabolic rate logged per day; % protein over 4 weeks; starting BMI, goal weight
  - Using only the top 10 features increases MSE by 4% & MAE by 2%




## Demo & Future Work

**Demo**

- https://mfp.ai

**Future Work**

- Identify important features in the NN models
- Include users with manual weight entries
- Predict 12-week weight change using 4 weeks of data
- Determine minimum data to predict weight change
- Focus on outcomes for individuals with obesity